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Investigaciones Mastozoológicas

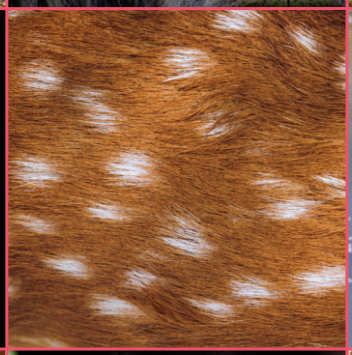
Volume 3

Introduced Invasive Mammals of Argentina

Mamíferos Introducidos Invasores de Argentina









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The Argentine Society for the Study of Mammals (Sociedad Argentina para el Estudio de los Mamíferos – SAREM) was created in 1983, and currently has about 300 members from several countries. SAREM is an interdisciplinary society of natural sciences professionals whose main goals are the promotion of scientific and technical research, the consolidation of national collections and research centers, and the publication and diffusion of research on living and/or extinct mammals. SAREM has organized scientific meetings for mammal researchers since 1994, publishes the journals *Mastozoología Neotropical* and *Notas sobre Mamíferos Sudamericanos*, and has edited books on the systematics, distribution and conservation of the mammals of southern South America, including *Libro Rojo de los mamíferos amenazados de la Argentina* (first ed. 2000, second ed. 2012) and *Mamíferos de Argentina. Sistemática y distribución* (2006), as well as contributing to the *Libro Rojo de los mamíferos y aves amenazados de la Argentina* (currently out of print).

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Introduced Invasive Mammals of Argentina

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Introduced invasive species are a major driver of local to global environmental change, including important negative impacts on biodiversity, ecosystem processes, economies, health and other social values. At the same time, however, different social actors can hold diverse representations of these species, particularly of introduced invasive mammals (IIMs). Such divergent values and perceptions can lead to conflicts regarding the management of IIMs, but also invite researchers and managers to be reflexive regarding their own work at a more fundamental level. Therefore, it is key that we advance towards a holistic understanding of IIMs and develop strategies to manage them based on solid technical information and plural perspectives regarding their multiple values. Despite a rich history of initiatives in Argentina to study and manage IIMs, until now there has not been an opportunity to assess the state-of-the-art knowledge in our country. This book seeks to provide rigorous, relevant and legitimate information to support research, policymaking and management decisions regarding IIMs in Argentina. With this objective in mind, the book presents a series of chapters selected to highlight priority topics concerning the conceptualization and implementation of IIM research and management. Then, fact sheets are provided for the different IIMs found in Argentina. Finally, beyond the realm of academic inquiry, the timing of this publication is ideal to re-enforce policy and decision-making, such as the recently approved National Invasive Exotic Species Strategy, which seeks to implement actions and enhance institutional capacities related to invasive species management in Argentina, and the Convention on Biological Diversity's new Global Biodiversity Framework, which also addresses biological invasions as part of broader efforts to attain the 2050 Vision for Living in Harmony with Nature.

Dr. Alejandro E.J. Valenzuela
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Editors, Vol. III SAREM Series A

Contents

Foreword

Biological invasions by introduced species are one of the great changes rapidly transforming the globe today, with innumerable impacts on economics, human health, ecosystem services, and biodiversity. Mammals are among the most impactful of invasive species, transmitting diseases to humans, livestock, and native animals, trampling native grasslands, voraciously devouring vegetation from groundcover to saplings of forest trees, fouling water, causing erosion, and preying on and outcompeting native animals. They were among the first species humans introduced worldwide and in Argentina, both deliberately (*e.g.*, livestock) and inadvertently (*e.g.*, rats and mice). They have been introduced for sport (*e.g.*, deer, boar) and companionship (*e.g.*, cats, dogs), or simply as attractive ornamentals (*e.g.*, squirrels). Some that are meant to be kept in captivity, such as cats, dogs, and squirrels, escape and establish feral populations.

Argentina looms large in the history of biological invasions by introduced mammals. The earliest permanent European settlers of Buenos Aires in 1580 discovered huge herds of feral horses already on the pampas, and soon after, Vázquez de Espinoza described feral horses in Tucumán that were "in such numbers that they cover the face of the earth…". Many sheep were in Tucumán as well at that time, and of course later sheep were enormously numerous in Patagonia, effecting huge changes in the vegetation and driving land degradation and desertification to this day. When Charles Darwin visited the La Plata region in 1832 during the voyage of the Beagle, he reported that "…countless herds of horses, cattle, and sheep, not only have altered the whole aspect of the vegetation, but they have almost banished the guanaco, deer and ostrich. Numberless other changes must likewise have taken place; the wild pig in some parts probably replaces the peccari; packs of wild dogs may be heard howling on the wooded banks of the less-frequented streams; and the common cat, altered into a large and fierce animal, inhabits rocky hills."

Approximately 40 mammals have been introduced to South America, of which 25–30 have established populations; most of these are in the Southern Cone. In Argentina, I count 23 successfully introduced mammal species, including feral cats, dogs, and cows. Many, such as rats, rabbits, boar, and goats, are widely distributed around the world. By contrast, the hairy armadillo has been introduced nowhere else but from the mainland of Patagonia to Tierra del Fuego Island. Strikingly, except for the rats and house mouse, all these mammals were brought to Argentina deliberately; this is very different from, say, introduced insects. A few of these invasive mammals, like the squirrel, were not intended to be released, but I hesitate to term such invaders truly "accidental," because the people who brought them should have realized that escapes or later releases were almost inevitable. Of course, almost all of these mammals were introduced before the late twentieth century, which was when most scientists and the public began to recognize the extent and importance of impacts of introduced species. However, the squirrel and armadillo introductions were recent enough that potential impacts should have been foreseen. Things could be worse, of course—mammals deliberately brought to Argentina that either were released, but did not establish persistent populations or have not yet escaped from hunting preserves include reindeer, silver fox, mule deer, African buffalo, white-tailed deer, Père David's deer, thar, barbary sheep, wisent, mouflon, chamois, and ibex.

