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Research Article

The Effect of Human Presence on the Representations of Children 4-6 Years Old in the Case of Air Within Vases

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Abstract: A distinctive direction within the framework of Early Childhood Science Education research is the study of young children's mental representations of natural world phenomena and concepts in science. The study of representations offers the possibility of developing activities that address the real difficulties of children and lead to the construction of new representations compatible with school science knowledge. The current research presents a study on the potential effect of the presence of humans on the representations of children aged 4-6 years regarding the case of air within vases. 41 children attending a kindergarten in Patras (Greece) participated in the study. During individual semi-structured interviews, children were presented with 3 different images displaying a vase with people standing next to it in different settings and were asked to indicate whether there is air in the vase and whether this is related to that people. The results showed that the presence of air in the containers was best identified in the outdoor environment, while few children attributed the air to human presence, especially when the vases were placed indoors. Based on the frequency table, it seems that regarding the outdoor environment, there are more adequate responses, as the presence of human elements influences less the participants, while in indoor settings there are more intermediate and inadequate responses, suggesting that the presence of the human element has a greater impact in participant's responses.

***Keywords*:** science education, mental representations, air, preschool children

1. Introduction

The study of the formation of mental representations in students' thinking about the phenomena of the natural world and the concepts of Natural Sciences, constitutes a research area of both the field of psychology that focuses on learning and the field of Science Education which tries to exploit mental representations in the design of effective teaching interventions. In the last decades, research in these two fields has also turned towards students in early childhood education, since at these ages children's representations are supposed to have a significant impact on their ability to approach phenomena and to form early but stable patterns of understanding the natural world.

Along this perspective, the recording, classification and explanation of the representations of 3-8-year-old children in a number of fields in learning and teaching science such as visual phenomena (Günşen & Gök Çolak, 2024; Öcal et al., 2021; Pantidos et al., 2017; Ravanis et al., 2005), thermal phenomena (Amorín de Abreu et al., 2022; Cruz-Guzmán et al., 2017; Ioannou et al., 2023; Jelinek, 2022; Kaliampos & Ravanis, 2019; Kampeza & Delserieys Pedregosa, 2024),

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electricity (Calo Mosquera et al., 2021; Gavrilas et al., 2024; Kalogiannakis & Lantzaki, 2012; Pantidos & Kaliampos, 2023) or elementary astronomy (Hu et al., 2021; Jelinek, 2024; Kampeza & Ravanis, 2012; Raviv & Dadon, 2021) has highlighted the difficulties, barriers and potential possibilities of children approaching the natural world in ways compatible with those of school scientific knowledge (Al Jadidi et al., 2022; Chachlioutaki & Pantidos, 2024; Ravanis, 2020). The data of these studies, which were conducted in the context of Early Childhood Science Education, are consistent with those conducted in the psychological research domain which studies the development of children's scientific thinking at an early age (Christodoulakis & Adbo, 2024; Kuhn, 2011; Zimmerman, 2005). These studies have highlighted the difficulties in the construction of knowledge and skills due to the prelogical nature of children's thinking.

A topic of particular interest is the representations that young children form in their thinking about air, as it is a physical entity with very limited perceptual properties that appears in a series of everyday phenomena in different ways, whether the focus is on its presence as an entity in space or on the effects it has in its interaction with the objects it encounters (Ravanis, 2021; Siry et al., 2023). The current study poses a specific research theme regarding the effect of human presence on the representations of children 4-6 years old in the case of air within vases.

2. Literature review

Research that deals with the way that air is approached by children in early childhood education, that is 3-8 years old, is very limited. This research mainly moves along two directions: on the one hand, lie those studies where young children's mental representations of air as an entity or of phenomena related to air are sought and recorded, and on the other hand, lie those that aim at trying to transform children's representations into new representations that are compatible with school scientific knowledge.

Along the first direction, Rochovská's (2015) research attempted to assess mental representations of 5-6-year-old children about nature and the basic properties of both air and air pressure as well as wind. The data of this research highlighted the difficulties that young children face while at the same time enabled the formulation of ideas for relevant teaching interventions. In research by Kornelaki (2023), representations of 6-8-year-old students about air were also studied. The results showed that the representations of children of this age have a prelogical character. However, in the study were recorded specific dimensions of children's thinking which indicate that with appropriate teaching interventions they could be led to the cognitive construction of precursor models. Furthermore, Kontili et al. (2023a) investigated whether 5-6-year-old children detect air in the indoor and outdoor spaces of houses. Here it emerged that children could better detect air in 'open' rather than in enclosed spaces, as they tended to link the existence of air to openings (doors, windows, etc.) to the outside.

