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PICTURES, GESTURES AND DISCOURSES: A CASE STUDY WITH KINDERGARTEN STUDENTS DISCOVERING LEGO BRICKS

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The awareness of the importance to look, through a mathematical lens, to the children drawings, gestures and discourses, considering them as diagnostic tools for the mathematics competences, stays at the base of this contribution. It discusses a didactic experience conducted in a Kindergarten (students 5 or 6 years old) in which we asked children to represent and discus a Lego block with a drawing and speech, observed from different prospective. The discussed results seem to us interesting both for researchers in Mathematics Education and for Kindergarten teachers who want to deepen the role of drawing and gestures as an expressive and diagnostic forms to analyze students' knowledge, abilities and mathematical skills.

INTRODUCTION

Kindergarten in Italy is an integrated system in evolution, characterized by the fundamental right to an education. Therefore, the final goal of a kindergarten education is to promote the development of independence, sharing, social skills, and good behavior in children.

Therefore, if on one hand it is necessary to select essential knowledge concerning the basic literacy of different study plans, in particular the Italian National Indications (MIUR, 2012), on the other it is necessary to use the appropriate tools and environments to introduce, through significant methodologies that convey the knowledge at stake in a formal or informal way, activities for the construction of mathematical meanings. The Italian Ministerial Guidelines in their latest formulation, (MIUR, 2012) propose in the field of experience "knowledge of the world" the following: "Children continually explore reality, but need to learn to reflect on their experiences by describing them, representing them, and reorganizing them with different criteria. They lay the foundations for the subsequent elaboration of scientific and mathematical concepts that will be introduced in primary school" (p.21)

What the teacher should put forward in this department is: "play, move, touch, browse, ask questions, describe, represent, and imagine situations and events ..." (p.16).

In particular, the mathematical skills referred to in this document are organized around the two main subjects, "number" and "space". With regards to space: "Moving around in their own space, children can choose and execute the most suitable paths to reach a pre-established goal by discovering

geometric concepts such as direction and angle. They know how to describe the shapes of three-dimensional objects, recognize geometric shapes and identify their properties." (p.22)

In scholastic reality, however, a lot of attention is devoted to numbers, especially in counting and writing skills, while skills related to space tend to be neglected. Everything that the child experiences in class during his "first" three-year educational period, should then be lived in continuity in the transition to primary school, that through the educational experiences introduced during kindergarten, should lead him to enhance the independent exercises of different cognitive styles that gradually, on the path to growth, will allow him to develop an intelligent and critical thinking process, through the characteristic alphabets of the various disciplines. (Di Paola, Battaglia & Fazio, 2016) Looking at the typical didactics of this scholastic level, one of the most common modes of expression is certainly free or guided design, together with narration, the use of symbolic games and play activities defined on semiotic resources of various kinds (Bartolini Bussi, 2008). Drawing is often used by teachers as a technique, an opportunity to let children know their "naive" ideas, their vision of the world, so as to try and discover their "stories" (Anning & Ring, 2004), their abilities, and their skills (Cherney et al., 2006; Fandiño Pinilla, 2008).

The drawings, "read" through a mathematical lens, in our opinion, can represent a very powerful diagnostic tool from the mathematical point of view, framing the discipline in the Field of Experience, the "knowledge of the world". In accordance with what has been discussed in the literature on the topic, a careful analysis of a figurative representation proposed by a child as a response to a specific cognitive task, also in relation to other forms of communication such as the natural or gestural language used by the child to describe their drawing, he/she can allow the teacher a deeper study (and therefore a subsequent enhancement of the related underlying competences) of mental models and of the patterns of reasoning typical of our culture (Di Paola, 2016; Donaldson, 2010), of a mathematical type, implemented by the child in the graphic-pictorial action.

In this paper we analyze the figural representation of Lego blocks realized by 15 kindergarten students (8 of them are 5years old and remain 7 are 6 years old) connected with their use of gestures as a semiotic resource into the description of their representation and into mathematical discussion.

