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How Do Five- to Six-Year-Old Children Interpret a Burning Candle?

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Abstract: Many studies have been conducted in recent years on the explanations given by preschool-age children about different natural phenomena. Nonetheless, very few studies have actually focused on the important domain of matter and its transformations. Specifically, the field of chemical reactions remains unexplored. This qualitative study aims to investigate the explanations of twenty-two 5- to 6-year-old children about combustion, while at the same time evaluating the effect of prior experience with science activities on their interpretations. For this study, the following experiment was proposed: burning a candle inside an inverted vessel. The following data collection tools were used: a Predict-Observe-Explain (POE) strategy and audio and video recordings. The children's explanations were analysed using classification frameworks, which had been developed in previous studies. The results of this study suggest that young children tend to provide naturalistic explanations about combustion. This finding is an indicator that young children are able to construct mental representations within this conceptual domain. Likewise, the results indicate that children who are used to engaging in inquiry-based activities may be more likely to establish a relationship with previous learning experiences to interpret other natural phenomena.

Keywords: preschool children; explanations; precursor models; natural phenomena; combustion

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1. Introduction

Young children have a natural curiosity and an innate desire to explore the world around them [1]. It is important that we use this enthusiasm and desire to learn to engage young children in science, taking into account the well-documented benefits, which include improved intellectual and linguistic development [2]. Moreover, exposing children to scientific phenomena at an early age provides them with a solid foundation, which will enable them to further develop scientific concepts and attitudes that will be presented to them at higher educational levels [3].

The current consensus suggests the need for preschool-age children to be engaged in the scientific practice of developing and using models, given their ability to construct their own theories and models about the world through an induction process [4]. These internal representations are formed through their interaction with the natural, social, and cultural environment in which young children develop [5]. As a result, the main aim of including science in early childhood education is not for young children to acquire scientific concepts, but to encourage them to question their own models and construct new ones that are increasingly closer to the models of school science [6]. Therefore, it is important to note that young children's models or explanations should not be evaluated as 'right' or 'wrong' [7].

There is an extensive body of literature in the field of science education which deals with students' views on matter and its transformations. Nonetheless, the majority of these studies have focused on primary and secondary school students (see, e.g., [8]) and, as a result, the information regarding the kind of explanations or representations that very young children construct about phenomena in which transformations of matter occur is very minimal. Specifically, the introduction of the chemical reaction concept in early childhood education is a field that is yet to be researched.

This paper aims to investigate young children's representations and explanations of the everyday phenomenon of burning a candle, which is intimately related to the transformation of matter. This study was guided by the following research question:

What types of explanations do young children use when reasoning about combustion? To what extent can these explanations be considered as indicators of the existence of a precursor model, and to what extent may children's familiarity with science activities influence the interpretations they construct?

1.1. Precursor Models and Explanations in Young Children

Within the field of cognitive science, it is widely accepted that individuals develop and use internal representations that allow them to explain facts and phenomena of the world around them [9,10]. The mental model construct was originally described by psychologist Craik [11], who suggested that people have a small-scale model of how the world functions engrained in their minds. A few decades later, psychologist Johnson-Laird [12] built on Craik's idea, defining a mental model as a reasoning mechanism, which enables people to understand phenomena and make inferences.

Within the field of science education, Gilbert [13] understands a mental model to be a private and personal representation that is developed for a specific purpose by an individual, either alone or as a part of a group. Since mental models are conceived as generative tools, these allow people to explain, predict and describe multiple phenomena [14]. Mental models may involve distortions or alternative ideas, which can lead to inaccurate explanations [15]. However, these internal representations are dynamic in nature, and, as such, they are constantly subjected to a review process with the goal of removing internal contradictions [16]. In this way, models that differ from school science models in terms of content can reach a higher level of sophistication if adequate teaching strategies are implemented.

