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► To cite this version:

Alice Delserieys, Maria-Antonietta Impedovo, Glykeria Fragkiadaki, Maria Kampeza. Using drawings to explore preschool children's ideas about shadow formation. Review of science, mathematics and ICT education, 2016. hal-01794664

HAL Id: hal-01794664

<https://amu.hal.science/hal-01794664>

Submitted on 22 May 2018

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Using drawings to explore preschool children's ideas about shadow formation

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ABSTRACT

This paper aims at exploring children's ideas concerning shadow formation as they are expressed through their drawings. A qualitative research approach was adopted using two sets of data (89 drawings in total) collected over a period of 6 months in two kindergartens, one in France and a second in Greece. The drawings in each group were realised using similar instructions defined jointly by the team of researchers. The indicators that were used to analyse the drawings can be aggregated in four categories: presence of the three entities needed to represent the phenomenon of shadow formation, shadow characteristics, alignment, and nature of light. Results are presented not with the intention of comparison of the two groups, but with the disposition of highlighting the diversity of categories that emerged. Findings and educational implications for science at kindergartens are thoroughly discussed.

KEYWORDS

Physics learning, preschool, formation of the shadows, early science education, drawings

RÉSUMÉ

Cet article vise à explorer les idées des enfants concernant la formation des ombres telles qu'elles s'expriment dans leurs dessins. Une approche qualitative a été adoptée. Celle-ci s'appuie sur deux séries de données (89 dessins au total), recueillis pendant une période de 6 mois dans deux écoles maternelles en France et en Grèce. Dans chaque groupe, les dessins ont été réalisés sur la base de consignes similaires, définies conjointement par l'équipe de chercheurs. Les indicateurs utilisés pour analyser les dessins peuvent être regroupés en quatre catégories: présence des trois éléments nécessaires à la représentation du phénomène de formation des ombres, caractéristiques de l'ombre, alignement, et nature de la lumière. Il ne s'agit pas, ici, de comparer les deux groupes, mais de mettre en évidence la diversité des catégories émergeant de l'analyse des dessins. Les implications en matière d'éducation scientifique à l'école maternelle sont discutées.

MOTS-CLÉS

Apprentissage de la physique, école maternelle, formation des ombres, éducation scientifique précoce, dessins

THEORETICAL FRAMEWORK

Introduction

The way in which young children's thinking approaches the natural world is a central topic in the field of Science Education (Fleer & March, 2009; Ergazaki, Saltapida & Zogza, 2010; Boilevin, 2013). Using cognitive, psychological or epistemological perspectives, research in early childhood science education highlights significant results on how young children approach concepts and phenomena from the natural world and how they develop their scientific thinking and understanding. However, the selection and use of the appropriate methodological tools in order to get a deep access and capture the dynamic of young children's thought are crucial research issues which are systematically raised. In this paper we are interested in exploring children's drawings related to the understanding of the scientific concept of shadow formation.

Children's drawing activity

Most of the children enjoy drawing, especially during their early years and they usually do it to serve different purposes in various everyday activities at home and at school. Children's drawing activity is considered as one of the "hundred languages" children use to express themselves and communicate with others about the way they perceive the world around them (Edwards, Gandini & Forman, 1993). Especially very young children often struggle to communicate efficiently through verbal language and drawing helps them over-

come such restrictions in communication. However, some parents and educators consider drawing activity mostly as a prewriting activity that reinforces the development of fine motor skills or as an artistic activity, a way of individual expression where children's drawings are assessed on their visual realism or aesthetic merit, and not on the purposes they serve (Frisch, 2006; Wood & Hall, 2011; Papandreou, 2014). Some argue that children's construction of realistic pictures serves for evaluating their development on the basis of specific developmental stages (Matthews, 2003). On the other hand, research has shown that the connection between a symbol and meaning making is an important factor of mental activity and it can take place in early years (Knight, 2008). "The focus is on understanding the more complex purposes that drawing fulfils for young children, as an intrinsically valuable form of abstraction and communication, as a social practice, and as a symbolic means of bridging home and school contexts" (Wood & Hall, 2011, p. 270). Drawing activity is open-ended and enables the relation between symbols and meanings. "As children gradually discover graphic formulas and patterns that serve their specific intentions and as soon as they realize that these graphic symbols are accepted by the others, they consider them suitable for using again and again in various drawing, thus creating their own semiotic code and acknowledging the power of drawing activity as a means of communication" (Papandreou, 2014, p. 88). Young children frequently use oral speech when they draw and they talk about their drawing; they provide explanations or narrate a story (Van Oers, 1997). In any case, it is necessary to ask children to explain their drawing because the drawing might mean something different to a child than to an adult (Chang, 2012).