The technology of eradicating introduced invasive mammals has made enormous strides in the last thirty years—at least 31 mammal species have been eradicated from islands worldwide, including relatively large islands like South Georgia. Both Norway and ship rats have been eradicated hundreds of times, and house mice about 100 times. Most large mammals, such as deer and horses, are technologically easier eradication targets—many can simply be tracked and shot, for instance. However, mammals more than any other introduced species pose the complication that many people—especially hunters—simply do not want to eradicate them, and many animal welfare advocates, even those recognizing the damage some invaders cause, object to eradicating them by the only currently feasible means—killing them, humanely if possible. Even rat eradication has been impeded on animal rights/animal welfare grounds, and free-ranging dog and cat populations frequently are seen more as animal welfare issues than as conservation problems to broad sectors of some societies. In Argentina, the problem of implementing feasible eradication programs for invasive mammals is epitomized by the rather schizophrenic attitude taken by the National Parks Administration (Administración de Parques Nacionales – APN) towards red deer. The APN's conservation imperative is supported by the section of Law #22,351 that forbids propagating introduced animals, yet red deer, known to damage native species and ecosystems, are managed in Lanín National Park to foster ongoing hunting, and even to improve the size and quality of the deer for better hunting trophies. Additionally, there is often inconsistent and inadequate funding for managing and eradicating invasive mammals in protected areas, almost always constituting a supervening impediment even when a rational and effective goal is stated.

Argentine scientists have participated heavily in the rapid growth of modern invasion science since its inception in the 1980s, and they and overseas colleagues have conducted substantial research on the biology and impacts of many of the introduced invasive mammals in Argentina, as well as other invasive species. Some of the threats posed by these mammals have even become widely known to the general public in Argentina and beyond—the spread of the beaver from Tierra del Fuego to the mainland has been an international news story. *Introduced Invasive Mammals of Argentina* is therefore an exciting and timely addition to the literature on invasions in southern South America for both the Argentine public (and its political representatives and environmental managers) and scientists worldwide. The many authors assembled for this book explore how these biological invasions happened in the first place, how they spread, what they do to biodiversity, ecosystems, and human enterprises, what has been done about them so far, what can be done about them now, and what might be done with them in the future. The editors and authors are to be congratulated for an excellent exposition of the Argentine part of a growing global phenomenon.

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9 | EXOTIC SPECIES IN THE FORMAL EDUCATIONAL SPHERE IN ARGENTINA

LAS ESPECIES EXÓTICAS EN EL ÁMBITO EDUCATIVO FORMAL EN ARGENTINA

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Editors' note: *to avoid miscommunication, there was an editorial decision reflected throughout this book to avoid the term "exotic" and instead favor "introduced" to describe these species (see Car* et al.*, this volume). However, in this chapter, "exotic" was retained because it was appropriately part of the analytical framework used to assess formal science education programs that employ ecological definitions of "native" and "exotic."*

Abstract. Education about exotic species is essential for controlling and managing biological invasions and constitutes a part of the environmental knowledge a scientifically literate citizen should have. Scientific information is converted into knowledge "to be taught," as expressed in official curricula, documents and programs, and school textbooks. At the same time, knowledge "to be taught" is adapted to classroom settings as knowledge "actually taught," which results from an interaction among knowledge, teachers and students. Here, we analyze 1) how exotic species are portrayed in formal curricula (national documents and provincial curriculum designs in Córdoba, Buenos Aires and Mendoza) and textbooks, and 2) what are the views and conceptualizations of exotic species held by teachers and students, placing emphasis on the teaching of exotic species as a problem. In curriculum documents, biological invasions are only mentioned as contents in one primary grade level (7th grade) and in the initial cycle of secondary school. However, many contents related to ecosystem dynamics and biodiversity conservation offer the opportunity to include exotic species in the latter curricular cycle of elementary education and throughout secondary school. A variety of terms are used in school textbooks to define biological invasions and exotic species, calling into question the coherence of concepts being taught as compared to scientific knowledge. The examples offered by textbooks are not always accompanied by images, but encompass several species, particularly exotic mammals. Two native mammals were reported as exotic (Patagonian mara, *Dolichotis patagonum*, and Patagonian huemul, *Hippocamelus bisulcus*). Our studies also show that students are more familiar with exotic mammals, particularly domestic or charismatic ones like dogs, horses, etc., than

with native species. Indeed, many students even believe that these exotics are native. Nonetheless, in their last years of high school, students can name more native species. Teachers recognized 41 exotic species from Argentina, seven of which were mammals, but almost all teachers surveyed consider that the definition of "exotic species" is instead that of "invasive species." We recommend that teachers make pedagogical decisions concerning the contents of curricula and school textbooks based on sound science as a dynamic knowledge-construction process.

Resumen. Los saberes se producen, circulan y son apropiados en contextos particulares y mediante procesos complejos de negociación. El saber científico, aquel producido por los investigadores y dado a conocer en el mundo académico, debe adaptarse para ser enseñado en la escuela. En el camino desde su producción hasta la llegada a las aulas ocurren una serie de transposiciones didácticas que dirigen el saber en direcciones definidas, con fines determinados, en contextos históricos y políticos particulares y con una perspectiva ideológica. Un saber científico se transforma en un saber «a enseñar», el cual nuevamente se adecua para llegar al aula como saber «enseñado», producto de la interacción entre saberes, docentes y alumnos.

La educación sobre las especies exóticas es un apoyo imprescindible en el control y la gestión de las invasiones biológicas y ha pasado a formar parte de los conocimientos que debería tener un ciudadano científicamente alfabetizado. En este capítulo revisamos algunos aspectos de la educación sobre especies exóticas en Argentina. Primero, analizamos cómo el tema es abordado en documentos curriculares (nacionales y de las provincias de Córdoba, Buenos Aires y Mendoza) y libros de texto escolares. Luego, analizamos la familiaridad de los alumnos y docentes con saberes acerca de las especies exóticas, haciendo énfasis en la perspectiva de la enseñanza de estas especies como problema.

El análisis de los documentos curriculares muestra que la introducción de especies exóticas solo se menciona como contenido en séptimo grado de la primaria y en el ciclo básico de la educación secundaria. Sin embargo, contenidos relacionados con la dinámica ecosistémica, relaciones tróficas y conservación de la biodiversidad brindan la oportunidad de estudiar las invasiones biológicas en general y de mamíferos exóticos en particular, en el último ciclo de la primaria y a lo largo de la secundaria. Del análisis de los libros de texto concluimos que no todas las editoriales responden adecuadamente a los aprendizajes propuestos en los documentos curriculares. La variedad de términos que se evidenció para definir a las invasiones y a las especies exóticas pone en duda que se alcance una conceptualización coherente con el conocimiento científico, ya que no se revisan los referentes empleados ni se dan oportunidades a los estudiantes para que cuestionen sus conocimientos cotidianos. Con ello se reforzarían concepciones intuitivas de lo que es nativo, exótico, invasor, etc. Los ejemplos que brindan los textos incluyen varias especies, entre las que se destacan los mamíferos exóticos, pero en un par de casos es errónea la información aportada (p.ej., se mencionan a la mara, *Dolichotis patagonum*, y al huemul, *Hippocamelus bisulcus*, como especies exóticas en Argentina). Dado que no siempre la información está acompañada de imágenes, sugerimos a los docentes recuperarlas a partir de fuentes confiables para identificar correctamente a las especies nativas y exóticas.