From an early age, children feel an innate need to develop models that enable them to interpret the world around them, and in order to do so they use the resources that are at their disposal [17]. These initial models, which are known as precursor models, are cognitive structures that are built on certain core elements, which are included in the scientific models [17,18]. Although the range of application of precursor models is limited, only allowing simple causative correlations, they constitute the bases on which the school science model is built [17,19]. If these bases did not exist, the school science model would be very difficult or impossible to construct [20].

Based on the precursor model approach, some studies have investigated how these representations are formed in young children's thoughts. Ravanis et al. [18] found that 5- to 6-year-old children were able to construct a precursor model of thermal expansion and contraction of metals that allowed them to predict and explain phenomena within this conceptual domain. This precursor model was established and expanded through experimental activities, based on a Predict-Observe-Explain (POE) teaching strategy. Koliopoulos, Tantaros, Papandreou and Ravanis [19] also concluded that 5- to 6- year-old children were able to construct a precursor model of flotation that is based on an intuitive concept of density.

As mentioned above, mental models enable people to construct explanations. The construction of explanations is considered one of the most important discursive practices in science teaching [21]. However, there is still no consensus definition of the term "explanation" in the literature [22]. Gilbert, Boulter and Rutherford [23] stated that a simple definition would consider the meaning of "explanation" as the response given to a specific question. Other authors such as Braaten and Windschitl [24] have pointed out that students are able to generate explanations to clarify meanings or describe the reasoning used when answering a given problem (explanation as explication), define the causal mechanism of a phenomenon by establishing cause-effect relationships (explanation as causation, or justify an idea (explanation as justification).

Legare [25] pointed out that characterising children's explanations about the physical world provides crucial information about the mechanisms that this collective activate in order to understand the environment, acquire new knowledge, and develop causal learning. Based on Piaget's theory of cognitive development, young children resort to non-naturalistic explanations in their accounts of natural phenomena, since the boundaries between the real and the mental world are diffused at an early age [26]. As a result, young children tend to construct explanations in which life and intentions are attributed to inanimate entities (animism), in which certain psychological processes such as dreams or thoughts really exist (realism), or in which it is assumed that everything that exists around us has been created by the human being with a specific purpose (artificialism).

However, recent research studies have suggested that preschool-age children are able to give spontaneous explanations of different natural phenomena, in which an incipient understanding of the physical causality is appreciated [27,28]. Hickling and Wellman [29] found that even at 2–3 years of age, children were able to construct causal explanations, with the occurrence of this type of explanations increasing with age. A study conducted by Christidou [30] found that most 5- to 6- year-old children attributed the occurrence of phenomena such as flotation, magnetic properties, and dissolution to certain intrinsic properties of the substances or objects that were involved in the process. For instance, young children mentioned that the object sunk due to its weight or due to the material that it was made of. In a subsequent investigation, Christidou and Hatzinikita [27] concluded that 5- to 6- year-old children give naturalistic explanations about plant nutrition, assuming the intervention of an external agent. For instance, the participants mentioned that plants are able to grow thanks to human beings watering them. A naturalistic explanation is rational and this is considered as the beginning of physical causality [5,27,30,31]. Other authors such as Saçkes, Flevares, and Trundle [32] characterised the understandings of twenty-two preschool-age children (aged 4 to 6) regarding the rainfall mechanism. These authors observed that the older children were able to construct plausible explanations about this phenomenon, referring to the idea that the water is stored in different locations, such as the clouds or the sea, and that rainfall simply involves the water changing location.

On the other hand, they found that young children used different modes of explanations depending on the entities that were being considered. For instance, preschool-age children often used psychological reasoning for human beings, biological reasoning for living things, and physical reasoning for inert entities [29]. Christidou and Hatzinikita [27] also found that the young children's familiarity with the phenomenon had an impact on the explanatory mode that they selected.

1.2. Previous Research on the Concept of Matter and Its Transformations

In recent years, many studies have been conducted on the conceptions of preschool-age children on natural phenomena. Nonetheless, only a small number have investigated the topic of matter. Most of them have referred to other conceptual domains such as rain formation, flotation, plant growth or magnetic properties (see, e.g., [27,30,32]. Therefore, in an effort to summarise the students' conceptions of the concept of matter and its changes, we have presented descriptions by children of a range of ages, beginning with those in early childhood education before ending with a brief reference to primary and secondary school students.