Along the second direction, Borghi et al. (1998) having found that 6-8-year-old students did not treat air as a discrete material entity, designed a series of experimental activities based on the processing of everyday air-related situations. The results showed that children's participation in this teaching intervention led to the formation of mental representations in which air seems to be understood as a material entity. The possibility of forming precursors models regarding air in young children's mind that was invoked by Kornelaki (2023) was also tested by Lorenzo Flores et al. (2018) and Sesto Varela et al. (2022) who worked with 3-5-year-old children. Using a teaching approach known in the literature as Predict-Observe-Explain, children, while not recognizing air as an entity, began to expose higher level reasonings in which the existence of air dominated. Using the same teaching approach, Liang (2011) designed and implemented activities for 6-year-old children on the existence, motion, and weight of air. The design anticipated conflicts between predictions and experimental data, resulting in some children identifying air in space. Specifically, in the study of Liang (2011), it was apparent that children aged 6 years old were able to abandon their pre-existing views and identify the presence of air throughout the environment after the implementation of an appropriate educational intervention. Van Hook et al. (2005) studied the effectiveness of certain hands-on, inquiry-based science activities in the construction of mental models of kindergarten students regarding the concept of air. These activities mainly focused on the assumption that air is made up of particles ('air balls') and that it occupies space. During the activities it became apparent that several children were able to make more sophisticated arguments about air phenomena, often using the 'air balls' model in their explanations of various phenomena. The research of Mazas et al. (2018) followed the same orientation with similar results. Indeed, in this study an attempt was made, through specific activities, to help children

construct models of the concept of air as they observed and explained properties and characteristics of the environment. The results confirmed that even from these early educational stages it is possible for children to work on science ideas as soon as they have constructed in their minds initial models. It becomes evident therefore that through the introduction of construction models and the development of science skills, pre-school students are able to connect their ideas about the scientific world with those they will study later in primary and secondary education.

A particular area of research is the identification of the presence of air in vases, that is in strictly confined spaces. A study by Kontili et al. (2023b), attempted to study the mental representations of 4-6-year-old children about the presence of air in closed or open containers in outdoor or indoor spaces. The results of this study showed that children have difficulties in identifying the air inside the vessels and this difficulty becomes even greater when these vessels are depicted closed within indoor spaces.

In this perspective, the question of whether human presence affects children's representations was studied as human breathing could confuse the way children approach air as an entity. Thus, in the current study, an attempt was made to explore the effect of human presence on the representations of children 4-6 years old in the case of air within vases. In particular, the main research question was whether children identify the existence of air in vases regardless of the human presence in the space around the vases or the external characteristics of those humans such as whether they wear a mask or not.

3. Methodology

3.1 *The sample*

The sample of the study consisted of 41 students (26 aged 4-5 years and 15 aged 5-6 years) from a kindergarten in the region of Patras (Greece). The children voluntarily participated in the research by agreeing to 'play' a game on the computer screen with the researcher. The written consent of the children's parents was requested for the research and the researchers obtained the permission of the ethics committee of the Department of Educational Sciences and Early Childhood Education of the University of Patras. No air-related activities had been carried out in the children's classrooms.

3.2 *The procedure*

The research was qualitative in nature and the data collection was done through semi-directed individual interviews of about 10 minutes, which took place in a specially designed area of the school. Each child was asked to participate in three different tasks designed to study how children approach the existence of air in open vases when it is apparent the presence of the human factor, either indoors or in an open environment. Through the interview process the common terminology was used by the researcher while each child was encouraged to freely express his/her views. In some cases, the researcher tried through specific questions to elicit students' mental representations regarding the effect of human presence in the case of air within vases. All three tasks were based on three digital images that children were asked to comment on. Digital images were used in the current study as these kinds of images seem to have benefits in the way tasks are perceived by children (Blumberg et al., 2024). The discussions with the children were recorded and transcribed in order to use this material in the analysis and interpretation of the data, while at the same time children's non-verbal behaviours were recorded using a special protocol.

