Models of living and non-living beings among indigenous community children

Leticia Gallegos-Cázares, Beatriz García-Rivera,
Fernando Flores-Camacho, Elena Calderón-Canales

Cognición y Didáctica de las Ciencias
Centro de Ciencias Aplicadas y Desarrollo Tecnológico
Universidad Nacional Autónoma de México
Mexico
leticia.gallegos@ccadet.unam.mx
beatrizegr@hotmail.com
fernando.flores@ccadet.unam.mx
elena.calderon@ccadet.unam.mx

Abstract

The aim of this paper is to understand the way indigenous Nahua children classify entities as living/non-living and justify their classification and to determine whether there is a biological thinking related to their particular cultural background. Thirty-three children from a public elementary school located in the Sierra Norte of Puebla were interviewed within and outside an academic context. From the analysis, we identified three main models: an intuitive model, a school biology model and a cultural model. The data suggest that the three models can coexist in children's explanations. The use of both the intuitive model and school biology model increase with education, but the cultural model is not abandoned.

Keywords

Indigenous education, biology education, models, living beings classification

Résumé

L'objective de cet article c'est celle de comprendre la façon auquel les enfants indigènes d'origine Nahua ils identifient et caractérisent aux êtres vivants et aux êtres non-vivant, autant que déterminer s'il y a une pensée biologique en rapport

avec son contexte culturel. On a interviewé trente-trois enfantes d'une école primaire située dans la Sierra Norte du département du Puebla les entrevues ont eu lieu dedans et hors du contexte scolaire. À partir de cette analyse, on a identifié trois modèles principaux: un modèle intuitive, un modèle biologique scolaire et un modèle culturel. Les données suggèrent que le trois modèles peut coexister dans les explications des' enfants. L'utilisation de deux modèles, intuitive et biologique scolaire augmente avec le niveau éducative, mais le modèle culturel ne s'abandon pas.

Mots-Clés

Éducation indigène, éducation en biologie, modèles, classification d'êtres vivants

Introduction

School has an important role in the construction of scientific notions in children, and the way in which science is taught and learned in diverse cultural contexts has been studied from different points of view. One of the most relevant issues, without doubt, is science teaching and learning in indigenous cultures. From an international outlook, several studies can be acknowledged. For some authors, the problem of science learning lies at the lack of knowledge of "native" epistemologies, which makes it difficult for students to have the necessary elements to relate their "native" explanations to those of school science. (Lee, Yen & Aikenhead, 2012). From this point of view, classroom work aims to help students navigate among different ways of knowing the world (intercultural processes); that is, the science of the school culture represents a different world, and the teacher's work involves helping students to construct "bridges" between both cultures (Harding, 1994; Ogawa, 1995; Aikenhead, 2001; Bang & Medin, 2010). Other studies consider that there are diverse points of view about the world (many sciences), all of them equally valid, making it necessary to teach the "science" of each culture (Harding, 1994; Ogawa, 1995). There are also studies suggesting that indigenous knowledge should not be taught as science as it has a different structure from science. However, such studies recognize that incorporating indigenous knowledge allows students to think over diverse topics, such as the importance of the environment (Cober & Loving, 2001). Finally, there are studies that focus on the cognitive process and analyse how students use their knowledge in different contexts. These approaches consider that learning in diverse cultural environments occurs independently and that students produce multiple representations of the same topic that can coexist with the scientific conceptions. In this case, the construction of the notions of scientific culture does not interfere with the indigenous cultural beliefs, and vice versa (Morris & Peng, 1994; Hong, Morris, Chiu & Benet-Martínez, 2000; Harris, 2011; Legare, Evans, Rosengren & Harris, 2012; Gallegos-Cázares, Flores-Camacho, Calderón-Canales, Perrusquía-Máximo & García-

Rivera, 2014). That is, a person can use scientific and supernatural arguments to explain the same phenomenon. For example, Gallegos-Cázares et al. (2014) published a research study examining, from the school environment, the construction made by children in Nahua communities on the process of colour mixing that showed independence of their cultural knowledge of colours (traditions, magical thinking, etc.). The study found that even when children express their cultural notions, these are not incorporated into their school models.

In Mexico, there are no studies with empirical evidence about teaching science in indigenous schools (INEE, 2007). Science education is determined by the objectives of the Ministry of Education, which intends for all children to develop the necessary skills to build explanations about natural phenomena, so they can have a scientific worldview. Moreover, the current curricula consider the necessity of working with topics that reflect the indigenous people's views (Candela, Sánchez & Alvarado, 2012) but do not provide specific guidance about how to do it. There are at least three main approaches (Jiménez-Naranjo, 2001): studies focused on the pertinence of topics, that is, the acquisition of relevant knowledge that is linked to equity and equality; studies with a main focus on coordinating local knowledge and school topics; and studies that examine the interrelations among particular elements in each context and seek coordination among the local and the global. This interrelation can be developed in two ways: by focusing on including ethnic topics in the curriculum and thus adapting it to the community context, or by favouring an intercultural dialogue and identifying common frameworks.

Although many studies have examined the way in which scientific notions about few physical process concepts are produced, little research has focused on ideas about living or non-living beings. If, as we assume, these ideas have a strong relation to the cultural background, some independence is expected to be found among the phenomenological models and the cultural context. Inagaki and Hatano (2002) showed by comparing Japanese and American children that even if there is an "intuitive biology" that acts as a common base for children's development, there are certain cultural aspects that influence conceptual differences between populations. In the case of Nahua culture, the notions of living and non-living beings encompass more than just biological aspects (Pitrou, 2011). It is possible to expect that such cultural influences have an impact on the conceptual elements that children use to identify, classify and explain what living and non-living beings are. This possibility forms the main hypothesis of the current paper.

The next sections will describe first some relevant research about children's notions about "living" and "non-living", following of a brief description of the ideas and concepts regarding living beings in the Nahua culture, both to establish a point of reference for the analysis and interpretation of the obtained data.