In early childhood education, Cruz-Guzmán, García-Carmona, and Criado [33] investigated how young children (aged 2 to 4) learned about changes of states through an inquiry-based approach. These authors found that many children were able to understand that when ice is heated it turns into liquid water. However, none of the participants were able to understand the reverse process. Bar and Galili [34] compared the responses of children of different ages to questions about drying laundry and water evaporating from a container. The authors concluded that the younger children (aged 5 to 7) were able to describe evaporation as the disappearance of water, but that the concept of water being absorbed into the surfaces only emerged among children from the age of seven. Tytler and Peterson [35] also explored the ideas of five-year-old children regarding the evaporation phenomena. Unlike Bar and Galili [34], these authors found that young children were able to grasp the idea that liquid changes position, for example, by absorbing into surfaces or by going to the clouds, therefore suggesting that their thinking is more complex than expected. Moreover, Tytler and Peterson [35] concluded that young children do not have a mental model that enables them to explain how the water might exist in a non-perceptible form in the air.

On the other hand, Kambouri and Michaelides [36] investigated the effect of an intervention in which drama techniques were used on the young children's understanding of the water cycle. The results indicated that prior to the intervention, the participants (aged 4 to 5) found it difficult to define how clouds are formed, referring to the intervention of divine entities. After the intervention, many young children managed to acquire vocabulary relevant to the water cycle (e.g., vapour), and they were able to provide much improved explanations of what the rain is or what the clouds are made of. A recent study by Malleus, Kikas and Marken [37] also examined kindergarten and primary school children's understanding of cloud formation and rain. These authors concluded that, although some of the younger children (aged 5 to 7) mentioned that the clouds are made of water vapour, most of them relied on the observable aspects of the phenomena (e.g., the idea that clouds are made of cotton or smoke).

The ideas of primary and secondary school students concerning the concept of matter have been well documented in science education literature. With regard to the particle nature of matter, Özmen [38] concluded that children (aged 12 to 13) considered the existence of other material such as air between the particles. In terms of the conservation of matter, Hesse and Anderson [39] found that 11-year-old children considered that matter is not conserved in the reactions in which gases are released. Regarding physical changes, Ahtee and Varjola [40] found that a widespread alternative conception among students (aged 12 to 14) was the idea of considering dissolution and changes of state as a chemical reaction. It must be clear that the substances remain the same during a physical change, whereas during a chemical change a break and formation of new bonds between atoms occurs, which enables the initial substances to be transformed into other different substances. Prain, Tytler and Peterson [41] found that 11-year-old children describe the condensation of water vapour as a transmutation of cold into liquid water, or as the leakage of water. With regard to chemical reactions, Eilks and Moellering [42] concluded that children (aged 12 to 13) did not conceive the existence of chemical reactions in the case in which one initial substance formed other substances. In the case of combustion, it was observed that the students' explanations about this phenomenon depended on the combustible material. Meheut, Saltiel, and Tiberghien [43] concluded that children (aged 11 to 12) described the combustion of wax or metal as melting or evaporation. BouJaoude [44] found that students (aged 13 to 14) explained the combustion of alcohol as evaporation, and the combustion of wood as the change to ashes. Prieto, Watson and Dillon [45] argued that the inconsistency in the student's interpretations is due to the fact that they are beginning to reconstruct their mental models in the search for great explanatory power.

According to Kypraios, Papageorgiou and Stamovlasis [46], many of the difficulties that children experienced when dealing with the concept of matter were derived from their limited understanding of the particulate nature of matter. Developing a deep understanding of the particulate nature of matter is essential in order for students to be able to explain the changes that occur at macroscopic level [47].