In the field of Early Science Education children's drawing activity is frequently used as a mean for eliciting children's ideas combined to individual interviews (Kampeza & Ravanis, 2012). There is a close relationship of drawing with thinking since the construction of meanings, through graphic symbols, is a mental activity as well as drawing supports and develops the thinking process. "A drawing activity can serve as a means for recalling and expressing previous experiences and knowledge, elaborating new information, and organizing all the above" (Papandreou, 2014, p. 93). Therefore, drawing is not only an enjoyable activity for the children but reinforces the development of individual skills (e.g. observation) and understanding as well as the learning process (e.g. facilitate the generation of questions by the children) (Hayes, Symington & Martin, 1994). Chang (2005, p. 104) underlines the fact that using drawings during different phases of an inquiry can help children "revisit their learning and rethink what has been addressed". In addition, with the aid of drawings, educators can keep track of children's ideas and therefore they are able to reshape and adjust curriculum plans and teaching strategies. In another study, Chang (2012) argues that drawing activity function as a tool in facilitating children's learning and in different teaching situations such as assessment, communication, boosting confidence or integrating curriculum. Therefore, it is important to recognize the use of drawings as well as its function as a learning tool.

Understanding and drawing the phenomenon of shadow formation at preschool

Previous researches have highlighted children's difficulties to understand the phenomenon of shadow formation (Ravanis, 1996; Parker, 2006). In particular, they stress the difficulty to recognize the role played by light in the process of shadow formation, and to identify non-transparent objects as an obstacle to a light beam. It is particularly expressed by young children in a difficulty to define the position of a shadow with respect to its corresponding object and a light source (Ravanis, 1996). Moreover, young children might see the shadow as an autonomous entity, with colours and features reminding the corresponding object (Gallegos-Cázares, Flores-Camacho & Calderón-Canales, 2009).

Considering the importance of a multi-modal communication for learning science in preschool, different types of artefacts and languages can be used to support children's understanding of shadow formation (Kress, Jewitt, Ogborn & Tsatsarelis, 2001; Herakleioti & Pantidos, 2016). To study the understanding of scientific phenomena such as shadow formation in the context of pre-school, children interviews are often used (Ravanis, 1996; Delserieys, Jégou & Givry, 2014). We have seen that drawing can have potential to allow children to express scientific thoughts. Fleer (1996) supported that after a suitably planned teaching intervention, preschool children are in a position to discuss the concept of light and to refer to light sources and objects that were used in teaching. Upon studying their drawings, a certain progress in children thinking is established, although it is also noted that they have not fully understood the nature of light. In that sense, asking children to draw the phenomena of shadow formation represents a challenge linked to the intrinsic nature of the phenomena. The formation of shadows is explained by a topological relationship between 3 entities: a light source, an object and a projection plane. The shadow itself is to be understood as an "anti-image", or the geometrical blocking of ray of light (Feher & Rice, 1988). In order to work with young children, the approach of the phenomenon can be described identifying a dark area of similar shape to the blocking object with no other details than its outline. This has been previously expressed under the idea of "precursor model" where shadow is seen as light being blocked by an object (Ravanis, 1996; Delserieys, Jégou & Givry, 2014). An important presupposition is the understanding by children of light as an independent entity that enable children "to understand the process of the notion of a straight path of light" (Ravanis & Boilevin, 2009, p. 183). The drawing of a shadow therefore pushes children toward an abstract form of representation and modelling of a scientific phenomenon.