THEORETICAL FRAMEWORK

"Signs" left in the drawing space

Figurative activity has always been a source of study and reflection in the fields of psychiatric, psychological, graphological, pedagogical and education research. According to Lowenfeld (1947), the figural expression is used as an indicator of emerging skills in different areas such as motor, perceptual, linguistic, symbolic, sensorial, spatial, etc. In this sense, a drawing can be considered an "indicator" of the designer's intellectual abilities. There are numerous papers which discuss drawings and the development phases traceable through this form of representation. Research by Luquet (2001) highlighted how a child, thanks to a slow and progressive cognitive growth, gradually moves from scribble to the conscious use of signs and sketches to represent reality. The first phase of development is the *fortuitous realism*, traceable around two years of age, in which the child draws some lines and gives it their own precise meaning, abstractly linked to an emotional or psychological aspect. The *missing realism* follows the *fortuitous realism* and lasts up to about 4-5 years old. During this time frame we find an absolute lack of synthesis made in the child's drawings. In the figural

representations, the signs left in the white space on the paper are often unrelated, uncertain, and confused. The figures drawn appear in many cases incomplete, and composed of parts not related to each other. The third phase is the *intellectual realism*, which covers the time span of about 5 to 8 years old. At this stage the child appears more competent in reproducing the appearance of what he draws. The sketches on the paper appear more "mature" and there is a greater sense of control in what the child produces. In the last phase, nominated *visual realism* by Luquet (2001), the child draws objects as they appear before his eyes, highlighting a high level of representational skills.

We believe that figurative representation is a powerful diagnostic tool in kindergarten and in the first years of primary school. In the representation of a three-dimensional object it is also possible to trace the relationship between emotion, imagination and an observational point of view. Furthermore, as Pontecorvo (1992) argues, a drawing which correctly shows the signs in a spatial relationship useful to better represent a real object, highlights a good ability of the designer of "spatial decentralization" (Pontecorvo, 1992, p.335). This aspect refers to the difficult skill, in the act of drawing, of taking into account the different points of view (Bartolini Bussi, 2008), correctly placed in relation to one another. Research by Luquet (2001) in this field, shows how the analysis of a drawing of a three-dimensional object made on a white sheet of paper, represented in perspective, can highlight various evolutionary stages related to mathematical competences. The child designer, over the years, in fact passes from a simple "flat figure" (typical of a front view) to the design of one or more sides/faces between them, overturned or overlapped on the same plain. This representation then slowly turns into another that, although initially incomplete, highlights the first approaches to more complex geometric concepts such as the parallelism between the sides and the faces of a solid. The designs that the child of the kindergarten sketches in his figural representations can "tell" the progressive maturation and reorganization, on a cognitive and emotional level, of the mental images that gradually improve in his mind.

According to Duval (1998) there is no construction of a mathematical meaning, if this is not accompanied by its representation, realized by means of signs. Every form of knowledge is therefore, always and at any age, inseparable from an activity of representation. The drawing is one of such forms. In the reproduction of a geometric figure, through sketching, the cognitive task required of the child is to "generate a mental image of the figure, to keep it active for a certain period of time and to compare its graphic production with the mentally generated image ". Until entry into kindergarten, children seem to show only cognitive functions related to recognition and reproduction, albeit often with errors, gaps, and distortions (Clements, 2004).

Returning to the complex relationship between the known geometric object, the drawing that depicts it, and what that drawing represents for the child, it should also be emphasized that for a possible significant learning cultivation by a subject it is necessary that the student "move" among more semiotic resources, linked to more representations of the same mathematical object (Duval, 1998). These operations, now known by research in mathematical education, are based on transformations of treatment and conversion (Duval, 1998). Therefore, analyzing the knowledge and skills of a learning subject requires you to resort to the same functions of transformation of treatment and conversion between several semiotic resources.

Semiotic representations and the role of gestures in mathematical education

In recent years, many researchers have studied and highlighted the role and coexistence of various semiotic resources that come into play in the processes of learning and teaching mathematics. The words (written or spoken), the specific symbols of the discipline, gestures, body position and all other aspects related to the embodied nature of knowledge (Edwards & Robutti, 2014), are considered as fundamental mediators of the mathematical thinking of students and teachers alike, and not as mere accidental elements (Nemirovsky & Ferrara, 2009; Radford, Edwards & Arzarello, 2009;). McNeill (1992), defines gestures as closely related to speech, that the subjects (students and teachers) execute while performing cognitive activities.

[Gestures] are tightly intertwined with spoken language in time, meaning, and function; I am talking about the process of a single underlying mental process (McNeill, 1992, p.1).

Radford et al. (2009) describe gestures as important sources of abstract thinking and as the very texture of thinking. Therefore the activation of different cognitive and semiotic components together with the perceptive-motor and "embodied" activities, such as the manipulation of materials or artifacts, drawing, gestures, body movements, and rhythms, support the thinking process of a student. (Arzarello et al., 2009).