2. Materials and Methods

This study involved a qualitative methodological approach, since it sought to describe, become aware of, and gain an in-depth understanding of a phenomenon of interest in context-specific settings [48]. It is important to consider that due to the qualitative nature of the research, which involved a small sample group, the generalisation of the results is limited. However, this paper includes comparisons with other studies of a similar nature, therefore contributing to the knowledge of young children's explanations about phenomena in which transformation of matter occurs.

2.1. Participants

A total of 22 preschool-age children, ten girls and twelve boys, participated in this study. The participants' ages ranged between five- and six-years old. The research was conducted in two public schools in north-west Spain. Eight children, three boys and five girls, attended a school located in a mid-sized city, and these children were accustomed to more traditional teaching methodology, with little room for the inclusion of science activities. From this point on, we will refer to this group of children as group A. Fourteen children, five girls and nine boys, attended a school located in a rural area, and these children were used to doing different science projects in the classroom. From this point on, we will refer to this group of children as group B. The difference in the instruction received by the two groups of participants will allow us to determine to what extent the young children's familiarity with science activities influences the way in which they construct their explanations.

Some weeks before the intervention, group B had engaged in several guided-inquiry activities related to changes of states, as part of a science project about the water cycle. Inquiry-based learning is an approach that is frequently used in science education, and the main goal is for students to infer meaning, with learning focused on questioning, critical thinking and problem solving, in which the teacher acts as a learning facilitator [49]. One of the learning activities consisted of filling a container with water so that the students could measure how the water level decreased over the course of several days. This allowed the teacher to introduce the idea of evaporation. Another activity consisted of placing a mirror over the water vapour that was being released from a kettle, so that the children were able to see how the vapour changed into liquid water again. This allowed the teacher to introduce the idea of condensation. None of the children had previously engaged in any activities concerning combustion.

In terms of the ethical considerations, it is important to mention that we requested the informed consent of the parents for the participation of each child. In addition, the participants were identified using pseudonyms, in which their gender but not their real names were maintained. The fictitious names began with the letter of the group to which each child belonged.

2.2. Data Collection

The natural phenomenon that was proposed to the participants in this study was the idea of burning a candle inside an inverted glass vessel. This experiment was chosen for two main reasons. On the one hand, in early childhood education, contents related to facts that are perceptible by the children and that are present in their daily lives must be addressed [50]. On the other hand, Löfgren and Helldén [51] have suggested that the ability to use the scientific concepts concerning matter and its transformations in order to interpret everyday phenomena is an essential goal in compulsory science education.

In order to collect the data, a Predict-Observe-Explain (POE) teaching strategy was designed [52]. The protocol followed was as described below. Firstly, the researcher presented the phenomenon to the children, telling them that a lit candle was going to be covered with a glass and asking them to make predictions as to what might happen. They were also asked to provide their reasoning behind their predictions. Once the children had written or drawn what they thought was going to happen on the questionnaire, the researcher performed the experiment in front of the children so that they could observe the changes that were taking place. In this stage, the researcher guided the children to help them make relevant observations that they had not considered. Finally, the researcher asked the children to record all of their observations on the questionnaire, as well as an explanation of what had happened.

Because of their young age, many of the participants did not have the sufficient skills to be able to write, so the majority of the answers recorded on the questionnaires were in drawing format. To obtain more insight into the children's drawings and make their ideas explicit, the researcher asked them questions while performing the experiment. These dialogues were recorded on audio and video files, which were subsequently transcribed. The video recording was necessary in order to unequivocally identify the intervention of each participant, as well as to capture how the children interacted both with the learning material and with their classmates. As a result, the richness of the data was found predominantly in the discourse of the group guided by the researcher, and not in their responses to the questionnaire. The excerpts that are included in the results section have been translated from Spanish and Galician.

2.3. Data Analysis

We have chosen the explanations provided by the young children as the unit of analysis. According to Christidou [30], an explanation can be defined as 'a coherent segment of an interview accounting for an object's or a substance's behaviour, or a mechanism underlying a phenomenon' (p. 22).