Indagando acerca de las concepciones de los alumnos, encontramos que los estudiantes están más familiarizados con los mamíferos exóticos domésticos y carismáticos que con las especies nativas, salvo en los últimos años de la secundaria, en que son capaces de nombrar más especies nativas. Algunas especies muy conocidas para los alumnos (como vaca, perro, caballo, burro o gato) son consideradas nativas, porque asumen que todo lo que nace en el país o se observa en la naturaleza tiene

la condición de nativo. Estas conceptualizaciones de los alumnos necesitan ser tenidas en cuenta a la hora de abordar el estudio de la introducción de especies exóticas como problema para la conservación de la biodiversidad. Los docentes encuestados nombraron un total de 41 especies exóticas, de las cuales siete fueron mamíferos: castor (*Castor canadensis*, 40% de las respuestas), liebre europea (*Lepus europaeus*, 20%), jabalí (*Sus scrofa*, 20%), ciervo colorado (*Cervus elaphus*, 12%), «ciervos» (3%), ciervo axis (*Axis axis*, 0.7%), ardilla de vientre rojo (*Callosciurus erythraeus*, 0.7%) y gato doméstico (*Felis sylvestris catus*, 0.7%). Los docentes de casi todos los niveles educativos consideran que una especie exótica es aquella introducida en un ecosistema del cual no es originaria y que logra establecerse y dispersarse produciendo diferentes impactos, definición que corresponde a especie invasora. Cuando los docentes fueron indagados acerca de los problemas causados por las especies exóticas mencionaron principalmente efectos a nivel ecológico. Sin embargo, consideran que el conflicto con especies exóticas es complejo y se necesita desarrollar nuevas estrategias y enfoques que permitan valorar las especies nativas. De esta forma, se puede trabajar el tema de las especies exóticas teniendo en cuenta todos los abordajes posibles, como el conflicto con especies exóticas que resultan beneficiosas o útiles para el ser humano o la protección de ambientes dominados por especies exóticas que aun así brindan bienes y servicios.

Para abordar la educación acerca de las especies exóticas invasoras proponemos a los docentes enseñar sobre biodiversidad y los problemas asociados como un proceso en donde los saberes no constituyan monumentos que el profesor expone a los estudiantes, sino como un conjunto de constructos conceptuales, procedimentales y axiológicos que se ponen en juego para resolver problemáticas. Proponemos trabajar en el contexto social a través del uso de estrategias didácticas que promuevan la argumentación, la toma de posición, la participación y el diálogo de saberes. Este enfoque permite identificar a los actores involucrados, comprender los roles y discursos que tienen respecto a la problemática e interpretar las relaciones de poder que se ponen en juego. Pueden utilizarse diversos recursos, además de los saberes relacionados con las ciencias naturales, como entrevistas, juegos de roles, notas periodísticas, información disponible en la web, interpretación de imágenes, relatos históricos, estudio de casos, etc.

El trabajo didáctico de selección y organización del contenido exige al docente una transposición que adapte los saberes de expertos a las necesidades e intereses del nivel educativo y su contexto particular de enseñanza. El docente debe formarse para ser un mediador calificado en la construcción del conocimiento escolar que incorpora la vigilancia epistemológica a las competencias y saberes profesionales. Como recomendación para la práctica docente, invitamos a los docentes a tomar decisiones sobre los contenidos que figuran en la currícula y en los libros de texto, teniendo en cuenta que la ciencia es dinámica y los saberes están en continua construcción.

Introduction

At the present time, the teaching of science constitutes a field of social action that acknowledges and values the anchoring of scientific activity in complex realities. Thus, science education should (and often does) seek to transcend a positivist position and go beyond the mere development of cognitive activities (Sauvé, 2010). Indeed, education efforts recognize that knowledge is produced, circulates and is appropriated in specific contexts and through complex processes of negotiation. Therefore, scientific knowledge, which is produced by

researchers and released into the academic world through publications, journals, reports, congresses, etc., must be adapted and integrated with other knowledges to be taught and incorporated into the broader society.

Along the path from the generation of scientific knowledge through to its incorporation in classrooms, a series of content adaptations and didactic transpositions occurs that drive knowledge in defined directions and for specific purposes, in particular historical and political contexts and ideological perspectives (Cardelli, 2004). Scientific knowledge is converted into knowledge "to be taught," which then is transposed into knowledge "actually taught" in the classroom (Chevallard, 1991). This process depends on the interaction between knowledge, teachers and students. According to a constructivist scientific-pedagogical position, students are active and subjective in the construction of their own knowledge (*e.g.*, Piaget, 1984; Caravita and Halldén, 1994).

Education about invasive and exotic species is essential for controlling and managing biological invasions and has become part of the knowledge that a scientifically-literate citizen should have (Verbrugge *et al.*, 2021). The Convention on Biological Diversity (CBD)'s Article #8, Section h states that the introduction of "…alien species which threaten ecosystems, habitats or species" will be prevented, and those species controlled and eradicated (United Nations, 1992: p. 8). Plus, although it addresses the conservation and sustainable use of biodiversity in a general fashion, when the CBD refers to education and public awareness, it posits the novelty of considering education as a strategy for promoting and encouraging the comprehension of issues related to biological diversity. Years later, it was acknowledged that there is still a need to intensify these efforts through education and dissemination of scientific knowledge (Morgera and Tsioumani, 2010).

In this chapter, we review some aspects of how exotic species are integrated and represented in Argentine educational programs. First, we analyze the way the topic is approached in curricula and school textbooks. Then, we assess the views and conceptualizations of both teachers and students, placing special emphasis on the perspective of teaching about exotic species as a problem.