Children's Ideas About Living And Non-Living Beings: A Review

To understand the way in which children distinguish the living from non-living, it is necessary to consider the attributes they draw upon to classify these entities and the explanatory mechanisms they use. For this reason, the following paragraphs provide a synthesis of the studies on this topic.

Piaget (1929/1975) was one of the first to consider and identify animism as the origin of biological thinking; he posited that children consider objects intentional, living beings. Recent studies consider that, contrary to Piaget's assertions, biological knowledge emerges from early stages of development as proper biological thinking that is part of a biological domain that comes from biological intuition (Backscheider, Shatz & Gelman, 1993; Inagaki & Hatano, 2006). This position is similar to that of other domain theories, such as intuitive physics (Carey & Spelke, 2002). A domain is understood as the implicit recognition of elements that allow the subjects to interact with a physical or biological referent as it is. In fact, Inagaki and Hatano (2002) establish that the intuitive biology comes from the recognition of the living as having the characteristics of feeding, drinking water and growing within a vitalist conception of elements (water and food) that provide a "vital energy" for living beings. Several research papers report that even four-year-old children can differentiate among animals and things according to biological properties that go beyond perceptual references, such as movement (Dolgin & Behrend, 1984; Backscheider, Shatz & Gelman, 1993; Hatano et al., 1993; Inagaki & Hatano, 1996).

According to Opfer (2002) and Opfer and Siegler (2004), the main element through which children identify a living being is movement. Some studies even found that children as young as four years old can distinguish between animals that move by themselves and objects, which are moved by an external agent (Massey & Gelman, 1988; Gelman & Gottfried, 1996). Children as young as five years old can identify a living element by its capacity for goal-directed action rather than by the action alone (Gelman & Opfer, 2002; Opfer, 2002).

The early identification of living beings starts with animals; plants are identified as living later because the difficulty of identifying their processes (Brulé et al., 2014) delays children's ability to incorporate plants into their concept of living beings (Hatano et al., 1993; Waxman & Medin, 2007; Anggoro, Waxman & Medin, 2008).

Intercultural research has shown that there is certain independence between cultural and academic notions. Children from different cultures know that plants and animals have different properties; this understanding supports the idea that there are general cognitive mechanisms that allow the necessary reasoning to be established in an implicit way. Such a distinction occurs in children as young as four or five years old (Inagaki & Hatano, 1987; Hatano, et al., 1993; Ross, Medin, Coley & Atran, 2003). Nevertheless, other research papers have demonstrated that this identification process has relevant variations

according to cultural differences in the identification of inanimate entities as living and vice versa (Inagaki & Hatano, 1987; Ross et al., 2003; Atran & Medin, 2008; Legare et al., 2012).

In summary, the specific domain theory (Hirschfeld & Gelman, 1994) permits the identification of the biological domain described by intuitive biological thinking, which allows children to recognize essential characteristics of living beings, such as feeding (Inagaki & Hatano, 2002). Such characteristics are not immediately applied to plants; however, the rate at which this occurs can be affected by the child's cultural environment. This cultural milieu should not be just understood as the original traditional culture; it also comprises the information expressed in the school culture, which attributes specific characteristics to the living and non-living. The great quantity of information and controversial perspectives of previous studies show the complexity of constructing a concept of life (Zogza & Papamichael, 2000) and the need to broaden the analysis of factors that may influence the construction of such concepts in diverse cultural environments.

Ideas about living beings in Nahua communities in the Sierra Norte of Puebla

Although conceptions of life and death have been studied in depth in the history of the Mexicas (Matos, 2010) and current Nahua cultures (Lorente, 2011), there are few studies that describe their notions about life and the classification of living and non-living beings by ancient and modern communities. However, the available information provides some ideas that can be useful for understanding the cultural history's influence on present-day children's notions regarding living and the non-living beings. To perform such an analysis, it is necessary to synthesize the cultural ideas of the Nahua people in relation to their conceptions about life.

In most Mesoamerican cultures, including the Nahua culture, the idea of "life" extends beyond animate beings and extends to everything that provides a component of or source for life. According to this notion, animals, plants and humans are living, as are rivers, mountains, the sun and Earth (Pitrou, 2011). The Nahua believe that Earth is a living being with a heart and is protected by its "owners" (Stromberg, 2003). Its owners are represented by a variety of gods that belong to the Nahua's ancient cosmogony. This notion provides one reason for the still-present ceremonies in which the Nahuas ask the owners of Earth for their permission to use the land for agriculture, cutting trees, building a house, etc.

In the Nahua culture, there is a distinction between living and non-living entities. Animate beings have movement, growth, taste and destiny, attributes that only apply to humans and animals. Mushrooms, plants and moss are not considered animate and do not have ancestors; that is, they have no parents (Argueta, 2008).

According to the Nahua people's beliefs, living beings have a specific purpose in life;

they exist for a reason. For example, the owl has the purpose of telling tragedies, and other animals have the purpose of becoming food. Plants and animals can also have magical effects over people as elements of sorcery, in addition to their capability to bite, stink or even cause death (Taller de Tradición Oral CEPEC & Beaucage, 1987). There is a close relationship between humans and animals because they share a soul or "tonal". If an animal is harmed by sickness, its corresponding human being will also become sick, and only a sorcerer will be able to cure both of them (Taller de Tradición Oral CEPEC & Beaucage, 1987). In the Nahua culture, the difference between animality and humanity is not stable; in some cases, sorcerers can transform themselves into animals and harm other people.

For Nahuas from the Sierra Norte of Puebla, the main elements that sustain life are ground, water, air and fire. Ground is linked to the feminine; it gives birth to life and contains every element that will end life, being the start and end of every living being. Water is the most vital liquid. Air represents the wind that distributes rain over the ground, guaranteeing the harvest. Fire is essential for allowing human beings to eat; it is necessary for cooking and transforming animals into food and for heating the water to clean human beings' impurities. The mountains provide human sustainability; they are home to mythical creatures and gods and provide the most essential liquid, water. The "owners" of the mountains are the most respected and feared entities (Báez, 2004). The sun is also important because it provides everything that helps plants to grow (Lupo, 2001; Báez, 2004).