3.3 *Instrument*

The instrument used in the current study was divided into three tasks. Particularly, in the first task, participants were shown Figure 1a which depicts two children within a room with an open window, one of them wearing a mask as he holds the open vase, while the other without a mask, holding the lid of the vase (Figure 1a). Children were asked to tell us if there was air in the vase. In the second task participants were shown Figure 1b, which depicts the same room, with the difference that the window is closed. Here a child wearing a mask is holding an open vase while another child without a mask is standing next to him (Figure 1b). Children were asked to tell us if there was air in the vase. Finally, in the third task participants were shown Figure 1c, which depicts the two children with an open vase, but this time the

environment totally changes as they are placed in a typical outdoor open space. Here, a child wearing a mask is holding an open vase while another child without a mask is standing next to him (Figure 1c). Children were asked to tell us if there was air in the container.

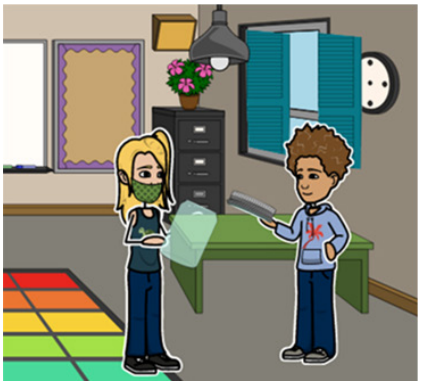

Figure 1(a)

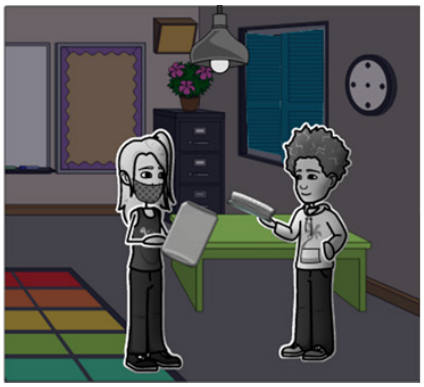

Figure 1(b)

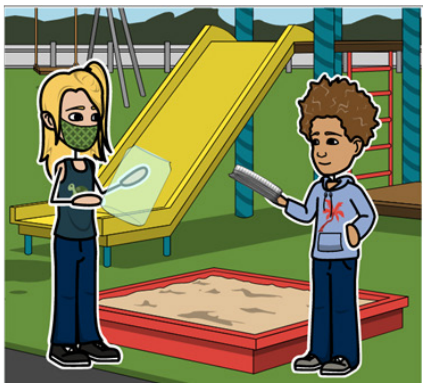

Figure 1(c)

Figure 1. The digital virtual material used in the 3 tasks

3.4 *Analysis of data*

The data of the study was qualitative in nature and was examined using the methodology of content analysis. The children's responses and the dialogues with the researchers in each task were classified into categories corresponding to different types of mental representations. Children's responses to each task were compared with the characteristics of the school scientific knowledge, in a macroscopic approach, which predicts that air is continuous, homogeneous, evenly distributed inside and outside enclosed spaces while the presence of air is not affected in any way by the presence of people. The content analysis was thematic in nature and children's phrases or dialogue excerpts during the interviews were used to characterize the answers. In general, the analysis categories were based on the assessment of the deviation of children's representations from the school scientific model. Thus, children's responses were classified into the following three categories:

(1) In the first category were classified those responses that were 'adequate' in terms of school knowledge. That is, they recognized the existence of air in the vases without limitations related to other factors, such as the presence of people or the arrangement of objects in the room.

(2) In the second category were classified 'intermediate' responses that were influenced by parameters such as the position of the vase in the room or open or closed windows, without attaching importance to the presence of people though.

(3) In the third category were classified 'insufficient' responses in terms of school knowledge where the existence of air was attributed to humans' presence in space.

4. Results

In this results section categories of responses along with typical examples of children's speech and/or dialogue are presented. Here children's responses classified into three categories namely sufficient, intermediate and insufficient are presented for each task. In addition, a summary Table of children's responses to Tasks 1, 2, 3 is given (see Table 1).

Table 1. Frequencies of children's responses to Tasks 1, 2, 3

		Children aged 4-5 years	Children aged 5-6 years
Task 1	Sufficient	2 (7.7%)	1 (6.7%)
	Intermediate	20 (76.9%)	11 (73.3%)
	Insufficient	4 (15.4%)	3 (20%)
	Total	26	15
Task 2	Sufficient	0 (0%)	0 (0%)
	Intermediate	21 (80.8%)	9 (60%)
	Insufficient	5 (19.2%)	6 (40%)
	Total	26	15
Task 3	Sufficient	14 (53.8%)	8 (53.4%)
	Intermediate	8 (30.8%)	5 (33.3%)
	Insufficient	4 (15.4%)	2 (13.3%)
	Total	26	15

Task 1-open window. Here children's responses were classified into three categories.