The participants' explanations about combustion were analysed, taking into account some classification frameworks that have been developed in previous studies that aimed to categorise young children's explanations of natural phenomena belonging to other conceptual domains [27,30,32]. In the analysis tool that was adopted, the young children's explanations were divided into scientific, synthetic, naturalistic, and non-naturalistic explanations. Scientific explanations are those that include ideas compatible with the current state of scientific knowledge [32]. Synthetic explanations contain elements that are consistent with scientific knowledge, but that also incorporate some alternative conceptions [32]. Naturalistic explanations are rational and objective, and they reveal an incipient understanding of physical causality [27,30]. If a naturalistic explanation involves the intervention of an external agent that participates in the phenomenon causing the change, this is referred to as agentive. Otherwise, if the internal properties or actions of the substance or object itself are the ones that trigger the change, the naturalistic explanation is referred to as non-agentive. Non-naturalistic explanations can be teleological, intentional, or metaphysical [27,30]. Teleological explanations assume that natural phenomena occur to fulfil a specific purpose. Intentional explanations define animist thinking and attribute intelligent and conscious nature to inanimate entities. Metaphysical explanations attribute the occurrence of natural phenomena to supernatural powers or divine entities.

In order to facilitate the understanding of the analysis tool used in this paper, each type of explanation is illustrated in Table 1, with examples described from previous research. We have not provided any examples of the combustion phenomenon due to the lack of studies in the field of chemical reaction in early childhood education.

To ensure the validity of the qualitative analysis and provide a certain degree of triangulation, the children's explanations were coded by the authors independently [48]. By comparing the authors' coding, an 89% level of inter-rater reliability was achieved.

Table 1. Types of young children's explanations about different natural phenomena reported in previous studies and listed considering the desirable knowledge: from the lowest (non-naturalistic explanations) to the highest (scientific explanations) level of sophistication.

Types of Explanations	Examples
4. Scientific	Rainwater evaporates and becomes a cloud when it condenses [32].
3. Synthetic	Clouds are made of snow and bring water. Fallen rainwater mixes with seawater and the snow falls and returns to clouds [32].

Table 1. *Cont.*

Types of Explanations		Examples
2. Naturalistic	Agentive	Why can't you see the sugar now? It went down into the water and when we stirred it, it broke [30].
	Non-agentive	Why did the marble go down? Because it is heavy. [. . .] It is made of iron [30].
1. Non-naturalistic	Teleological	How come it rains? It rains because the plants need to be watered [30].
	Intentional	Why does it float [the cork]? Because it is very careful. [. . .] It keeps its eyes open [30].
	Metaphysical	Where does the rain come from? It comes from God. God pours water from the sky [30].Why does the paper clip stick onto the magnet? Because it's [the magnet] got glue on it [30].

3. Results

Table 2 shows the types of explanations that were given by the children, making a distinction between group A and B. It is worth mentioning that the number of explanations exceeds the number of participants because some children produced more than one explanation throughout the different phases of the experimental task. To contrast how each child's answer evolves from the prediction to the conclusion phase, Table 2 includes both the frequency and the name of the children whose response fits into each category of explanation.

Table 2. Children whose explanations fit into each category and frequency of each type of explanation: group A (N = 8) and group B (N = 14).

Types of Explanation		Prediction Phase		Conclusion Phase	
Group A (N = 8)		Students	f	Students	f
Scientific		-	0/8	-	0/9
Synthetic		-	0/8	-	0/9
Naturalistic	Agentive	-	0/8	Alberto, Alexandre, Andrea, Amanda, Aurora, Alicia	6/9
	Non-agentive	Alberto, Adrián, Alexandre, Andrea, Amanda, Aitana, Aurora	7/8	Adrián, Aitana, Aurora	3/9
Non-naturalistic	Teleological	-	0/8	-	0/9
	Intentional	Alicia	1/8	-	0/9
	Metaphysical	-	0/8	-	0/9
Group B (N = 14)		Students	f	Students	f
Scientific		-	0/14	Belinda, Benjamin	2/15
Synthetic		Beatriz, Blanca, Belinda, Berta, Brenda, Borja, Balbino, Baltasar, Benedicto, Boris	10/14	-	0/15
Naturalistic	Agentive	Blas, Bernardo, Bruno, Benjamin	4/14	Beatriz, Blanca, Berta, Brenda, Borja, Balbino, Baltasar, Benedicto, Boris, Blas, Bernardo, Bruno, Benjamin	13/15
	Non-agentive	-	0/14	-	0/15
Non-naturalistic	Teleological	-	0/14	-	0/15
	Intentional	-	0/14	-	0/15
	Metaphysical	-	0/14	-	0/15