From scientific knowledge to knowledge to be taught

The role of curricula

A first step in transposing scientific knowledge to pedagogical settings is in the definition of contents in official curricula, documents and programs. In this section, we analyze the presence of exotic species, particularly mammals, and indicators of their study in national and provincial education programs. Specifically, we assess national curriculum documents and the curricular designs in the provinces of Córdoba, Buenos Aires and Mendoza, looking for allusions to specific content (*i.e.*, knowledge "to be taught") related to issues threatening biodiversity, particularly invasions by exotic species.

National Law #26,206, sanctioned in 2006, established that secondary education (SE) is mandatory in Argentina and that it constitutes a pedagogical and organizational unit for those who have completed their elementary education (EE) (Article #29). This regulation

allows jurisdictions to choose between two possible structures: six years for EE and six for SE, or seven years for EE and five for SE. For the purposes of this analysis, we delimited the assessment of curricula to both EE and SE.

Priority learning nuclei for Argentina. In the framework of the Consejo Federal de Cultura y Educación, a core set of priority learning objectives and contents were established in 2006 (Ministerio de Educación, Ciencia y Tecnología, 2006). A priority learning nucleus (PLN) encompasses a set of relevant and significant core knowledge, which as content contributes to "developing, constructing and expanding cognitive, expressive and social possibilities that children put into play and recreate daily in their encounter with culture, thus widely enriching their personal and social experience" (Ministerio de Educación, Ciencia y Tecnología, 2006).

In 2011, after a long process of federal cooperation and participation among the provinces, the PLNs developed in 2006 were reorganized, given the differential implementation regarding the number of years for EE and SE established by Law #26,206. Thus, for the seventh year of EE or the first year of SE in a six-year EE program, the standards became "interpretation of trophic actions, their representation in networks and food chains, and recognition of the role of producers, consumers and decomposers" and "explanation of some modifications in ecosystem dynamics caused by disappearance and/or introduction of species into food webs" (Ministerio de Educación, 2011a). Then, for the first year of SE in jurisdictions with a seven-year EE, and for the second year of SE with a six-year EE program, PLNs included the "problematizing around the classification of living beings and identification of some criteria for grouping them, from the perspective of the classical division into five kingdoms" and "explanation of the importance of preserving biodiversity" (Ministerio de Educación, 2011b).

During the three last years of SE (in what is termed the "Oriented Cycle"), Biology can be taught over one to three years, depending on the jurisdiction. Agreed knowledge is organized into axes and as a text without scaling by grade, and contemplates subsequent jurisdictional adaptations (Consejo Federal de Educación, 2012). In this sense, for the axis "in relation to evolutionary processes," the "recognition of current and past biodiversity as a result of changes in living beings over time, highlighting the macro-evolutionary processes (massive extinctions or adaptive radiations) and the interpretation of the impact of human activity on its loss or preservation" are considered a priority nucleus (Consejo Federal de Educación, 2012).

Curriculum designs in Córdoba province. SE is organized into two cycles: a Basic Cycle (BC, first three years) and an Oriented Cycle (OC, last three years). Currently, Biology is a part of two subjects in the BC; one in the 1st grade (called Natural Sciences – Biology) and the other in the 2nd grade (called Biology). In presenting the area of natural sciences for the BC, both "diversity" and "organization, unity, interaction and changes" are acknowledged as being the major structural concepts (Ministerio de Educación de la Provincia de Córdoba, 2011).

For the 1st grade, "identification of material and energy exchanges in ecological systems and interpretation of their inherent trophic relationships" and "manifestation of interest in seeking explanations to some changes in ecosystem dynamics (*e.g.*, consequences of introducing exotic species, or indiscriminate logging, among others)" are listed as contents. For the 2nd grade, one of the objectives shared with Chemistry is that students should interpret "the consequences to environment and health entailed by human decisions and actions." For Biology in particular, students are expected to be able to "recognize diversity as an outcome of the evolution of living beings over time" and are encouraged to "search for explanations to the importance of biodiversity preservation from the ecological and evolutionary viewpoints." In the OC, Natural Sciences orientation for the 5th grade is focused on the "recognition of the consequences of biodiversity loss and their relationship with human health."

Curriculum designs in Buenos Aires province. SE in Buenos Aires province is structured to last 6 years and is divided into Basic Secondary Education (BSE) and Oriented Secondary Education (OSE) cycles. The latter cycle offers the students different modes or "orientations," one of which being in Natural Sciences.

Also, according to the organization of the curriculum design, one of the subjects for the first year of the BSE corresponds to Natural Sciences, structured in four thematic axes with their respective nuclei of contents (Dirección General de Cultura y Educación de la Provincia de Buenos Aires, 2006). Biodiversity-related topics are located on the axis called "interaction and diversity in biological systems," which contains the "life: unity and diversity" and the "living beings as open systems that exchange matter and energy" nucleus of contents. In these PLNs, it is indicated that, through the "analysis of journalistic and outreach texts," the goal is to refine the prior ideas that students have constructed about "biodiversity, its importance and the causes and consequences of its alteration by human activities." At this point, and depending on the didactic orientation of the design, it is recommended that students debate and discuss the effects on ecosystems of the disappearance and/or introduction of species into food webs.

In Biology for the 2nd year of the BSE, the central topic is the origin, evolution and continuity of biological systems (Dirección General de Cultura y Educación de la Provincia de Buenos Aires, 2007). Contents are grouped into units, with the first of these thematic units being "evolution: origin and diversity of biological structures." In the curriculum design, this unit intends to provide opportunities for the treatment and discussion of the value of biodiversity, including issues of economic importance or health issues, and for analyzing the effects of species extinction by the impact of human activities.

In the 6th year of the OSE, the "environment, development and society" subject is specific to the Natural Sciences orientation and provides a broad overview of environmental issues and possible solutions, such as responsible citizen practices (Dirección General de Cultura y Educación de la Provincia de Buenos Aires, 2011). Themes related to biodiversity loss, its consequences and likely risks, as well as conservation strategies, are included in the axis called "air, water, soil and biodiversity" and "responses," presenting examples of case studies relative to current problems in the country, so that the teacher can address the themes put forward.