In the present research, the aim is to feature the potentials of drawing as a medium used by children in order to express scientific ideas about shadow formation and also as an analytical tool for children's scientific thought. Considering the difficulties for preschool children to explain the phenomena of shadow formation, and the complexity to

collect and construe young children's ideas, drawings were used in order to communicate ideas and criteria of analyses of children's drawings of shadow formation were proposed. The research question is the following: what are children's ideas concerning shadow formation as they are expressed through their drawings?

METHODOLOGICAL FRAMEWORK

Research design

A qualitative research approach was adopted; categories derived from empirical data. The research used two sets of data collected over a period of 6 months in two kindergartens: drawings from a first group of preschool children in France, and from a second group of children in Greece. The context in which the drawings were realised was part of a larger project concerning children's understanding of the formation of shadow. In this project, similar series of activities were designed jointly by a team of researchers and implemented in France and in Greece. They consisted in: 1) production of a drawing 1, 2) interactive reading of a children's story, 3) production of a drawing 2, 4) experimental manipulation, 5) group discussions, and 6) production of a drawing 3. For the purpose of this paper, we used drawing 1 and drawing 3 because they were realised using similar instructions where children drew individually on a blank sheet of paper. In this communication, the focus is made on the drawings themselves, the diversity of representations used by young children, and the possibility for educators to use these drawings to identify children's ideas about the phenomena of shadow formation. As a result, the nature of the teaching activities and their effectiveness concerning the construction of a scientific representation of shadow formation in children's thinking will not be addressed.

To encourage the children to produce the drawings during the teaching activity, the teachers always gave the same instructions: "Draw yourself with your shadow and everything needed to have that shadow". The children were then invited to explain their drawing to the teacher. In this phase, each child was invited by the teacher to verbalize what he/she had drawn with open questions, "What is this?"; "What did you think in order to draw this?"; "Why did you draw this?". Children's expression was written on each drawing by the teacher.

Sample

The research was organized in two public kindergartens. One situated in an urban area of a big city in France, in a multi-cultural context and medium-low social conditions. The other is situated in an urban area of Western Greece. The two teachers involved were experienced teachers with more than 10 years of teaching experience, also involved in teacher education in France, and with good knowledge of research education in Greece.

The children participating in the study were from two age groups: the younger children were 4 to 5 years old and the older children were 5 to 6 years old. In both schools, the children are used to cohabit in the same class and sometimes do similar activities. In total, the corpus data consists in 48 drawings in France (29 from the younger children and 19 from the older children) and 41 drawings in Greece (9 from the younger children and 32 from the older children).

Data analyses

To analyze the drawings, some indicators were identified prior to the analyses from the scientific characteristics of a shadow, and the main difficulties in children's understanding of shadow phenomena found in the literature. An iterative process was used to adapt these main indicators along the analyses of each set of drawings independently, and along exchanges regarding both sets of drawings. The indicators can be classified in 4 categories:

- Presence of the 3 entities in a shadow formation: light – object – shadow: There is evidence of the 3 entities in the drawing; if not, light is omitted; or shadow is omitted; or object is omitted.
- Shadow characteristics: (1) the shape of the shadow is similar to the shape of the object; (2) the shadow is represented as dark or black area, (3) it has with no details other than its outline.
- Alignment: (1) when the 3 elements are present, there is a rough alignment of light – object – shadow; (2) the shadow seems projected on the floor (shadow reversed compared to the object) or on a wall beside (shadow beside the object).
- Nature of light: (1) Natural or artificial; (2) light represented as an independent entity.

The drawings were classified by two researchers for each set of data.

RESULTS

In table 1, the categories that emerged from the analyses of drawings are presented as well as the frequency of occurrence of the different characteristics identified in the drawings. The results from both groups of children for each age range are presented. The objective was not to compare the two groups, but to highlight the diversity of categories that emerged from combining two sets of data, and the ideas expressed by 4-6 years old children about shadow formation.