In the prediction phase, in which the young children were asked what they thought would happen if a lit candle was covered with a glass vessel, most of the participants in group A provided naturalistic explanations that did not involve the intervention of an external agent. The children of preschool age predicted that the candle would explode, melt, or emit light just because it was a lit candle, as we can see in the following excerpt:

Researcher: 'What do you think will happen when the candle is lit, and a glass is placed on top of it?'

Alberto: 'It will melt'.

Researcher: 'Why?'

Alberto: 'Because what is inside melts.'

One girl in group A constructed an intentional non-naturalistic explanation, by attributing characteristics inherent to a human body, such as a heart to the candle.

Researcher: 'Alicia, what do you think is going to happen?'

Alicia: 'The candle is going to turn orange, yellow and red, because then it will come out like a heart.'

Most children in group B made synthetic predictions. Seven children of preschool age mentioned that a condensation process was going to take place on the walls of the glass, but they thought that the substance that was going to be condensed was smoke or droplets that came from the candle. The last fragment of the prediction is inconsistent with the scientific explanation of the phenomenon, given that the substance that is condensed is the water vapour which is released during the combustion of paraffin or wax. As an example, we have included the following excerpt from the transcribed discourse:

Researcher: 'We have a candle, we are going to light it, and then cover it with a glass [...]. You have to think about what is going to happen.'

Beatriz: 'There is condensation on the glass. Because when the droplets are so hot due to the fire, they may also condense [...]. A candle ... a glass that covers it ... and this is what is tarnished [talking as she explains her drawing].'

The other three children whose predictions were ascribed to the synthetic category referred to the fact that the candle would go out, since it was cold inside the glass, as shown in the excerpt below:

Blanca: 'Perhaps the candle that is lit will go out because it (the glass) is very cold.'

Researcher: 'Why will the candle go out?'

Borja: 'Because the cold can extinguish anything.'

From a scientific perspective, the flame is extinguished due to a decrease in the amount of oxygen inside the vessel. However, it is worth mentioning that it was not expected that the young children would make a spontaneous reference to the fact that the candle would go out, and it is important to remember that these children had not received specific prior instruction on combustion.

Four young children's predictions were coded as agentive naturalistic explanations, given that their responses referred to the idea that the candle would set fire to or melt the glass that covered it due to the intervention of an external agent (the fire), as can be observed in the following example:

Blas: 'The candle will burn the glass because the glass is made of iron and the candle will burn it [...]. In a cartoon that I saw, the lava from a mountain fell on some cars, and they put iron and the lava destroyed it.'

Researcher: 'But the vessel that we are going to cover the candle with is made of glass.'

Blas: 'But it can melt too.'

After performing the experiment, all of the children observed how the candle went out. Moreover, sixteen of the children noticed that the glass was tarnished, however their interpretations varied depending on which group they belonged to. In group A, four of the children thought that the glass had become foggy, however they did not provide any further explanations for this, with one child mentioning that the fire had stained the glass. Eleven of the children in group B related mist formation with water vapour, or with drops coming from the flame, or more generically, from the candle. Previous experiences during their schooling, including their participation in a science project about the water cycle, helped this group of children to easily identify water vapour.

In the conclusion phase, when the researcher asked the children why the candle had gone out, six of the children in group A gave agentive naturalistic explanations. Most of them mentioned that the candle had gone out because there was a cloud inside the glass and it was very windy, as indicated in the following example:

Researcher: 'Now can you explain your drawings?'

Alicia: 'There was a cloud inside the glass and it was very windy, and the candle went out.'