Gestures do not just reflect thought, but have an impact on thought. Gestures, together with language, help constitute thought (McNeill, 1992, p.224).

McNeill proposes five categories of gestures and their respective meanings:

iconic gestures: have a relationship of similarity with the semantic content of the accompanying oration; *metaphoric gestures*: similar to iconic gestures, but semantic content is an abstract idea *deictic gestures* (pointing): usually made with the index finger to indicate objects or positions in space *beats*: accompany the rhythm of speech; *cohesive*: link together thematically related, but temporally distant parts of the discourse.

RESEARCH METHODOLOGY AND RESEARCH QUESTIONS

According to the main assumption concerning the role of gestures as a semiotic resource used by young students (5-6 years old) in the learning process, and Luquet's point of view concerning the figural representation as an "indicator" of the child's intellectual capacity, a teaching sequence has been designed. However, the main hypothesis consists of alternating activities involving the use of drawing and a description of representations that could make the evolution of the significance concerning spatial thinking explicit. Keeping in mind, that at this scholastic level it is more "natural" for children to resort to model making and activities that are part of three-dimensional geometry (Cottino & Sbaragli, 2004), the proposed task involved the representation and subsequent treatment and conversion of objects well-known to children in kindergarten and primary school, such as Lego blocks. The teaching sequence was carried out in a pilot study with the participation of ten kindergarteners attending the last year of kindergarten (5/6 years old). The teaching experiment evolved throughout 6 lessons, each of them lasting three hours. In order to analyze the students' drawings, students' gestures and the related discourse, the teaching experiment was videotapes. Transcriptions were also used.

In this paper we present some of the protocols (drawings) of the children and a qualitative analysis of the students' gestures, tracked during a mathematical discussion. The teaching experiment was

conducted, following three different phases of research, by teacher that asked to students to draw a Lego block, observed different point of view and to manipulate it, discovering its spatial relationship between all of its parts. (eg. Faces, angles, parallelism…). The interpretations of the drawing was analyzed by the teacher and researchers who observed also the videotape of students' interactions and his/her gestures used to present his/her pictures to teacher and to the other students.

The following questions guided the research conducted:

• What kind of design do kindergartens produce when asked to represent a real object known to them as a Lego block?

• What conversations and what gestures do the children produce when they explain their design?

The different researches phases are breathing presented in the following section.

OVERVIEW OF THE TEACHING SEQUENCE

The first phase involves the Lego blocks. Through the exploration, manipulation and observation of the blocks, each child verbally presents their creation to their fellow students. The child becomes familiar with the three-dimensional object and through the use of personal symbols, describes the shape, the presence of edges or "points" and how many there are. The second phase involves the drawing of the block. With the objective of expressing the perception of the parts of the three-dimensional object and the relations between the parts in the design, the students are requested to draw the block freehand on an A4 sheet of paper. As in the first phase, each child initially observes (through manipulation) the blue block, trying to grasp its shape, the presence of edges, "points", their relative amount and so on. Later, the block is placed on a bench and the children line up in front of it. This setting is chosen to favor more observation points of view in the children, and to link it to their spatial position. We try to encourage the production of drawings of the same object, but with different perspectives.

The third phase, executed in the days following those dedicated to the previous phase, was carried out in the kindergarten through a mathematical discussion, we tried to bring out the critical aspects of the figurative representations made by children and the importance of their point of view. Children were asked to describe their design to the rest of their classmates. The teacher asked them to "compare" the various drawings with one another. The selection of the drawing most similar to the blue block among those made by individual children, was made by the class thanks to a discussion orchestrated by the teacher (Bartolini Bussi & Boni, 1995), and was designed to allow all students to independently assess the designs of their classmates and its accuracy in relation to the point of view used.

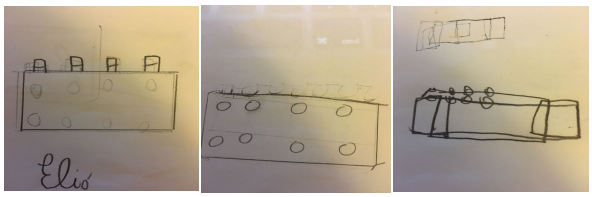
RESULT DISCUSSION

Below we discuss the drawings and the students' discurses produced in the various phases by some of the children involved in the experimentation. The protocols listed here are only some of the most significant in relation to the variety of strategies, identified in the drawings produced by all children.