According to a teacher from the community where the study was performed, the mountains, rivers and water springs have guardians. If humans do not care for these elements, their guardians will make humans sick, placing acne in their mouths or damaging their bodies. According to the teacher, "The guardians are in the wind; they are always there, even if you don't see them".

Objectives of the study

The main objective of the present study is to understand how primary-school children from indigenous Nahuatl-speaking communities identify and characterize living and non-living beings and whether there is a biological thinking related to their particular cultural background. This investigation is grounded on the assumption that cultural notions are a type of implicit knowledge that is present even in children's explanations of concepts they learn in school, in this work we seek elements that let us answer the following research questions:

Which are the criteria used by primary school students in a Nahua community to classify living beings and the non-living?

Are there, in this classification and justification, elements of the Nahua culture with an influence in the conception students have on living beings?

Method

This research gives an account of a case study about students in three primary schools in the Cuautempan Municipality, in the Sierra Norte of Puebla. The sample has three groups, in accord with the school cycles in the indigenous schools in Mexico. Data were obtained in two different times, first, in individual interviews in the school and after that, a walking trip was made in which interviews were made in open manner by asking questions that the children answered spontaneously.

Sample

The research sample included 33 students between six and twelve years old from three primary schools in the Sierra Norte of Puebla. Eleven students from each school cycle (I cycle, 1st and 2nd grade; II cycle, 3rd and 4th grade; III cycle, 5th and 6th grade) were analysed. Students took part in a voluntary way. Table 1 presents the sample distribution and shows which are the expected learnings that students in each cycle must reach according to the official curriculum from the Public Education Ministry.

Two of the included schools are located within the municipality of Cuautempan, and one is located within Tetela de Ocampo. The three are indigenous bilingual schools (Nahuatl and Spanish) with a multi-grade organization (a teacher teaches more than one grade level simultaneously). Students in first grade have little fluency in Spanish, while students in later grades can communicate with their teachers in both languages with proficiency.

Table 1

Total number of students by cycle and expecting learning in official program (SEP)

Cycle	Grade	Total students	Expecting learning
I	1st	6	Identify changes in plants and animals (born, grow, reproduce and died).
	2nd	5	Classify plants and animals as living beings.
II	3rd	6	Identify different forms of nutrition in animals and plants. Identify breathing in animals. Explain reproduction in plants. Explain reproduction in animals.
	4th	5	Explain the relationships between abiotic factors (water, soil, air, and sun) and biotic factors (living beings).
III	5th	6	
	6th	5	

According to the INEGI (2010), the students in this sample live in a marginalized zone, and their schools have a remarkable lack of educational materials. Most of the teachers belong to the above mentioned communities or communities nearby and are bilingual. Most of the residents, of these communities, work in agriculture-related areas and have scarce access to services such as sewage and health care.

Research design

To elicit the children's conceptions about living beings, individual interviews were conducted. The interviews used questions supported by an interactive application (on a tablet) that included examples of animals, plants, and inanimate objects for the children to identify and group into the categories of living and non-living beings as shown an example in figure. The tasks in the interactive application presented animals, plants and objects in two scenarios (desert and forest). The total of species and inanimate objects in both scenarios were: 13 animals (lizard, coyote, tarantula, snake, skunk, mouse, eagle, turtle, spider, owl, frog, butterfly); 11 plants (yucca, organ pipe cactus, dry grass, agave, nopal cactus, leafless plant, echinocactus, pine, oak, grass, leafless tree); 6 inanimate objects (clouds, mountains, sun, soil/ground, stones, waterfall). After the classification, the children were asked about the reasons for their decisions and the characteristics that they considered living beings to possess. All the interviews were conducted at the schools. In every case, the researchers received support from the school teachers, who provided translation for the children who did not have enough Spanish language skills to complete the interview in Spanish. Every interview was video recorded for posterior analysis.

Figure

Task' example in the interactive used in the interview for classify living and non- living being

To account for the possibility that children would use scientific explanations in school settings and diverse non-scientific explanations outside school (Taber, 2000), a few days after the school interview, a walking trip with the students and teachers was undertaken to address the research topic outside an academic context. In this case, the interviews were conducted during the hiking trip (the cycle I and II students participated on one day, and the cycle III students participated on another day) by asking questions that the children answered spontaneously. To gather the children's ideas, each researcher stood near a group of two or three students. These clusters served as focal groups in which the interviewer acted as a facilitator to explore the children's ideas about living beings in a non-school context. Each of the researchers (5 researchers for each walking trip) asked several questions during the activity. The objective of this methodology was to help the students to explore their viewpoints in an open-ended way (Winter, 2015). The questions were similar to those posed during the individual interview but included more detail; for instance, the children were asked how they used plants (to cure diseases, curses, etc.) or about their community beliefs regarding water and the ground (for instance, whether water might retain your spirit). These interviews were also video recorded for analysis.

The children's explanations were considered as shared with the focal group if they and the group supported the explanations with other examples or arguments. These explanations were compared with the data obtained from the individual interviews and determined to be similar; therefore, the answers were analysed as a whole. For data gathering and data analysis were used qualitative methods.

Data analysis

The individual interview responses and the ideas that the children offered during the walking trips were analysed to identify the classifications, explanations and descriptions the children used to categorize beings as living and non-living. For the analysis, three categories were considered: A) Identification of the living/non-living. B) Children's criteria for classifying animals and plants as living. C) Children's criteria used for classifying inanimate objects as living.

The characteristics of a living being were based on the school biological model (Gómez, Sanmarti & Pujol, 2007; SEP, 2011a, b) and included breathing, nutrition or feeding (including drinking water), growth, and reproduction.

Results

A. Identification of the living/non-living

During the interviews, the children classified the examples as living or non-living, first, they were asked to identify what was on the screen and then, for each of the examples, they were asked if they considered it to be alive or not and to say if it was an animal, plant or an object. Table 2 shows the number of children that classified as living beings the examples in the interview.