Sufficient responses. Corresponds to those responses in which children recognized the existence of air in the open vase without mentioning any other conditions related to the space or the presence of people. For example:

Researcher (R): In this picture you can see a classroom with the window open and two children inside. One child is wearing a mask and holding the vase, while the other has the lid in his hands. Now that the children are in the classroom, is there air in the vase?

Student 1 (S1): Yes (pointing all over the place).

R: Why, what do you think so?

S1: Yes, look between his hair and her hair and… look here… (points with his hand to places where he recognizes the air like in the boy's hair, in the girl's hair, in the room in general and finally in the vase).

R: If the vase was on the table away from the children, would it still have air in it?

S1: Yes, it would have… here and here and here all over (pointing to the space) and on their shirts.

This response was categorized in this way since it appeared that the participant had understood the existence of air in the whole surrounding space, as indicated by his body movements. In particular, the child pointed to the whole image even to points outside the researcher's reference, beyond the jar, such as the shirt or the hair of the subject depicted, referring to the existence of air independently of the presence of the human element.

Intermediate responses. Corresponds to those responses in which children stated that the existence of air in the vase was influenced by external factors, such as its position in the room, without making any correlation with the human presence though. For example:

R: In this picture you can see a classroom with the window open and two children inside. One child is wearing a mask and holding the vase, while the other has the lid in his hands. Now that the children are in the classroom, is there air in the vase?

S3: Yes.

R: Why, what do you think so?

S3: Because is the window open…

R: If the vase was on the table away from the children, would it still have air in it?

S3: If… if it was open (the window)?

R: Yes.

S3: Then yes.

R: If the vase was held by the child who is not wearing the mask would something in the vase change? Would it still have air in it?

S3: Yes, it would have air.

R: So, is there any effect on the children that are in the classroom?

S3: No.

R: In this picture you can see a classroom with the window open and two children inside. One child is wearing a mask and holding the vase, while the other has the lid in his hands. Now that the children are in the classroom, is there air in the vase?

S24: No.

R: Why, what do you think so?

S24: Because it's open and (the air) is coming out.

R: If the vase was held by the child who is not wearing the mask, would there be air in the vase?

S24: Yes.

R: Why?

S24: Since air comes from here (from the window) … look… if the vase was held by the little boy then air would come in this way since the little girl does not stand near to the window.

These answers are a prominent example of the category of intermediate answers as here seems that the existence of air is not influenced by the existence of the human element but is influenced by the external factor of the open window. Particularly, the window here acts as an intermediate for transferring air from the external to the internal environment which is depicted in the image.

Insufficient responses. Corresponds to those responses in which children considered the existence or absence of air from the vase to be related to human presence. For example:

R: If the vase was held by the child who is not wearing the mask, would there be air in it?

S15: It would have air.

R: Why?

S15: Because he can take breaths and put the air in it.

R: That's an interesting thought. How about the other child, can she put air in it (vase)?

S15: No.

R: Why?

S15. Because she is wearing a mask.

R: So, if that child (without the mask) was holding the vase away from the window, would there still be air in the vase?

S15: Yes.

This response was categorized as inadequate since the participant seems to believe that the existence of air in the jar is affected by the person holding the jar. That is, the person wearing the mask was supposed to be unable to transfer the air through the biological function of breathing into the jar due to the barrier, as opposed to the child not wearing the mask.

Task 2. Task 2-closed window This task did not record sufficient responses, that is responses in which the existence of air in both the space and the vase is not influenced either by the environmental conditions nor by any kind of relation to human presence and actions. Thus, here children's responses were classified into two categories.

Intermediate responses. Corresponds to those responses in which children correlated the presence or absence of air in the depicted vase with external factors, such as its position in the room or whether the container is open or closed, without making any correlation with the human presence though. For example:

R: Now that the children are in the room, is there air in the vase?

S5: Yes (shakes his head affirmatively).

R: Why, what do you think so?

S5: Because the air enters through the holes of the window and the vase is open without lid.

R: If the vase was on the table away from the children, would it still have air in it?

S5: Yes.

R: If the vase was held by the child who is not wearing the mask, would there be air in it?

S5: Yes, it would have.

R: Is there anything the children can do in order to keep the air out of the vase?

S5: Yes… they can close the lid.