Curriculum designs in Mendoza province. The provincial curriculum design of EE in Mendoza details the capacities to be developed in the permanent education of youths and adults (Dirección General de Escuelas de la Provincia de Mendoza, 2015a). Among them, it is proposed to "recognize ourselves as subjects of socially productive, politically emancipatory, culturally inclusive and ecologically sustainable practices." Within this capacity, the curriculum mentions "favoring local, national and regional organization for promoting policies that guarantee the life of present and future generations and of the ecosystems into which they are inserted." Among the stated problematizing contexts, which visualize fundamental aspects of contemporary society, we find the "dichotomy between development and care of nature" and the "denaturing of that which is technological: visualizing everyday scientific production." In module 4, the curriculum structure for the 2nd cycle of EE sets forth the development of the problematizing context: "citizenship-emancipation," and for Natural Sciences, it details the following specific learning goals along path 1: "man and nature," "recognition of habitats and different levels of organization of living beings," "participation of man as an environment-modifying agent and importance of prevention;" and along path 2: "analysis and integration of the elements composing the environment," "awareness raising about the importance of caring the environment to attain a better quality of life" and "analysis of the interrelation between human needs and natural resources."

In the 1st year of SE basic formation, in the axis called "in relation to living beings: diversity, unity, interrelations and changes," in the area of Natural Sciences, knowledge is proposed that allows recognizing unity in the diversity of all biological systems, these being acknowledged as open systems, taking into account the classification of diversity. Also highlighted is the value of biodiversity from ecological and economic perspectives, as well as identification of human actions that endanger or protect diversity. On the other hand, within the same axis in the 2nd year of SE basic formation, knowledge is more closely related to biological evolution (Dirección General de Escuelas de la Provincia de Mendoza, 2015b).

In the OC, problematizing contexts and subjects vary depending on orientation. Thus, in the Natural Sciences orientation, in the 4th year, the following axes are detailed in Biology: "population as an ecological system" and "population and evolutionary processes." In the subject Environmental Issues for the 5th year, problems are identified, the factors that put at risk and/or cause biodiversity deterioration and loss are recognized, and conservation strategies are discussed (Dirección General de Escuelas de la Provincia de Mendoza, 2015c).

Synthesis. From the analysis of the knowledge to be taught, as stated in national curriculum documents and in the curriculum designs of the provinces of Córdoba, Buenos Aires and Mendoza, it becomes evident that biological invasions are only mentioned as contents in the 7th grade of EE and the initial cycle of SE. However, there are also diverse objectives and contents related to ecosystem dynamics, trophic relationships, and to the study and conservation of biodiversity that offer the opportunity to study invasions in general and of exotic mammals in particular, in the latter cycle of EE and across SE. The priority status of these contents allows the design of more varied and extensive didactic units that promote in students a better and sustained learning of core contents. This entails a selection and

adaptation process on the part of the teacher, who can discard those contents that can be omitted or subsumed, thus generating further opportunities for teaching and learning fundamental and primordial contents.

The role of school textbooks

A second step in didactic transposition is the use of school textbooks, which provide a valid conception of the knowledge to be taught and are an important assistance for the teacher in daily classroom work (Cobo Merino and Batanero, 2004). However, some problems have been described regarding high school textbooks' treatment of different topics. For example, with respect to the study of biological diversity, school textbooks show a lack of axiological and social contextualization and present species richness as the only component of biodiversity (Bermudez *et al.*, 2014; Bermudez and Nolli, 2015). Additionally, children's books show a strong bias toward exotic flora, fauna, and environments with far-reaching implications for conservation efforts and children's appreciation of native biodiversity (Celis-Diez *et al.*, 2016).

In this section, we evaluate how school textbooks for Natural Sciences and Biology present and define the issue of biological invasions and exotic species, placing a particular emphasis on mammals. For this purpose, we identified the textbooks published from 2010 to 2015 by editors of national circulation in Argentina, finding 17 books destined for the BC and six books for the OC (Table 1). We analyzed the inclusion and definition of biological invasions and exotic species, and the examples given by these school textbooks and the images they show of exotic mammal species of Argentina.

It is important to highlight that varied terminology is used in the analyzed textbooks to refer to exotic species and biological invasions (see also Car *et al.*, this volume). We found 12 different ways of mentioning these topics, and even eight different ways in just one of the textbooks. For example, in Balbiano *et al.* (2012a), we found "introduction of exotic species," "exotic species," "rare/odd species," "biological invasion," "invaders," "introduced species," "intruding species," and "bio-invasions" used at different times.

Overall, Argentine textbooks include the treatment of biological invasions, especially for Natural Sciences 1, corresponding to the first year of SE. Notwithstanding the inclusion of these terms, only approximately half of the school textbooks that refer to the issue of biological invasions actually define the concept explicitly (Table 1). For instance, Balbiano *et al.* (2012a) question "what happens in an ecosystem where species from another ecosystem are introduced? The consequences are always unpredictable. They often become invaders, because aside from persisting in the environment where they have been introduced, they proliferate and expand beyond determined limits. These species, called exotic, have neither predators nor parasites […]." Other conceptualizations are less specific, and indicate exotics as typical from another place: "native species are characteristic of an area; exotic ones live in other regions. Introduction of the latter is frequent […]" (Mollerach *et al.*, 2013). In the case of Adragna *et al.* (2013), exotic is defined as synonym with alien: "one of the negative actions of human beings on the environment consists of introducing alien or exotic species, without considering the consequences this may have on a region's native species."

Table 1. Analysis of how school textbooks in Argentina treat the topics of biological invasions and exotic mammal species. Secondary education is divided into a Basic Cycle (**BC**) and Oriented Cycle (**OC**).