Table 2

Number of students by cycle that classify as living beings the examples in the interview

Entities	Students by cycle			Total percentage
	I	II	III	
Animals	11	11	11	100
Plants	5	10	7	66.6
Sun	6	7	5	54.5
Waterfall	3	6	2	33.3
Cloud	4	5	2	33.3
Ground /soil	4	2	1	21.2
Mountain	1	1	1	9.1
Rock	0	1	0	2.7

As Table 2 shows, all the children recognized animals as living entities; however, that did not occur in the case of plants; in the three cycles they had a recognition of only a 66.6%. although it is significant that 10 children of cycle II recognized plants as living beings, it stands out that only five of the youngest children (cycle I children), and seven of the older children (cycle III) had also done so. The difficulty that these children had with recognizing plants as living beings is in agreement with several previous studies (Brulé, et al., 2014). Inanimate objects, such as the sun, waterfalls and clouds, are frequently considered living, as shown in Table 2. However, some elements, such as the ground/soil (21.2%), mountains (9.1%) and rock (2.7%) are less likely to be considered living, which could be related to those items relationship with the community's beliefs.

B. Children's criteria for classifying animals and plants as living

The children attributed different characteristics depending on whether the entity was an animal, plant or inanimate object. For the plants and animals, most of the expressed characteristics that distinguished them as living beings were biological characteristics followed by movement and structure descriptions, shapes and colours.

Example 1. Cycle II student (9 years old)
Interviewer (I): What would you place here (the living beings category)?
S1 (Interviewed Student): (Points to an animal)
I: All animals, or just that one?
S1: All animals
I: All of them?
S1: Yes
I: Beside the animals, would you place something else as living?
S1: Yes

I: What?
S1: Plants
I: All plants, or just some of them?
S1: All of them
I: Why would you place all animals and plants in the living beings area?
S1: Because they are living beings
I: But how do you know they are living beings?
S1: Because they also need food
I: All of them (pointing animals and plants) need food?
S1: Yes
I: Do plants need food?
S1: Yes
I: Do animals need food?
S1: Yes

The student in example 1 exemplifies the majority of the answers that the children gave by indicating feeding as the basic criterion with which to identify and differentiate living from non-living beings.

Table 3 shows the biological and non-biological characteristics used by children to define the different examples of plants and animals as living beings. It shows the number of children that, in each cycle, used that characteristic at least once.

TABLE 3

Biological and non-biological characteristics used by students for classify animals and plants as living beings

	Characteristic	Cycle			Total percentage
		I	II	III	
Biological	Eats/dinks (water)	6	7	11	72.7
	Breathes	–	2	7	27.3
	Reproduces	2	1	5	24.5
	Grows	1	2	2	15.2
Non-biological	Moves	9	7	9	72.7
	Structure descriptions, shapes and colours	3	4	5	36.4
	Benefits human or other living beings	1	–	1	6.1
	Anthropomorphic characteristics	1	–	1	6.1
	Is composed of a particular material	–	1	–	3.0
	Has needs/requirements	–	1	–	3.0

Note. The percentages reflect the number of children that described a characteristic on at least one occasion.

Eating/drinking water and breathing are two of the most representative biological characteristics of living beings. According to Inagaki and Hatano (2002), feeding is one of the vital functions of a living being that is most strongly correlated with the characteristics of growth and regrowth. Other characteristics, such as reproducing and growing, were present in the children's interviews to a lesser extent.

It is important to note that these results identified breathing as a relevant attribute of living beings, a finding that differs from other studies that included growing as a main characteristic of living beings, as in Inagaki and Hatano (2002).

It is important to note that biological characteristics are usually related to a known and used organ that students recognize and understand the function of. This relationship is noted in example 2, an extract of the interview which establishes a direct relationship between breathing and the nose, (in a previous time, the student had already classified these examples as living beings):

Example 2. Cycle II student (8 years old)
I: It is a rooster. Where does the rooster live?
S5: In a chicken pen
I: Does the rooster breathe?
S5: Yes
I: How does the rooster breathe?
S5: With his nose
I: And this one? (showing an image of a cactus)
S5: It's a plant
I: The cactus is a plant. Does the cactus breathe?
S5: No
I: So plants don't breathe?
S5: Maybe
I: But how do they do that?
S5: No
I: Do you know this animal? Have you ever seen something like this? (pointing to the picture of a crab)
S5: What is that?
I: It is a crab. Do you think that the crab breathes?
S5: Yes
I: How does the crab breathe?
S5: By smelling

Students also use non-biological characteristics that identify animals and plants as living beings. Such characteristics include mainly movement (I – nine children, II – seven

children, III – nine children); structure descriptions, shapes and colours (for example, the green colour of plants indicate that they are living, while the brown colour indicates that they are dead, I – three children, II – four children, III – five children); the benefits they provide to human beings (I – one child, III - one child); anthropomorphic characteristics, such as talking (I - one child, III - one child); composition (for example, they are made of soil; II - one child); and needs and requirements (for example, warmth, shelter; II - one child).

The results indicate that the ability to recognize biological characteristics that can identify living beings increases according to the children's school cycle. There were important differences between school cycles I and II and less prominent differences between cycles II and III. The results seem to indicate that it is during cycle II that students' understanding of the concept of living changes. These results are similar to those obtained by Salleh, Venville and Treagust (2007).

Children's criteria for classifying living entities as non-living are based on the absence of specific biological and non-biological characteristics: lack of movement (I - five children, II - two children and III - one child); dying, which they only applied to animals (III - one child); feeding (eating/drinking water) (I - one child); reproducing (II - one child); and breathing (III - one child). The children used only three non-biological characteristics to explain why something is not living: movement (I - five children, II - two children and III - one child); structural descriptions, shapes and colours, which they applied to plants (II - one child), and anthropomorphic characteristics (such as talking), which they applied to animals (I - one child).

C. Children's criteria used for classifying inanimate objects as living

The children used biological characteristics to explain their identification of inanimate objects as living beings, these characteristics included growing, breathing, eating/drinking water and dying/drying out. However, other kind of non-biological criteria were used to identify inanimate objects as living beings. Such characteristics included movement; providing benefits to human beings; having some power to act upon humans (e.g., the ground and water have power over human souls, such as when humans fall into the river); having needs and requirements (warmth, needing shelter, etc.); being composed of a particular material (e.g., being made of soil); being located in a specific place.