Amanda: 'Because it [the glass] has no outlet and there was wind inside, it extinguished the candle.'

In group B, most of the children provided agentive naturalistic explanations. Similar to the prediction phase, five children mentioned that the candle had gone out because of the cold temperature inside the vessel, and two of the children claimed that it was caused by moisture. Six children pointed out that the candle went out because there was air inside the vessel, as indicated in the following example:

Researcher: 'And why did it go out?'

Blas: 'Because there was air inside.'

Researcher: 'And is there no air in here [in the classroom]?'

Bruno: 'Yes, but here [in the classroom] you do not really know where it is because the air moves much more.'

One explanation, which is particularly worth mentioning was given by a girl, Belinda, from group B who explained the phenomenon consistent with the scientific idea that air is required to maintain combustion. She mentioned that the candle had gone out because there was no air entering the vessel. This explanation was triggered by a question asked by the researcher that made her rethink the reason why the candle did not go out when it was uncovered.

Researcher: 'Why does it not go out when I do not cover it? You can see that candles stay lit for a long time when they are not covered.

Belinda: 'Because there was no air coming in.'

During the activity, another child, Benjamin, expressed a similar idea, indicating that the candle had gone out due to the lack of oxygen in the glass. However, due to the influence of his classmates, he replaced this scientific explanation with an agentive naturalistic explanation.

In Table 3, we included the elements of explanation to which students referred in their answers both during the prediction and the conclusion phase. As show in Table 3, some children maintain the same response along the teaching sequence. This happens when there is not a disagreement between the empirical data and the original children's prediction. A sort of cognitive conflict between observations and what children expected to happen favor the development of ideas [18].

Table 3. Elements of explanation to which students referred in their answer during the teaching intervention and frequency of each element of explanation: group A (N = 8) and group B (N = 14).

Categories	Prediction Phase		Conclusion Phase	
	Students	f	Students	f
A condensation process takes place on the walls of the glass.	Beatriz, Berta, Brenda, Baltasar, Benedicto, Boris, Belinda	7/22	-	0/24
The candle explodes.	Amanda	1/22	-	0/24
The candle melts.	Alberto, Adrián, Alexandre, Andrea	4/22	Alberto, Alexandre	2/24
The candle changes color, and a heart comes out.	Alicia	1/22	-	0/24
The candle emits light.	Aitana, Aurora	2/22	-	0/24
The glass burns or melts.	Blas, Bernardo, Bruno, Benjamin	4/22	-	0/24
Stain appears on the glass.	-	0/22	Adrián, Aitana, Aurora	3/24
The candle goes out because of the cold temperature.	Blanca, Borja, Balbino	3/22	Blanca, Borja, Balbino, Berta, Brenda	5/24
The candle goes out because there is air/wind inside the vessel.	-	0/22	Alicia, Amanda, Aurora, Andrea, Blas, Bernardo, Bruno, Benjamin, Benedicto, Boris	10/24
The candle goes out because of the lack of oxygen/air.	-	0/22	Benjamin, Belinda	2/24
The candle goes out because of moisture.	-	0/22	Beatriz, Baltasar	2/24

4. Discussion

Regarding the first research question that aimed to identify the type of explanations used by children when reasoning about combustion, the results revealed that most children tend to give naturalistic explanations in which an incipient understanding of physical causality is evident. However, the characteristics of these explanations were different throughout the experiment. During the prediction phase, the young children's explanations were mainly non-agentive in group A. Seven children in this group indicated that the candle would melt or explode based on the internal properties of the changing object itself. However, the participants' predictions were mainly synthetic in group B, referring most of them to a condensation process on the walls of the glass. During the conclusion phase, children's explanations were predominantly agentive considering both groups. When explaining why the candle went out when it was covered with a glass, most of them included the action by agents such as moisture, air, or the wind. From previous experiences in their daily lives, the children were aware that a candle's flame is often extinguished by blowing on it, therefore their immediate intuition led them to think that the fire was extinguished by the air. Interestingly, no metaphysical or teleological explanations were recorded in either of the two groups. This result differs from that of previous studies on other natural phenomena in which it was determined, for instance, that young children explain the attraction of a paper clip in metaphysical terms, considering the intervention of magical powers [30].