Cycle	Publisher	Textbook	Biological invasions		Definition of exotic species	Exotic mammals of Argentina	
			General treatment (pp.)	Definition		Examples	Images
BC	Aique	De Dios *et al.*, 2011	Yes (p. 65)	No	No	No	No
		Mollerach *et al.*, 2013	Yes (p. 259)	Yes	Yes	red deer	red deer, European hare
	Estrada	Adragna *et al.*, 2013	Yes (p.196)	No	No	European hare, red deer	No
		Alberico *et al.*, 2013	Yes (p.172)	No	Yes (p. 228)	North American beaver	No
	Kapelusz/ Norma	Antokolec *et al.*, 2012	No	–	–	–	–
		Blaustein *et al.*, 2011	Yes (pp. 59/83)	No	No	North American beaver, red deer	Patagonian huemul*
	Longseller	Mosquera *et al.*, 2010	Yes (pp.131/133/155)	No	No	North American beaver, European hare	–
	Mandioca	Sarazola *et al.*, 2010	Yes (p. 202)	No	No	No	No
	Maipue	Mosso *et al.*, 2013	Yes (p.197)	Yes	No	No	No
	Puerto de Palos	Carmona de Rey *et al.*, 2010	Yes (pp. 89/94)	No	No	European hare	European hare
	Santillana	Balbiano *et al.*, 2012a	Yes (p.186)	Yes	Yes	European hare	Pallas's "beautiful" squirrel
		Balbiano *et al.*, 2012b	No	–	–	–	–
		Balbiano *et al.*, 2015	Yes (pp.185/189)	Yes	No	North American beaver	North American beaver
	SM	Antokolec *et al.*, 2010	No	–	–	–	–
		Carreras *et al.*, 2010	Yes (p.155)	No	No	No	No
		Furriol *et al.*, 2013	Yes (p.120)	No	No	No	No
		Irigoyen *et al.*, 2011	Yes (p. 69)	No	No	No	No
OC	Estrada	Bocalandro *et al.*, 2012	Yes (p.198)	No	No	red deer	red deer
	Kapelusz/ Norma	Adami *et al.*, 2010	Yes (pp. 275/9)	Yes	Yes	American mink, Pampa fox, European rabbit, North American beaver, European hare, wild boar, red deer	North American beaver
	Maipue	Tedesco *et al.*, 2012	No	–	–	–	–
	Santillana	Balbiano *et al.*, 2011	Yes (p. 208)	Yes	Yes	mara	mara*
	SM	Basterio *et al.*, 2011	Yes (p.185)	No	Yes	No	No
		Wolovelsky *et al.*, 2013	Yes (pp.180/215)	No	No	European hare	No

*The mara and the Patagonian huemul are native species.

Conversely, one of the most complex conceptualizations is contributed by Mosso *et al.* (2013), who reproduce a segment of a scientific text and make it clear that "for Ecology, a biological invader is a species native to another place (*e.g.*, another land, river or ocean) that arrives in a different ecosystem and colonizes it, becoming a part of the new environment. It reproduces quickly, occupies many places with different characteristics (generally due to the absence of their natural predators, who stayed in their place of origin) and interacts with other species of the same ecosystem […]." Finally, succinctly, De Dios *et al.* (2011) present the issue of invasions, alerting as to likely consequences, but providing no definitions: "introduction of invasive exotic species can be accidental or voluntary. Exotic species compete for resources with native species, or prey on them, or modify environments."

Regarding the consequences of introducing an exotic species, most school textbooks only mention the ecological disturbances it causes, as Blaustein *et al.* (2011) express "[…] introduction of exotic species, such as the sweetbriar, the North American beaver and the red deer, results in extinction of native species as a consequence of competition for food and space." Similarly, Balbiano *et al.* (2015) indicate that "invasive species proliferate and expand swiftly across a particular area, which brings unpredictable and often undesirable impacts, such as displacement of autochthonous species, alteration of food webs or of the original environment." In turn, the economic effects of introducing exotic species are mentioned, to a lesser extent, and always making reference to specific examples, such as the one presented by Balbiano *et al.* (2012a) related to the Pallas's squirrel (*Callosciurus erythraeus*) that "[…] damaged telephone, electric and television wires, peeled the bark off trees, and tore flowers and fruits by biting them."

Regarding the examples of exotic mammals in Argentina that are given by these textbooks, there is a clear predominance of the red deer (*Cervus elaphus*) and the European hare (*Lepus europaeus*). However, it is not always made clear whether or not these exotic species are invasive in Argentina. For example, Mollerach *et al.* (2013) contextualize the invasion of the red deer in our country, clarifying that it was "introduced in Argentina in the 19th century; it is considered one of the 100 most damaging invasive exotic species on the planet." In contrast, other exotic species are not considered in the context of Argentina, such is the case of the European hare, which is mentioned as "[…] introduced in North and South America, in Siberia […]" and the European rabbit (*Oryctolagus cuniculus*), which appears as"[…] taken to Australia, where it became a pest, that is, an invasive species that damages crops." Another text, instead, presents a table describing the continent of origin and the Argentine distribution for species of fish (salmon and trout, *Salmo* spp., and carp, *Cyprinus carpio*), birds (domestic pigeon, *Columba livia*, and sparrow, *Passer domesticus*), and mammals (red deer and European hare) (Adragna *et al.*, 2013). Moreover, this last text describes historical facts about how the hare was introduced and turned into a pest, stating that "towards the end of the 19th century, a German consul incorporated the European hare into Santa Fe province. Its striking ability to adapt to diverse climates and topographies, added to its astonishing reproductive capacity, made it possible for it to currently occur across nearly all of our country. In 1907, it was declared a pest for agriculture by law." Similarly, Alberico *et al.* (2013) present the circumstances under which the North American beaver (*Castor canadensis*) was introduced in Tierra del Fuego.

Several texts give examples of interactions among exotic mammals introduced in Argentina and native species that were directly affected. Such is the case of the European hare and the mara (*Dolichotis patagonum*) (Carmona de Rey *et al.*, 2010; Balbiano *et al.*, 2012a), the North American beaver and the lenga tree (*Nothofagus pumilio*; Mosquera *et al.*, 2010), the red deer and native deer, Patagonian huemul (*Hippocamelus bisulcus*) and southern pudu (*Pudu puda*) (Blaustein *et al.*, 2011). Also mentioned in these textbooks is the "[…] American mink (*Neogale vison*) introduced in the Patagonian forests […] that feeds on birds native to the region" (Mollerach *et al.*, 2013). Some examples may be confusing, because the terms are not correctly used. Such is the case of the example given in Antokolec *et al.* (2010), where it is mentioned that "[…] in Patagonian forests, all Chilean bamboos bloom together every fifteen years and an invasion of mice occurs […];" in this case the term *invasion* is used to refer to an explosive growth in native rodent populations, and not to biological invasions caused by exotic species.

As for the images used to exemplify exotic mammals in Argentina, only four species were found to be represented: Pallas's squirrel, red deer, European hare and North American beaver.