TABLE 1*Categories and frequency of drawings for each characteristic identify for the French corpus of drawings*

		French data		Greek data	
Categories		Younger children 29 drawings	Older children 19 drawings	Younger children 9 drawings	Older children 32 drawings
Presence of drawing elements	Light and object and shadow are represented	14	14	5	27
	Light is missing	10	4	4	5
	Shadow is missing	2	0	2	0
	Unrelated drawing	3	1	0	0
Oral comment absent on drawing	Role of light mentioned	3	1	0	0
Shadow characteristics	The shape of the shadow matches the shape of the object	18	17	6	30
	Shadow represented as a dark area	6	9	5	24
	Shadow with light colors	6	0	1	7
	Shadow with dark colors	0	0	4	17
	Shadow is outlined and empty inside	12	5	4	8
	Shadow includes unnecessary details (eyes, mouth, etc)	9	4	0	7
Alignment	Rough vertical alignment	1	3	0	0
	Rough horizontal alignment	9	10	2	19
	Projection on the floor	3	5	0	4
	Shadow behind	2	0	3	0
	Light on top and middle	3	0	1	4
	Shadow between object and light	8	2	0	1
Nature of light	Natural	14	12	2	15
	Artificial	1	2	3	12
	Both	0	0	1	0
	Ray of light modelised	0	1	0	7

In general, the results obtained following the analyses of the French and the Greek sample drawings showed a good engagement in the drawing activity and a majority of children, and in particular, older children were able to depict and describe the formation of shadow through their drawings. For only four children in France, the task itself represented a challenge and they drew something that was not related to shadow formation (geometrical figures, a house and flowers, etc).

The first categories concern the presence of the three elements needed to explain the phenomena of shadow formation. The majority of children, in particular older children, represented all the necessary elements for the formation of shadows in their drawings. For younger children, and in particular in the French data where there is a larger number of younger children, some elements are missing in the drawings. It is interesting to note that it is often the light source needed to cast the shadow that children do not represent. However, in some cases in the French data, the children mentioned the role of light orally but did not feel the need to draw it. In figure 1a, for example, the child commented her drawing saying that *“there was the sun that was coming through me and on the floor you can see a shadow”*, or another expressed that *“there is a shadow because it is daylight”*.

The analyses of drawings also revealed interesting characteristics in terms of how children represent the shadow itself. In most cases, the shape of the shadow matched the shape of the blocking object. It was usually represented as a dark area filled in black or dark colours (Figure 1c) and represented as a solid entity. Figure 1b and 1c are also examples of the dynamic of the drawings with traces of errors and changes made while drawing. Examples of children's comments are characteristically in that sense: S. 2: *“I'm gone make it the same [as the figure of herself that she drew], but I will not form it, I'll make it all grey”*, S. 7: *“That's my shadow! Oh, no... I shouldn't have drawn it inside in order to understand that it is a shadow... I'll do it again”*. However, it was common to find representations of shadows sketched with an empty outline (Figure 1d), including unnecessary details such as eyes and mouth (Figure 1b and 1c), or sometimes colours (S. 13: *“I know that shadow is grey in reality, but I want to draw it colourful”*).

Regarding the categories related to the alignment, several subsections were identified from the analyses of the drawings. In table 1, we can see that most children choose a horizontal alignment, in the sense that the three elements (light source, object and shadow) are placed one beside another in a 2D organization on the plane of the paper, like in Figure 2b. The idea of a shadow beside has been formulated by some children in Greece: S. 6: *“We have to be next to it...”*, S. 4: *“The light forms the shadow. The light comes upon us and next to us there is the shadow”*. As children tend to position the light source in one corner of the paper, this alignment is considered acceptable even if a strict line could not be traced to mark this alignment.

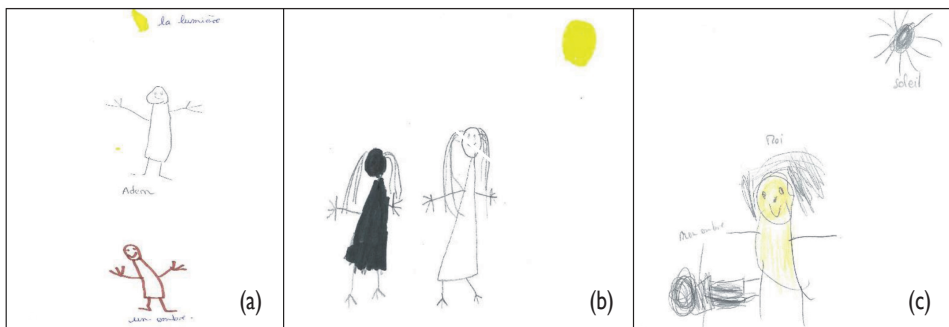
In the French data, some children choose a vertical alignment (Figure 2a) which