DIFFERENT POINT OF VIEW OF MATILDE, LAURA TERESA AND ELIO

During phase 3 children are involved in a mathematical discussion, during which, starting from the designs they produced, they are asked to describe their own design and compare it with the others'

drawings. Children do not have a block available. In particular, in the following episode, 3 drawings are compared, in which the block is represented by different points of view. In one of the drawings there is an attempt to represent the block in a three-dimensional perspective.



Teacher: Matilde…

M.: Maybe…

Teacher: no, tell me what you did…

M: In a first moment I have done, I did the shape of the square, then I made first one very small then as Elio, then I didn't like it, I erased it and I before did all these r, I didn't liked it and I did it again (while speaking she draws the edge of the figure with her index finger, then she goes through the two rows of dots in parallel; afterwards pointing with her index and middle finger on the couple of dots she counts) … two, two, two, two… eight. (she lays her open hand on the drawing and says) <u>because on that rectangle</u> there were eight.

Matilde tryes to remember the block used in the previous phases and thinks at its top face.

Teacher: the rectangle

M: there were eight dots (beating with her finger on each dot, touching them all)

Teacher: there were eight dots… you said you did the shape

M: the shape (she puts her right hand on the drawing, as if she hold in her hand the brick leaning exactly on the edge of the drawing)

Teacher: what is the shape?

M: I did the same edge (with her index finger runs along the rectangle she has drawn down) of the brick put in this way (putting her hands one in front of the other, making a rectangle matching thumbs and index fingers together, the other fingers closed, she goes down with her hands on the drawing, as holding the brick in her hands, showing the view from above.

Teacher: In the same way of LT?

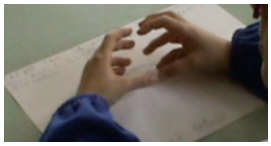
LT: The brick. We did the same thing, we took the brick (she moves he left hand as if there were a brick laying on the sheet of paper) that was in this position and we drew some lines, as if it was a ruler (holding a fictive brick with one hand and drawing the edge with the other one)

Teacher: So, LT you were saying…

LT: the lines with the brick, the shapes…

LT: we did it together, identical

Teacher: but why did you draw it in this way?



Teacher: as if it was on the desk. What did you choose? Did you make a choice to draw it, did you?

LT. Yes, I did

Teacher: that is?

LT. In a first moment I thought to do it above… like Elio and Matilde, then I changed my mind and I wanted to…

Teacher: and you put them under?

LT. I chose to draw them here, in the middle

Teacher: just a moment, you just told me: I did it above...

LT: above here (sliding with her index finger on the upper side of the rectangle)

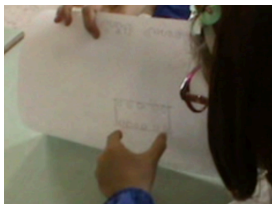
Teacher: and why over there? What is it "over there"?

LT: The circles

Teacher: Ah, but how comes they put them up there?

LT: yes, they drew it in this way (she lays the hand on one side of the rectangle, with the palm of the hand in front of herself) from the side

Teacher: ah, explain better this… from the side?

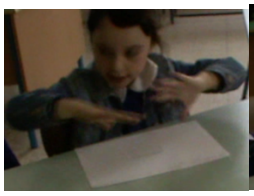


LT: (raising the sheet of paper and pointing to the rectangle with thumb and index finger, as if she wanted to lean the brick on a side face). They put it in this way, so…

Afterwards she puts the sheet on the desk rotate both her hands, as is she held the brick tight, in the movement of rotating the brick itself, changing her point of view from above to aside. In a first moment she uses the whole hand to contain the brick; in a second moment she lays on the sheet a thumb and an index finger only, representing the edge of the base. With the rotation of the fingers, only, she emphasizes the thickness of the brick which comes out from the sheet).

At this point intervenes M: He, in this way (stretching her arms in front of herself, she places them one in front of the other, as if she held the brick in her hands, she leans on the chair back and stirs between her hands as if she could see a brick, seen from aside).

…and we, from the top (she puts her open hands with her palms down, as if she were touching the upper part of the brick, getting them closer to the desk and with the whole body she leans on the desk, looking at it from above.




Teacher: aaah… you two from above! Elio, is that true, what Matilde is saying? That is… did you look at the brick from where?

M: in this way (she stretches her arms, puts once more her hands pararrel to each other in front of herself, with the open palms)

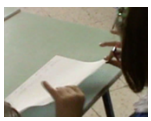
…we (she makes a quick gesture, pointing to LT and herself) in this way (putting her hands on the sheet, she overlooks it wither whole body), instead.