The topic of exotic species is once again dealt with in the textbooks for the OC. Santillana, SM, and Kapelusz/Norma publishers address the concepts with a level of complexity similar to that used in school textbooks for the BC. For instance, Balbiano *et al.* (2011) define biological invasion as the "process of expansion […] of a species mediated by the establishment of new populations which are viable in habitats where they had not been present before. In this context, a species is labeled as exotic when it is found at sites outside its region of origin." The incorporated examples correspond to mammal species introduced in Tierra del Fuego (American mink; Pampa fox, *Lycalopex gymnocercus*, which is native to the Patagonian mainland; European rabbit; North American beaver; European hare, which is not present in Tierra del Fuego; wild boar, *Sus scrofa*; and red deer), including a photograph of an individual beaver (Tedesco *et al.*, 2012). However, when Balbiano *et al.* (2011) describe the consequences of disturbances, including the introduction of exotic species, they erroneously exemplify and present a photograph of the native mara as an introduced species: "different types of disturbances can be observed […] and an introduced species (this is the case of the Patagonian mara)." As found in BC textbooks, in Wolovelsky *et al.* (2013) a non-contextualized example is given for Argentina "when a non-native species is introduced in a natural environment, there may be no predators for such species, and it can become a pest, as happened with European rabbits in Australia."

From the analysis of school textbooks, it is concluded that not all publishers comply appropriately with the learning contents proposed in the PLN regarding ecosystem structure and dynamics (Table 1). In addition, the variety of terms used to define invasions and exotic species calls into question that a coherent conceptualization can be reached with reference to scientific knowledge, since references used are not revised and no opportunities are offered to students for them to question their everyday knowledge. This would reinforce intuitive conceptions of what is native, exotic, invader, etc. (Bermudez *et al.*, 2021). The examples offered by school textbooks include several species, among which exotic mammals stand out, but in one case the information provided is wrong. As information is not

always accompanied by images, teachers are suggested to seek drawings, photographs and qualified websites to correctly identify native and exotic species. It is important to build a bridge between the students' own references and antecedents and new academic knowledge. Finally, as OC textbooks do not delve deeper into the treatment of the analyzed contents with respect to the BC (Bermudez and Nolli, 2015), teachers are encouraged to use ecology books for university students, scientific articles and outreach materials to enhance the didactic transposition on these contents into their science classes.

From "knowledge to be taught" to "knowledge actually taught": the role of students and teachers' knowledge about biodiversity and exotic species

Students

During knowledge construction processes, learners handle information by either accommodating (*i.e.*, adapting) their own cognitive structures or assimilating information to make it fit into their current worldview (Piaget, 1984). The existing conceptual structure, built by prior knowledge and ideas, has a tendency to be stable. This condition can be an obstacle for the learning process, especially when prior knowledge is opposed to the content to be learned. Therefore, for teaching processes, it is helpful to consider students' prior associations, concepts, and subjective theories to improve learning interventions and learning process (Meinardi *et al.*, 2010) (*e.g.*, when the aim is a better understanding of biodiversity issues).

Despite the interest in and curiosity of children and young people about living beings, some studies show that many have little knowledge of the species occurring in their surroundings (*e.g.*, Lindemann-Matthies, 2002, 2006; Lindemann-Matthies and Bose, 2008; De Melo *et al.*, 2021). Students, especially those living in urban areas, are often more familiar with species that are not part of local biodiversity, and which they know from sources like books, television or the internet (Paraskevopoulos *et al.*, 1998; Campos *et al.*, 2012). In a study conducted to determine familiarity with biodiversity of students from urban and rural areas of Mendoza province, 1,746 students between seven and 18 years old were asked to mention 10 animals and indicate the source of their knowledge (*e.g.*, experience in the countryside, a home garden, books, television, the Internet, etc.). Overall, students mentioned more exotic than native species and, like elsewhere in the world, they are familiar with domestic and charismatic exotic mammals (Campos *et al.*, 2012). The 10 species students found most familiar were, in order of descending mentions, dog (*Canis lupus familiaris*), cat (*Felis sylvestris catus*), lion (*Panthera leo*), horse (*Equus ferus caballus*), "monkey," cattle (*Bos primigenius taurus*), "birds," tiger (*Panthera tigris*), elephant (Elephantidae) and European rabbit. The students' place of residence (*i.e.*, urban or rural) and gender affected familiarity with species, whereby rural boys recognize more native species and mentioned going outside as their main source of contact with biodiversity. Girls, in turn, were more familiar with exotic species and, due to an aesthetic appreciation, are generally more familiar with pets and charismatic mammals (Badarraco, 1973). This trend is also reflected in adult women, who have been shown to fear or have less interest in native species (Kellert and Berry, 1987).

Similarly, when 865 students of rural schools in Valle Fértil (San Juan province) were asked about their favorite animal, 72% mentioned exotic domestic species (*e.g.*, dog, horse, cat) and 12% mentioned exotic wildlife species (*e.g.*, European hare); exotic domestic mammals were considered to be the most useful species (Nates *et al.*, 2010).

In a study conducted in Córdoba province, 328 students in the three last years of EE with a Natural Sciences orientation were asked to mention 10 animal species native to the province. In this case, half the species mentioned were mammals and 64% of them were species actually native to Argentina (*e.g.*, mountain lion, *Puma concolor*; Geoffroy's cat, *Leopardus geoffroyi*; plains vizcacha, *Lagostomus maximus*; and Pampa fox). But they also again included exotic domestic species as native (*e.g.*, cattle, dog, horse, donkey [*Equus africanus asinus*], cat) and exotic wildlife species (European hare). This confusion between exotic and native species may be explained by the fact students are conceiving these species based on their everyday experience and considering that every animal born in or observed in local nature is native (Bermudez *et al.*, 2015, 2021).

In synthesis, our research showed that students are more familiar with domestic and charismatic exotic mammals than with native species. Many of them even assume that these exotic mammals are native. Our results could be explained by the differences in the students' conception of "native" and by the species with which they are in closer contact or recognize as familiar. Students from the latter years of SE, however, were able to name more native species. In rural areas, domestic mammals, such as dogs and horses, are considered the most useful species.

Teachers

In this section, we attempt to promote an approach that facilitates communication between the scientific community and teachers, based on the exchange of and dialogue about knowledge, assuming that there are different modes of circulation for knowledge, values and beliefs, which are put into play during educational processes in diverse contexts. To better understand the way in which teachers approach the study of exotic species in the classroom, a survey was conducted among Argentine natural science teachers, inquiring whether exotic species are viewed as a problem. Most of the 212 teachers who responded to the survey were between 30 and 50 years of age (64%) and were women (76%). Teachers from 20 provinces participated, mostly from Buenos Aires (22%), Córdoba (18%), Mendoza (15%) and Misiones (9%). Most work in the public sector (81%) and have achieved either master's or doctorate degrees (31%) or specialization or postgraduate certificates (24%). The majority of respondents teach at the secondary level (41%) or higher (tertiary 22% and university 26%).