Table 4 shows the characteristics that the children used to identify inanimate objects as living beings. Percentages are about the total sample that, in each cycle, used that characteristic at least once.

Table 4

Biological and non-biological characteristics that students use for classify inanimate objects as living

	Characteristic	Cycle			Total percentage
		I	II	III	
Biological	Grows	–	1	2	9.1
	Breathes	–	2	–	6.1
	Eats/drinks water	1	1	–	6.1
	Dies/dries out	–	–	1	3.0
	Moves	6	7	7	60.6
Non-biological	Benefits human or others living beings	4	7	4	45.5
	Has some power that acts upon humans		1	1	6.1
	Has needs/requirements	3	–	2	15.2
	Is composed of a particular material	1	2	–	9.1
	Structure descriptions, shapes and colours	1	–	1	6.1
	Is located in a determinate place	1	–	–	3.1

Note. The percentages reflect the number of children that described some characteristic on least a single occasion.

As Table 4 shows, movement was the most frequently mentioned non-biological characteristic (e.g., the movement of water in the river, the wind, etc.). Movement accounted for the highest percentage of responses from the children in all cycles while biological characteristic as growing (9.1%), eating and/or drinking water (6.1%) and breathing (6.1%) were used with low frequency as criteria for recognizing an entity as living, although they were used to justify that something is not alive because it has not any of these characteristics, that is, children use them to exclude inanimate objects that were identified as non-living from the living beings (e.g., noting that a waterfall is not living because it does not breathe) (see Table 5).

Table 5

Characteristics used by children to exclude inanimate objects

Characteristic	Cycle			Total percentage
	I	II	III	
Do not move	7	7	9	69.7
Do not grow	-	2	2	12.1
Do not breathe	1	4	6	33.3
Do not eat/drink water	3	3	5	33.3
Do not reproduce	–	–	1	3.0

Note. The percentages reflect the number of children that described some characteristic on least a single occasion.

Living characteristics were attributed to some inanimate objects that are considered necessary for life and beneficial to humans. The prototypical case is the sun; as Table 2 shows, an average of 54.5% of the children considered the Sun to be living.

The next example shows how the children used biological and non-biological arguments to classify the Sun and the ground.

Example 3. Cycle III student (12 years old)
I: Where would you put the Sun?
S7: Within the living beings
I: Why?
S7: Because without the Sun, everything will be dark, and as… And when, well, I think that it is living, well, at least when there is light
I: So it is living because it gives us light?
S7: Yes
I: And the ground?
S7: In the non-living
I: In the non-living, why?
S7: Because, well, because it is not, it doesn't do, it doesn't breathe, it is not an animal or a plant or person.

The example illustrates the distinction between living and non-living conceptions. On the one hand, the Sun is living because it has a direct effect on living beings (non-biological characteristic); and on the other hand, a biological characteristic, such as breathing, is used to exclude items from the "living" category.

These results allow us to conclude that there is no consistency in the use of characteristics. A low percentage of children considered that life extends to everything that has life in it; for example, the ground/soil (21.2%) and mountains (9.1%). In the case of the sun, even children in cycle III (aged 11 to 12 years) considered it living; while this might be expected of younger children, it is a surprising finding among older ones. The conception that everything that contains or sustains life is a living being seems to be related to the children's cultural environment. The next example will consider some interview fragments in which children use non-biological characteristics to identify specific examples as living beings.

Example 4. Cycle III student (12 years old)
I: Is a waterfall living or not? (showing the picture of a waterfall)
S4: Hmm, yes
I: Yes? Why is that?
S4: Because it is made of water. They say it's living
I: Why? Do they say water is living?
S4: Yes

I: Who says water is living?
S4: Almost everyone
I: Almost everyone; and what do you think? Could you explain it to me so I can understand?
S4: I think it is, because if you throw rocks at it, the water will grab you
I: If you throw rocks into the water, it will grab you?
S4: Yes

The student considers that the water, along with the ground/soil, are living, and they can exert some power or action over humans, such as grabbing them. According to the teachers in the community, this means that if a person throws a rock in the water, his or her spirit will remain in the water, and the person will become sick from fear or even die. The spirit can only be recovered through a ritual performed by the shaman, a healer or a trained person.

Example 5. Cycle I student (6 years old)
I: What do we put in the living area?
S8: The ground
I: Why is the ground living?
S8: Because we live there
I: Because we live there. Why it is living?
S8: Because, for the animals
I: But, if we don't think about the animals, is the ground still living?
S8: Yes (nodding his head)
I: Yes, why?
S8: For the plants

In the example, the student establishes a relation between the life that grows on and in the ground/soil, including the animals and plants that inhabit it. For the student, a living thing can be something that contains other living beings. This idea was included in the category of benefits human or others living beings (see table 4).

Discussion

Based on the results, the children had no difficulties identifying animals as living beings (100%). They did have some difficulty recognizing plants as living beings (66.6%), and only in cycle II mostly all students were able to do. In both cases, the criteria that the children used to identify items as living or non-living were mainly biological (eat/drink water, breathe, and reproduce) among other characteristics such as autonomous movement.

The identification of such characteristics is consistent with the results of several studies that included even younger children (Dolgin & Behrend, 1984; Backscheider

et al., 1993; Hatano et al., 1993; Inagaki & Hatano, 1996); consequently, it is valid to assume that the children in our sample also drew on a biological intuitive knowledge that allowed them make predictions and explanations. In particular, among the children in this study, the characteristics "eats/drinks water", and "breathes", were the most important biological characteristics; thus, we can say that these children also possess an intuitive biology that is strengthened in school until a biological model develops. Henceforth, this model will be referred to as the intuitive biological model (*IBM*).