The interviewee here focuses on the general presence of air in space, which is solely influenced by the existence of external factors, such as the closed window and the fact that it leads to the outside space, from where through some 'facilities' such as tiny invisible holes in the window, air is allowed to enter the closed room and fill the jar with air. In addition, it is stressed that children cannot influence the nature of air through means such as breathing, they can do it through the use of external elements such as the lid of the jar.

Insufficient responses. Corresponds to those responses in which children pointed out that the existence or absence of air from the vase was related to human presence. For example:

R: If they blew into the vase would there be air in the vase? How about the little girl wearing the mask, if she blew would there be air in the vase?

S10: No.

R: Why?

S10: Because she is wearing the mask.

R: How about the case that the children blew while the vase was far away, for example they put the vase here on the table and blew from the carpet, would there be air in the vase?

S10: No.

…

R: So, tell me, where should the vase be and where should the children be in order to have air (the vase)?

S10: The vase should be on the table and the children should blow in the direction of the vase in order to get some air in it.

R: If the vase was held by the child who is not wearing the mask, would there be air in it?

S32: Yes, because it would come out (air) from his mouth.

R: How about the little girl that is wearing the mask, can she get air out of her mouth?

S32: No, she can't.

R: Why she can't?

S32: Because she's wearing the mask and can't get air out of her mouth.

The responses presented here were categorized as inadequately, as the first one referred to the fact that the mask prevents the child from 'creating' air and transferring it into the jar, emphasizing that both children would have to blow over the open mouth of the jar in order to get air inside. Along this line, the second response similarly focused on the inability of the child wearing the mask to 'create' air as he has this depicted obstacle in front of his mouth.

Task 3. Task 3-outdoor setting In this task children's responses were classified into three categories.

Sufficient responses. Corresponds to those responses in which children recognized the existence of air in the open vase regardless any other condition related to human presence and actions. For example:

S13: Yes, over here… and here… and everywhere (shows the swings, the slide and the whole image).

R: Even if the vase was under the slide?

S13: Yes.

…

R: What if the vase wasn't being held by either child?

S13: It would still have air.

R: Is there anything you could change on the children in order to leave the vase without air?

S13: No, nothing.

In this interview it is evident that the participant had understood the existence of air in the open jar and in the wider outdoor environment, without its existence being affected by the human element. Specifically, he stressed that the air is localized throughout the image, while pointing to the entire surface with his hand, and argued that any kind of alteration to the depicted children would not have any impact to air.

Intermediate responses. Corresponds to those responses in which children correlated the presence or absence of air

in the depicted vase with external factors, such as its location in the outdoor space, without making any correlation with the human presence though. For example:

R: Here, in the outdoor space, where does air exist? Could you show me?

S28: Here, here, here… and here… and here… everywhere! (points to the whole image with his hand as he repeats the same word).

R: If the vase was held by the child who is not wearing the mask, would there be air in it?

S28: Yes.

R: Why, what do you think so?

S28: Because there are different seasons… sometimes is cold and sometimes is hot.

R: If it were summer, would there be air in the outdoor space?

S28: No.

R: Why?

S28: Because the air is too cold.

Insufficient responses. Corresponds to those responses in which children associated the existence or absence of air from the vase with other external factors, such as the shape of the vase and the presence of people. For example:

R: If the vase was held by the child who is not wearing the mask, would there be air in it?

S15: Yes, then there would be more air in it (vase).

R: Why there would be more air in it?

S15: Because he's not wearing a mask and he's breathing… so he is blowing, and the vase is filled by air.

This response was categorized in this way as it was not simply referred to the existence of air but to the 'more' amount of air in the jar when this was help by the child who was not wearing a mask. Thus, indicating the influence of the human factor even in the external environment.

R: If the vase was held by the child who is not wearing the mask, would there be air in it?

S17: Yes, there would be air in it.

R: Why there would be air in it?

S17: Because he is not wearing a mask.

R: So, what happens now that he's sitting outside without wearing a mask? How does the vase fill with air? What is happening?

S17: Phhhfffff (makes the sound with his mouth to show that the child is breathing).

R: So, he is breathing… Phhhfffff… and the air comes from above. Why does this not happen in the case of the little girl?

S17: Because she is wearing a mask.

R: And what does the mask do?

S17: It cannot be filled.

R: What's the little girl got to do with it?

S17: Because she is wearing a mask, and the air cannot get in (the vase).