When teachers were asked to mention an exotic species from Argentina, a total of 41 were named. Only seven of these were mammals, but several were frequently mentioned, including: North American beaver (40% of responses), European hare (20%), wild boar (20%), red deer (12%), "deer" (3%), axis deer (*Axis axis*; 0.7%), Pallas's squirrel (0.7%) and domestic cat (0.7%). When they were asked whether they had had the opportunity to know about the issue of exotic species introductions, 85% of them commented on their experiences, such as "while volunteering in Parque Nacional El Palmar, I observed and knew

about the work carried out by the crew of "paradisers," who kept a record of the control tasks for the paradise tree (*Melia azedarach*)," "I got information in college," and "I learned from conferences I attended and from outreach articles throughout life." A minority of respondents explicitly answered that they had not had the opportunity to know about the issue (7%) or did not answer (7%).

To inquire about the conceptualization that teachers have regarding exotic species, they were offered three options: 1) it is an rare or odd species, because of its appearance or because we do not know much about it (*i.e.*, the definition of a little known species), 2) it is a species that has been introduced in an environment that is not its ecosystem of origin (*i.e.*, the definition of exotic or non-native species), and 3) it is a species introduced in an ecosystem of which it is not native and that manages to become established and disperse across extensive areas, causing economic and environmental damage or damage to human health (*i.e.*, the definition of invasive species). Teachers at almost all educational levels consider that the definition of invasive species is the one corresponding to exotic species (see also polysemy for exotic species found in the media, Car *et al.*, this volume) (Table 2).

Table 2. How teachers define exotic species, reported as percentages (%) according to the educational level at which respondents teach.

Respondent teaching level	Responses (n)	Little known species (%)	Exotic or non-native species (%)	Invasive species (%)
Informal	5	0	20	80
Initial-elementary	9	2	4	3
Secondary	110	2	39	59
Tertiary	58	7	46	47
University	71	3	39	58
Total	***253****	***4***	***41***	***55***

***This number is greater than the number of total respondents because some teachers work at more than one educational level.

When required to give an example of the problems caused by introducing exotic species, 31% of teachers referred to particular projects or species, whereas 15% provided no examples or did not answer. Most of the teachers who explained the problems caused by exotic species made reference to exclusively ecological aspects, such as "the introduction of trout (Salmoninae) in Río Negro resulted in it occupying the ecological niche of autochthonous species, causing their disappearance." To a lesser extent, they referred to broader environmental problems, considering historical aspects of how introductions or invasions occur: "the impact of exotic herbivores in colonial times;" economic problems: "they can bring about economic losses through damage to biodiversity or to the machinery man uses to exploit resources;" and health problems: "they cause diseases."

As final comments, teachers considered it necessary to device new strategies and approaches that allow valuing native species and to work on the topic of exotic species, bearing in mind all possible approaches to issues such as the conflict with exotic species that turn out to be beneficial and useful for the human being, or the protection of environments dominated by exotic species which, despite their being introduced, do provide ecological and social goods and services (see Bobadilla *et al.*, this volume).

Conclusions and proposals to educate about exotic mammals

Ecologists have generally placed considerable emphasis on a species being exotic, and many studies on biological invasions use emotional, militaristic, and even manipulative language to discuss the topic. Because of that, some authors have encouraged a critical reflection on whether metaphors currently used to characterize these species may actually contribute to social misinterpretation of invasion biology, thereby interfering with conservation objectives (Larson, 2005; Selge *et al.*, 2011). The use of loaded language in scientific works may have also led to an ambiguous and inconsistent use of terminology (Verbrugge *et al.*, 2021), especially in school textbooks. The confusing use of the terms "native," "exotic" and "invasive" does not do justice to the complexity of the issue. Even though native/exotic is mostly thought of as a dichotomous category (*i.e.*, a species is either native or not), in fact, species considered native for an area can be considered exotic for another, even in the same country (*e.g.*, Pampas fox in mainland Patagonia versus Tierra del Fuego). Therefore, defining nativeness (and non-nativeness) in a more concise manner might prevent a potential "reflexive anti-exotic bias" (Stromberg *et al.*, 2009), which automatically leads to suspecting that a species is problematic as soon as it is identified as exotic. Furthermore, when exotic species are considered useful (*e.g.*, horses in rural areas) or emotionally bonded to humans (*e.g.*, pets), the argument about non-nativeness can be detrimental by producing distrust in scientific knowledge. In this regard, Nuñez *et al.* (2018) suggested five key factors—arrival time, economic impact, aesthetic preferences and phobias, effect on human health, and origin of introduced species and origin of human immigrants—that can profoundly affect whether and when a species is reviled or prized by people. Nonetheless, the perception of the ecological effects of exotic species is often underestimated (Diaz Isenrath and Llano, 2020).

In both the fields of science and education, a more holistic and transparent debate is necessary regarding aspects like the social and historical context of species introductions, impact of invasive species beyond ecosystem disturbances, conflicts based on stakeholder values regarding species, and disagreements over invasive species control (Estévez *et al.*, 2015; Archibald *et al.*, 2020). In addressing the topic of learning about exotic species, teachers and students should be able to recognize the origin, usefulness, reason for being, and the why and wherefore of the knowledge about invasive and exotic species. We propose teachers to work on the social context by using didactic strategies that promote argumentation, taking of positions, participation and dialogue about knowledge. Such an approach allows identifying the stakeholders involved, understanding their roles and discourse about the issue and interpreting the power relations at stake. Different resources can be used,

besides the knowledge relative to natural sciences, such as interviews, role playing, journalistic notes, information available on the web, image interpretation, historical narratives, case studies, etc. (Massarini and Schnek, 2015; Bermudez *et al.*, 2021).

The didactic work of selecting and organizing contents demands that teachers be able to affect a transposition that adapts expert knowledge to the needs and interests of the particular educational level and teaching context. The teacher must become trained to be a qualified mediator in the construction of school knowledge that incorporates epistemological vigilance into professional competences and knowledge. As a recommendation for their teaching practice, we invite teachers to make decisions about the contents in the curricula and school textbooks, taking into account that science is dynamic and knowledge is in constant construction.

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