When students must explain why they classify certain objects as living beings, that is, which characteristics makes them living beings, most cite a biological characteristic. However, a percentage of children abandons the biological criteria that are a part of the intuitive biological model and turn to other non-biological characteristics to differentiate living from non-living beings. Among these characteristics, they mention providing benefits to humans or others living beings (45.5%); having needs/requirements (15.2%); being made of a particular material (9.1%); and having some power that act upon humans (6.1%). From our viewpoint, the use of these kind of characteristics seems to define another type of model, one that is influenced by the culture of these children. This cultural model (*CM*) has a perspective of life that differs from the biological perspective, in which being living means or implies the ability to eat/drink water, breathe, and reproduce, among other characteristics; in contrast, in the cultural model, being living implies that inanimate objects have the capacity to influence or affect the lives of humans and animals or being composed of a particular material (Báez, 2004; Pitrou, 2011). This *CM* model can be exemplified by the case of the sun; according to the children's descriptions, beyond having movement, the sun intervenes as an autonomous being with the capacity to create light and warmth in a way that is intended to benefit humans. Although when children classify objects as living beings by citing a biological characteristic, their use of non-biological characteristics shows that the biological model is only complementary because the explanations of children in all school grades becomes teleological, that is, objects are living beings because they have a definite finality or purpose (Kelemen, 1999), a characteristic of Nahua thinking (Taller de Tradición Oral CEPEC & Beaucage, 1987). As Inagaki and Hatano (2002) mention, the construction of intuitive biological knowledge is influenced, among other aspects, by sociocultural restrictions.

From the results and the described analysis, it is possible to establish three models that children use to identify and characterize living beings:

Intuitive Biological Model (IBM): Children use this model to explain what is living based on two biological characteristics: eating/drinking water, breathing and additionally moving. They also generalise it to identify and justify what is not a living being by negating some of these characteristics (for instance, it is not living because it does not breathe). We considered a student to have used this model if he or she cited two of the mentioned characteristics.

School Biology Model (SBM): This model was considered when the children cited characteristics of the intuitive model (*IBM*) and additional biological functions (growing and reproducing, excluding movement) and applied them to animals, plants, and inanimate objects. The difference between this and the previous model lies in the use of all characteristics that are part of the biological model; this model is the one that children are expected to construct over the course of their formal education.

Cultural Model (CM): The children who used this model identified as living everything that enhances or has some effect on other entities' lives, characteristics that originate in the Nahua culture. The characteristics included in this model are bringing benefits to humans and others living beings, having requirements or needs, being made of a particular material or having some power that acts upon humans. We considered a student to use this model (*CM*) when he or she cited at least two of these characteristics.

Table 6 shows the ways in which each student of the sample used the mentioned models to justify her/his classifications.

Table 6

Students' models used during interviews (cycles I, II and III)

	Cycle I				Cycle II				Cycle III			
Student	APL	OL	APnL	OnL	APL	OL	APnL	OnL	APL	OL	APnL	OnL
1	IBM	CM		¬IBM	IBM			¬IBM	IBM	CM		
2		CM			SBM			CM	SBM		¬IBM	
3		IBM			IBM		¬IBM		SBM			
4					MBI				SBM		¬IBM	
5	CM		¬IBM		SBM				IBM		¬IBM	¬IBM
6			¬IBM		SBM				IBM		¬IBM	¬IBM
7		CM	¬IBM		SBM	CM			SBM		¬IBM	
8	IBM		¬IBM		SBM				IBM			¬IBM
9			¬IBM		SBM			¬IBM	IBM		¬IBM	¬IBM
10	IBM		¬IBM		IBM			¬IBM	IBM	CM		
11	SBM		¬IBM	¬IBM	IBM				IBM			¬IBM

APL = animals and plants as living beings; OL = inanimate objects as living beings; APnL = non-living animals and plants; OnL = inanimate objects; IBM = intuitive biological model; ¬IBM = no biological model (students recognise the absence of some characteristics of this model); SBM = school biological model; CM = cultural model.

Concerning the explanations, the children used biological models mainly when they were referring to plants and animals and used their negation (¬*IBM*) to justify why animals and plants are not living. The use of the biological model increases with the students' age and school cycle (*3 IBM* and *1 SBM* for cycle I, *5 IBM* and *6 SBM* for cycle II, 7 *IBM* and *4 SBM* for cycle III). These biological models were used less frequently to explain why plants and animals were considered non-living by negating some biological characteristic. Generally, movement was the characteristic that students most often cited in their negations (7 students in cycle I, 1 student in cycle II and 6 in cycle III); however, the biological characteristic of breathing was also frequently used (for instance: "the spider is not a living being because it does not breathe"). The data suggest that the school model was applied mainly to animals and plants.

In comparison, the *CM* appeared in similar proportions among all three cycles; this is evidence of its independence from the schooling process. This model was used mainly to identify inanimate objects as living beings.

Conclusions

Similar to previous research studies in diverse contexts and locations, the children in the present study used an intuitive biological model (*IBM*) to identify and establish the characteristics of living and non-living beings. Particularly, this model, as applied to animals and plants, focuses on characteristics that indicate the conservation of life: eating/drinking water and breathing. This model is also used in its negated form to explain why plants, animals and objects are considered non-living. Movement is also an important part in their intuitive model; it always appears with a high frequency in all cycles.

The *IBM* model is the basis for the construction of the school biological model, *SBM*. The use of these two models increases with education, as Table 6 shows. In general, *IBM* was used more often than *SBM* among the children in all cycles, jointly; the use of these two models increases in frequency with school level. This increase leads to the consideration that school promotes the use of the biological characteristics of the intuitive model (all of the children in cycles II and III uses it) and the consolidation of the school biological model that was exhibited by 6 children in cycle II and 4 in cycle III. Another sign of this achievement is that only the children in cycle I used the intuitive biological model in their descriptions of living objects. However, this does not imply that those children have a greater understanding of the biological characteristics of the model; for example, the breathing function was only understood as the intake of air and was often confused with smell (see example 3, interview fragment). The children used biological factors as labels that enhanced the recognition but not the comprehension of life processes.