This response was placed under this category since the participant emphasized the role of breathing of the depicted child who is not wearing a mask and the way his breathing helps to fill the vase with air as opposed to his reference to the child wearing a mask, where the biological process of breathing cannot produce a similar effect since there is the obstacle in front of his face. Thus, revealed the interviewee's inadequate way of thinking about the existence of air inside the open jar outdoors, regardless of the existence of the human factor.

5. Discussion and conclusions

The aim of the current study was to explore the mental representations of 4-6-year-old children regarding the possible influence of human presence on the existence of air in vases. The analysis of the data showed that, in the majority of cases, young children did not attribute the existence of air to humans' presence. However, a number of children, ranging from 1/5 to 1/3 children in all three tasks, expressed reasoning that incorporated the influence of human breathing on the existence of air either in the bottle or in the environment. The emergence of such a

representation was most evident in the second task, where due to the displayed closed door, a large proportion of children of this age held the view that there is no air in the room. Indeed, due to this general belief, the representation of air creation by the breath of the people shown in Figure 1(b) was given the opportunity to manifest. This is probably the reason why in task 2, 5/26 children in the 4-5-year-old age group and 6/15 children in the 5-6-year-old age group gave such responses. A strong element of this finding is that the above-mentioned children's representation is linked to people's breathing since they think that the existence or not of the mask does or does not block the air respectively.

Therefore, a representation that recognizes humans as active creators of air, in conditions of real and not virtual experimentation, acts as a serious obstacle in the efforts of children within early childhood education to conceptualize air through specific teaching activities. This finding is consistent with findings of previous literature which highlight the barriers of young children's in conceptualizing the notion of air (Borghi et al., 1998; Liang, 2011; Mazas et al., 2018).

Of particular interest is the disparity between the very low number of children's responses on the category sufficient in the first two tasks and the high number of those in the third task. It seems that the image displaying an outdoor space facilitates the recognition of air in the environment without restrictions arising from the presence and organization of objects. This finding has already been identified in the literature (Kontili et al., 2023a, b).

In addition, of particular interest are children's responses that were classified as intermediate, since distinct difficulties were identified in recognizing the presence of air, such as its association with objects and their arrangement (open or closed doors and windows, open or covered containers, etc.).

The results of the current research showed no statistically significant differences among the two age groups of children. However, the study of the data overall indicated that at 4-6 years age group, some children tended to associate the presence of air in vases as well as the presence of air in indoor and outdoor spaces with human breathing. This mental representation acts as a significant cognitive barrier as air is not recognized as an entity of the physical environment independent of the presence of humans, but as a product of the human body. These findings are consistent with those in the related literature (Liang, 2011), where it appears that young children tend to detect the absence or presence of air with their senses, providing anthropomorphic explanations by arguing that living organisms 'carry' air inside them which can expel through the process of breathing. Recognizing such a natural function, they are therefore led to the idea that this air can be confined by physical barriers such as a mask or trapped inside a closed vase.

As a consequence, air is not attributed the properties of an autonomous entity that interacts with other natural or artificial agents and therefore an important field of didactic intervention emerges here. Indeed, based on the findings of the current study, the need to develop activities that aim to transition the thinking of early childhood education children to mental representations compatible with school scientific knowledge becomes evident.

The findings of the current study can be used in teaching contexts, where preschool teachers wish to formulate and introduce in their educational programme activities that have air as a central theme through the perspective of natural sciences. There are different teaching pathways and factors that can influence the formal or informal school environment, which in recent decades have formed a distinct field of research and application known as Science Education in Early Childhood. Along with this view, the current study can act as a guide within science curriculum in order to support curricular educational programmes and activities that have air as their main thematic core. In this perspective, there are different teaching pathways and factors that can influence formal or informal school environments, which in the last decades constitute a broad area of research and application known as Early Childhood Science Education. Along this context, research on the conceptualization of air needs to be developed in greater depth and extended to different fields such as the interactions of moving air with objects lying in the environment.

Undoubtedly, our findings are limited, as they are part of a broader spectrum whose mapping needs to be completed. Looking at the data and following the line of work, it is important to note that it is necessary to combine the qualitative nature of this study with quantitative data in order to add value to the findings. In addition, in some particular questions the wording of the questions used by the researcher may have had a biased impact in the interviewee (i.e. 'If the vase was held by the child who is not wearing the mask, would there be air in the vase?'). Therefore, a depuration of these questions should be done in case to replicate the situation of this study.

Conflict of interest

The authors declare no competing financial interest.

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