FIGURE 1



Representation of shadow as a (a) dark zone without a specific shape, (b) a shape that matches the blocking object and includes unnecessary details, (c) a solid figure that also include unnecessary details, and (d) an empty outline

FIGURE 2



Representation of alignments used by children to represent the phenomena of shadow formation (a) vertical alignment, (b) horizontal alignment, (c) shadow projected on the floor

could be seen as an attempt to draw in perspective. A third type of representation was identified, where the shadow is reversed, and seemed projected on the floor (Figure 1d and 2c). This last representation is interesting as it introduces the idea that a surface is needed for the shadow to be formed.

It has to be noted that the representation, on a 2D piece of paper, of the alignment of the three elements needed to explain the phenomenon of shadow formation, raises several challenges for young children. In Figure 3 some examples are introduced to illustrate categories linked to the difficulty to draw the alignment. The category 'shadow behind' is illustrated in Figure 3a. It concerns only the younger children. Drawings 3b and 3c highlight a position of the light source with respect to the object and the shadow that is approximate. It is positioned between the object and the shadow, on the top of the drawings (Figure 3b), or beside (Figure 3c). Finally, the category 'shadow between light source and object' is exemplified in Figure 3d and 3f). These categories highlight some of the difficulties encountered in terms of representing a 3D situation in 2D. The notions of in front, or behind are difficult to be represented in a 2D paper (S.2: *"Someone is walking and stands in front of the light and his shadow is formed"*). Moreover, there are difficulties linked to the physical phenomena itself where the shadow might be seen as a reflection off the object. Figure 3d is a good example of such idea. Similarly, in Figure 3e, this idea is found with a representation of shadow as a symmetrical reflection.

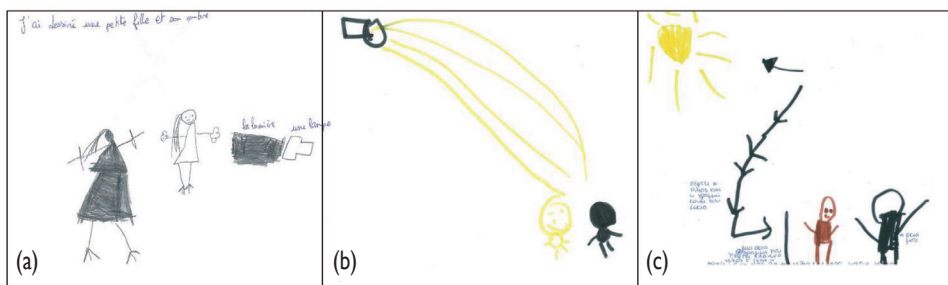
Finally, the drawings revealed some of children's ideas concerning the nature of light and the role of light in the phenomena of shadow formation. A first distinction can be made between natural and artificial light. The Greek data showed almost an equal repartition between the two types of light sources. The French data, however, showed a quasi-exclusive choice for natural light, and when artificial light is concerned, it represents flashlights also used in the classroom. This difference could be a good example of the influence of the context of the situations deployed in the classroom on children's activity. Finally, the category "Ray of light modelised" is illustrated in Figure 4. In these drawings, light can be seen as an independent natural entity corresponding to light beams coming out of the sun or a flashlight. None of the younger children managed to model rays of light rendering light as an independent entity. In Greece particularly, some of the older children were able to depict lines representing the beams or the direction of light towards the object (S. 8: [pointing at the lines he drew] *"It is the sun that shines on me"*, S.17: *"The sun creeps over and the line makes the shadow"*).