The construction of naturalistic explanations by young children is highly important, given that this demonstrates that they are capable of constructing representations that can be considered as precursor models [5]. In this study, the results showed that most of the children explained the combustion of a candle in naturalistic terms, without restricting their explanations to animism, metaphysics, or teleology. Therefore, it is clear that the children who provide these kinds of explanations are able to construct a precursor model in the domain of matter and its transformations. It even seems that some of the children in group B were already able to construct a precursor model based on previous learning experiences, such as those related to the water cycle. Some of these children were able to associate condensed water with the water vapour that was released during the combustion, and thanks to the observations and the challenging questions posed by the researcher, two of the children were able to explain that the candle went out due to a lack of oxygen.

On the other hand, the results showed that one girl in group A gave an intentional non-naturalistic response during the prediction phase. However, among children who were used to performing inquiry-based activities in which they were asked to interpret everyday phenomena, we do not observe non-naturalistic explanations. Moreover, those children who were used to doing inquiry-based activities gave more sophisticated responses during the prediction phase and some of them are even capable of providing construction explanations that incorporate incipient ideas about science after observing the phenomenon. Interestingly, thanks to the challenging questions posed by the researchers, two children in group B were able to conclude that the candle had gone out due to the lack of air or oxygen. This response was not expected of children in this age group, since previous studies have found that not even primary or secondary students mention the need for oxygen or air for the combustion [45]. Regarding whether experience doing science activities may impact on the young children's construction of explanations, based on the data, it is not clear enough that it has a benefit on the ability to interpret natural phenomena, given that in the conclusion phase (after the teaching intervention), there was no significative difference in the performance of both groups. Most of the young children in group B (13/15) made naturalistic explanations like children in group A (6/9). Further investigation around this topic is necessary. Further, the qualitative nature of this study involving a small sample size does not allow to generalise results and conclusions, but it allows for comparison with other studies of similar nature.

5. Conclusions

The results related to the experiment involving burning a candle inside a glass revealed that young children are able to handle naturalistic explanations, even without prior formal instruction on the topic of matter and its transformations. This finding is relevant for science educators and those entrusted with the task of designing curricula, given that the conceptual fields in which young children are able to provide naturalistic explanations seem to be appropriate for stimulating the development of children's causal reasoning during the preschool years [27]. Moreover, this study confirms that young children are capable of making predictions and reaching simple conclusions based on their observations, even though these may not be scientifically accurate or complete [32]. All of these results can be considered as indicators that young children are able to develop a precursor model of the concept of matter, which enables them to predict and explain different phenomena. This precursor model can be built on and expanded through relevant science activities in which suitable empirical data are provided [5]. Inquiry-based activities that require children to ask questions and provide explanations seem especially appropriate. These activities move away from the explanation-application format in which the information is first given and then applied to solving problems, and which make it difficult to develop models [53].

Our findings also indicate that when children are used to performing inquiry-based activities, it is more likely that they are able to establish relationships with previous experiences in order to explain the observed events. Probably thanks to their participation in activities related to water cycle, most of the participants in group B were able to identify the water vapour released during combustion. These findings reinforce the importance of introducing science activities in early childhood education [3]. However, at this stage of schooling, not all science activities offer the same potential. Science teaching in early childhood education must be organised around the choice of contexts that are familiar to young children, which allow them to think, ask questions, and construct explanations [54]. In addition, it is important to bear in mind that young children's learning is physical and practical rather than conceptual, therefore meaning that they learn by being in contact with their environment [55].

As final considerations, it is worth mentioning again that due to the qualitative nature of this study, which involved a small sample of children, further research must be conducted in order to expand on the existing knowledge about young children's conceptions of matter and its transformations, and also to confirm the hypothesis that they are capable of forming a precursor model in this domain.

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