One conclusion is that cultural aspects are present (*CM*), but from a very general viewpoint in which the classification of what is living enlarges and is applied to that which supports life, an aspect that also appears in studies in other cultures (e.g., Japanese children). There is no application of a criterion such as describing the Earth as a living being because it has a heart or a particular purpose (as owls that have the purpose of announcing misfortunes), which is consistent with studies on Nahua conceptions (Taller de Tradición Oral CEPEC & Beaucage, 1987). This differs from similar studies on other topics in the same population, such as the construction of the processes of addition and subtraction of colours (Gallegos et al, 2014), which found no clear interaction between the school and cultural contexts. However, the influence observed in the present study was not strong (27.3%), possibly because the children were still in the initial process of appropriating their culture, as shown in other studies (Legare, et al., 2012), and because certain topics might be more or less relevant to certain individuals. The relationships between the construction of scientific knowledge in school and the development of cultural notions among children in the indigenous communities in which the research is conducted seem to be reciprocal, as evident in the presented data and in other studies referred to in the text.

Finally, it is necessary to emphasize that the status of indigenous education in Mexico presents a highly complex panorama. The great social, cultural and linguistic diversity creates challenges for addressing the education needs of different native cultures without diminishing their cultural heritage. This highlights the need for new alternatives that facilitate equilibrium among school science knowledge and the knowledge gained from the cultural heritage of each community and allow students to differentiate between and recognize the importance of applying both types of knowledge in different contexts or conditions. Moreover, such alternatives will allow subjects to be conscious of the importance of knowing, conserving and strengthening their original culture while understanding that other culture's contributions (i.e., school) can provide basic scientific training.

Acknowledgement

This research was supported by the grant "Construcción del pensamiento científico en niños, niñas y docentes de comunidades indígenas sobre el tema de seres vivos" Conacyt, CGEIB - 189352.

The authors would like to thank Héctor Covarrubias for his helpful comments regarding this work.

References

Aikenhead, G. (2001). Integrating western and aboriginal sciences: cross-cultural science teaching. *Research in Science Education*, *31*(3), 337-355.

Anggoro, F. K., Waxman, S. R., & Medin, D. L. (2008). Naming practices and the acquisition of key biological concepts: evidence from English and Indonesian. *Psychological Science*, *19*, 314-319.

Argueta V. A. (2008). *Los saberes P'urhépecha: los animales y el diálogo con la naturaleza*. México: UNAM/Universidad Michoacana de San Nicolás de Hidalgo, Universidad Intercultural Indígena de Michoacán, Casa Juan Pablos, Gobierno del Estado de Michoacán, Programa de Naciones Unidas para el Medio Ambiente.

Atran, S., & Medin, D. (2008). *The native mind and the cultural construction of nature*. Cambridge, MA: MIT Press.

Backscheider, A. G., Shatz, M., & Gelman, S. A. (1993). Preschoolers' ability to distinguish living kinds as a function of regrowth. *Child Development*, *64*, 1242-1257.

Bang, M., & Medin, D. (2010). Cultural processes in science education: supporting the navigation of multiple epistemologies. *Science Education*, *94*(6), 1008-1026.

Báez, L. (2004). El espacio sagrado de los nahuas de la sierra norte de Puebla. *Perspectivas Latinoamericanas*, *1*. Retrieved from: http://www.ic.nanzan-u.ac.jp/LATIN/kanko/PL/ 2004PDF/3lourdesbaez.pdf.

Brulé, L., Labrel, F., Megalakaki, O., Fouquet, N., & Caillies, S. (2014). Children´s justifications of plants as living things between 5 and 7 years of age. *European Journal of Developmental Psychology*, *11*(5), 532-545.

Candela, A., Sánchez, A., & Alvarado, C. (2012). Las ciencias naturales en las reformas curriculares. In F. Flores (Coord.), *La enseñanza de las ciencias en la educación básica en México* (pp. 33-56). México: INEE.

Carey, S., & Spelke, E. (2002) Conocimiento dominio-específico y cambio conceptual. In L. Hirschfeld & S. Gelman (Eds), *Cartografía de la mente. La especificidad de dominio en la cognición y en la cultura* (pp. 243-284). Barcelona: Gedisa.

Cober, W., & Loving, C. (2001). Defining science in a multicultural world: implications for science education. *Science Education*, *85*(1), 50-67.

Dolgin, G. K., & Behrend, A. D. (1984). Children´s knowledge about animates and inanimates. *Child Development*, *55*(4), 1646-1650.

Gallegos-Cázares, L., Flores-Camacho, F., Calderón-Canales, E., Perrusquía-Máximo, E., & García-Rivera, B. (2014). Children's models about colours in Nahuatl-Speaking communities. *Research in Science Education*, *4*(5), 699-725.

Gelman, S. A., & Gottfried, G. (1996). Children´s causal explanations of animate and inanimate motion. *Child Development*, *67*, 1970-1987.

Gelman, S. A., & Opfer, J. (2002). Development of the animate-inanimate distinction. In U. Goswami (Ed.), *Blackwell Handbook of Childhood Cognitive Development* (pp. 151-166). Malden, MA: Blackwell.

Gómez, A., Sanmarti, N., & Pujol, R. M. (2007). Fundamentación teórica y diseño de una unidad didáctica para la enseñanza del modelo de ser vivo en la escuela primaria. *Enseñanza de las Ciencias, 25*(3), 325-340.

Harding, S. (1994). Is science multicultural? Challenges, resources, opportunities, uncertainties. *Configurations*, *2*(2), 301-330.

Harris, P. L. (2011). Conflicting thoughts about death. *Human Development, 54*, 160-168.

Hatano, G., Siegler, S. R., Richards, D. D., Inagaki, K., Stavy, R., & Wax, N. (1993). The development of biological knowledge: a multi-national study. *Cognitive Development*, *8*, 47-62.

Hirschfeld, L. A., & Gelman, S. A. (1994). Toward a topography of mind: an introduction to domain specificity. In L. A. Hirschfeld & S. A. Gelman (Eds), *Mapping the mind: domain specificity in cognition and culture* (pp. 1-36). New York, NY: Cambridge University Press.