FIGURE 3



Position and arrangement of shadow with respect to the light source and the object: (a) shadow behind, (b) and (c) light source on top and middle, (d) and (f) shadow between the object and the light source, (e) shadow as a symmetrical reflection

FIGURE 4



Representation of light as independent natural entity

DISCUSSION

In this paper, children's drawings related to the understanding of the scientific concept of shadow formation were explored. In particular, a possible methodological way to analyse the children's drawings was proposed. To reach our aim, we used two sets of data (89 drawings in total) collected in two different cultural contexts (children from 4 to 6 years old in kindergartens in France and Greece). The two cultural contexts did not merely enrich the sample in an international perspective, but provided complementary indicators of analysis of the drawings. Although a comparative study was not intended, research findings from the French and Greek data revealed similarities and differences. In terms of similarities, children in both groups were willing to represent their ideas concerning the formation of shadow and in most of the cases they managed to draw the three entities necessary to explain shadow formation (light source, object and shadow). It is worth noting that the ideas that emerged through the drawing activity revealed similar alternative conceptions found in relevant research using different methodologies, such as difficulties acknowledging the importance of the light source in order to form a shadow or difficulties concerning the relevant positions of the light source, the obstacle and the shadow (Ravanis, 1996; Parker, 2006; Ravanis, Zacharos & Vellopoulou, 2010; Herakleioti & Pantidos, 2016). In addition, drawing activity enabled children express conceptions that are not extensively recorded such as shadow's anthropomorphical characteristics (e.g. eyes, mouth) (Fleer, 1996).

More specifically, most children represented a shadow as a dark area. However, in the Greek sample, some children drew shadows with colours while the French older children did not. On the contrary, in the French sample, some children represented a vertical alignment while none in the Greek sample did so. An interesting difference between the two samples concerned the nature of light; French children chose in majority a natural source of light while Greek children were almost equal partitioned between the two types of light sources. Finally, the representation of light as an independent entity was evident in the Greek sample and concerned only one drawing in the French sample. This is interesting to note because it shows that it is possible to construct a representation of light and its presence in space with 5-6 years old children. Even if it is characterised as a major cognitive obstacle at that age (Ravanis & Boilevin, 2009), drawings could serve as a medium to help children construct a first model of this phenomenon. Moreover, this highlights that the categories emerging from the differences between the French and the Greek sample may serve as new points of focus to details in the different drawings. In other words, using the example of the light represented as an independent entity, as it was present only in one drawing in the French sample, it might have been omitted when it is an important feature in terms of its scientific meaning. This research constitutes a first step to extend and deepen the analyses to new contexts or different settings. In this way, we would like to build a common and joint reflection on

the analysis of children drawings oriented toward the understanding of scientific concepts in preschool.

Indeed, drawing activity is considered an important process for young children since it can take place in different contexts enables the creation of meanings as well as supports thinking and communication (Edwards, Gandini & Forman, 1993; Van Oers, 1997; Papandreou, 2014). This is particularly important at different stages of the learning process for educators to get a good picture of children's ideas about the phenomena they are studying with children. This is in line with the idea that the teacher provides appropriate mediation and scaffolding activities to enable children to progress in their conception of scientific phenomena, taking into account what they already know (Dumas-Carré, Weil-Barais, Ravanis & Shourchah, 2003).

Regarding to the drawing activity researchers as well as teachers should take into consideration some of the limitations concerning its effectiveness; dialogue with the children should ensue from the drawing activity in order to obtain a clear picture of each child's representation. In addition, despite the fact that drawing may lessen the stress for some young children in the acquisition of science concepts, there may be children who have little interest in drawing (Chang, 2012), have limited drawing ability, or believe that drawing has to do mainly with "realistic" representations. Therefore, drawings can be used as a complementary tool and combined with other forms of representations. For example, regarding the shape of the earth using 3-D shapes is necessary in order to define the difference between spheres and disks (Kampeza, 2006) or regarding the formation of clouds discussions with children can provide details that otherwise could be hidden (e.g. the dynamic of how clouds gain height or their composition on a microscopic level) (Fragkiadaki & Ravanis, 2014). Helping children realize that the drawing activity is about making meaning in a symbolic way, creating a representation of reality in terms of modelling or codification of experience may enhance the use of drawing as a dynamic tool in science education that serves communication and learning. The more the drawing activity is recognized and promoted in research and in classes as a communicative practice and a tool of thinking, the better use of it as a means of learning will take place.

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