Hong, Y. Y., Morris, M., Chiu, C. Y., & Benet-Martínez, V. (2000). Multicultural minds: a dynamic constructivist approach to culture and cognition. *American Psychologist*, *55*, 709-720.

Inagaki, K., & Hatano, G. (1987). Young children´s spontaneous personification as analogy. *Child Development*, *58*, 1013-1020.

Inagaki, K., & Hatano, G. (1996). Young children´s recognition of commonalities between animals and plants. *Child Development*, *67*, 2823-2840.

Inagaki, K., & Hatano, G. (2002). *Young children's naive thinking about the biological world*. New York: Psychology Press.

Inagaki, K., & Hatano, G. (2006). Young children´s conception of the biological world. *Current Directions in Psychological Science, 15*(4), 177-181.

INEE (2007). *La educación para poblaciones en contextos vulnerables. Capítulo 2: El caso de las primarias indígenas* (pp. 41-68). México: INEE.

INEGI (2010). Censo de población y vivienda (Population and dwelling census). Retrieved from http://www.inegi.org.mx/sistemas/mexicocifras/default.aspx?src=487andent=21.

Jiménez-Naranjo, Y. (2011). Los 'enunciados' de la escuela intercultural en el ámbito de los pueblos indígenas de México. *Desacatos. Revista de Antropología Social*, *35*, 149-162.

Kelemen, D. (1999). Function, goals and intention: children´s reasoning about objects. *Trends in Cognitive Science*, *3*(12), 461-468.

Lee, H., Yen, C. F., & Aikenhead, G. (2012). Indigenous elementary students' Science instruction in Taiwan: indigenous knowledge and western Science. *Research in Science Education*, *42*(6), 1183-1199.

Legare, H. C., Evans, M. E., Rosengren, S. K., & Harris, L. P. (2012). The coexistence of natural and supernatural explanations across cultures and development. *Child Development*, *83*, 779-793.

Lorente, D. (2011). Tempestades de vida y muerte entre los nahuas. In P. Pitrou, M. C. Valverde & J. Neurath (Eds), *La noción de vida en Mesoamérica* (pp. 259-287). México: Universidad Nacional Autónoma de México y Centro de Estudios Mexicanos y Centroamericanos.

Lupo, A. (2001). La cosmovisión de los Nahuas de la Sierra de Puebla. In J. Broda & F. Báez-Jorge F. O. (Eds), *Cosmovisión, ritual e identidad de los pueblos indígenas de México* (pp. 335-390). México: Consejo Nacional para la Cultura y las Artes, Fondo de Cultura Económica.

Massey, C. M., & Gelman, R. (1988). Preschooler's ability to decide whether a photographed unfamiliar object can move itself. *Developmental Psychology*, *24*, 307-317.

Matos, M. E. (2010). *La muerte entre los Mexicas*. México: Tusquets Editores.

Morris, M. W., & Peng, K. (1994). Culture and cause: American and Chinese attributions for social and physical events. *Journal of Personality and Social* Psychology, *67*(6), 949-971.

Ogawa, M. (1995). Science Education in a multiscience perspective. *Science Education*, *79*(5), 583-593.

Opfer, E. J. (2002). Identifying living and sentient kinds from dynamic information: the case of goal-directed versus aimless autonomous movement in conceptual change. *Cognition*, *86*, 97-122.

Opfer, E. J., & Siegler, S. R. (2004). Revisiting preschoolers´ living things concept: a microgenetic analysis of conceptual change in basic biology. *Cognitive Psychology*, *49*, 301-332.

Piaget, J. (1929/1975). *La representación del mundo en el niño*. Madrid: Morata.

Pitrou, P. (2011). El papel de "Aquel que hace vivir" en las prácticas sacrificiales de la sierra mixe de Oaxaca. In P. Pitrou, M. C. Valverde & J. Neurath (Eds), *La noción de vida en Mesoamérica* (pp. 119-154). México: Universidad Nacional Autónoma de México y Centro de Estudios Mexicanos y Centroamericanos.

Ross, N., Medin, D., Coley, D. J., & Atran, S. (2003). Cultural and experiential differences in the development of folk biological induction. *Cognitive Development*, *18*, 25-47.

Salleh, R., Venville, G. J., & Treagust, D. F. (2007). When a bilingual child describes living things: an analysis of conceptual understandings from a language perspective. *Research in Science Education*, *37*, 297-312.

Secretaría de Educación Pública (SEP) (2011a). *Plan de Estudios 2011*. Educación Básica. México: SEP.

Secretaría de Educación Pública (SEP) (2011b). *Programa de Estudios 2011. Guía para el Maestro, Primaria, Primer, Segundo, Tercero, Cuarto, Quinto y Sexto grados*. Educación Básica. México: SEP.

Stromberg, I. C. (2003). *La participación diferenciada de los pueblos indígenas y el derecho internacional ambiental y humana*. Retrieved from http://www2.inecc.gob.mx/ publicaciones/consultaPublicacion.html?id_pub=398.

Taber, K. (2000). Multiple frameworks?: evidence of manifold conceptions in individual cognitive structure. *International Journal of Science Education, 22*(4), 399-417.

Taller de Tradición Oral CEPEC & Beaucage P. (1987) Catégories pratiques et taxonomie: des notes sur la classification et les pratiques botaniques nahuats de Sierra Norte de Puebla. *Recherches Amériendiennes au Quebec*, *17*(4), 17-36.

Waxman, S. R., Medin, D. L., & Ross, N. (2007). Folkbiological reasoning from a cross-cultural developmental perspective: early essentialist notions are shaped by cultural beliefs. *Developmental Psychology*, *43*(2), 294-308.

Winter, K. (2015). Innovate qualitative research methods with children aged 4-7 years. In O. N. Saracho (Ed.), *Handbook of Research Methods in Early Childhood Education*. Review of Research Methodologies Volume I. Charlotte, NC: Information Age Publishing Inc.

Zogza, V., & Papamichael, Y. (2000). The development of the concept of alive by preschoolers through a cognitive conflict teaching intervention. *European Journal of Psychology Education*, *XV*(2), 191-205.