At this point LT takes the word, gesticulating in the space in front of her, opening her hands and moving them as if she touched the brick on its side face.

And says

LT: he, from this side. We looked at it from the upper side, instead (she stands up and overlooks the desk, bending her head forward.

Teacher: from above



LT: Not in this way (she lifts the sheet from the desk and she puts it in front of herself, as if it were the side face of the brick)

but in this other way (she leans the sheet on the desk and puts her open hand on the drawing, flattening/ pressing it from above) and LT repeats the same gestures as M.

The discussion goes on

CONCLUSIONS

The discussed results, considering the small number of children, do not want to have any general character. However, they highlight the behaviour that, in relation to literature, seem to be significant for the research and school field.

The objective to answering to the two research questions has allowed us to interpret the data collected in reference not only to the request to represent the Lego brick with a drawing but also to a subsequent description made by the same children with gestures and words and aimed at identification of the characteristics of their design. The treatments and conversions (Duval, 1998) made in the experimental field showed different behavioural strategies and therefore different levels of competence of the children. These are linked both to the representation of a three-dimensional object on a two-dimensional plane in relation to different observational points of view, and to the argumentative skills related to the natural language recorded during the interviews.

The analysis of the drawings produced by the children and the relative gestures used in the argumentative phases has also confirmed what has been discussed in the literature by several authors (D'amore et al, 2003; Luquet, 2001) related to different cognitive tasks but always associated with representations of two-dimensional and three-dimensional objects and figures. In our collected drawings we traced different representations related to various visions of the Lego solid from the front to the quasi-perspective one. In this one we noticed the presence of several visible faces drawn at the same time or an overlapping of several elements linked to different points of view.

As in many cases at Kindergarten level the geometric concepts of parallelism and depth traced in our students protocols are uncertain; this should not be surprising according to the age of the children and the phase of missed realism (Luquet, 2001) in which almost all of them are.

Looking at the Mathematics teaching/learning phases in a vertical perspective that embraces all school grades, we believe that the considerations presented here can be a good starting point for reflection for researchers in mathematics Education for future theoretical/experimental investigations on the development of the geometric thought in all its forms (looking for example to the model of Van Hiele, 1986) from the Kindergarten to University.

References

Anning, A., & Ring, K. (2004). Making sense of children's drawings. McGraw-Hill Education (UK).

Arzarello, F., Paola, D. Robutti, O., & Sabena, C. (2009). Gestures as semiotic resources in the mathematics classroom. Educational Studies in Mathematics, 70(2), 97-109.

Bartolini Bussi, M. G. (2008). Matematica: i numeri e lo spazio. Bergamo: Junior.

Bartolini Bussi, M., & Boni, M. (1995). Analisi dell'interazione verbale nella discussione matematica: un approccio vygotskiano. L'insegnamento della matematica e delle scienze integrate, 18(3), 221-256.

Battista, M. T. (2007). The development of geometric and spatial thinking, Second handbook of research on mathematics teaching and learning, 2, 843-908.

Cherney, I. D., Seiwert, C. S., Dickey, T. M., & Flichtbeil, J. D. (2006). Children's drawings: A mirror to their minds. Educational Psychology, 26, 127-142.

Clements, D. H. (2004). Geometric and spatial thinking in early childhood education, Engaging young children in mathematics: Standards for early childhood mathematics education, 267-297.

D'Amore, B., Godino, D. J., Arrigo, G., & Fandiño Pinilla, M.I. (2003). Competenze in matematica. Bologna: Pitagora.

Di Paola, B. (2016). Why Asian children outperform students from other countries? Lin-guistic and parental influences comparing Chinese and Italian children in Preschool Education. IEJME-Mathematics Education, 11(9), pp. 3351-3359.

Di Paola, B., Battaglia O. R., & Fazio C. (2016). Non-hierarchical clustering as a method to analyse an open-ended questionnaire on algebraic thinking. South African Journal of Education, 36(1). Estratto da http://dx.doi.org/10.15700/saje.v36n1a1142.

Donaldson, M. C. (2010). Come ragionano i bambini. Milano: Springer.

Duval R. (1998). Signe et objet (I). Trois grandes étapes dans la problématique des rapports entre répresentations et objet. Annales de Didactique et de Sciences Cognitives. 6, 139-163.

Duval, R., Godin, M. (2005). Les changements de regard nécessaires sur les figures, Grand N, 76, 7–27.

Edwards, L. & Robutti, O. (2014). Embodiment, modalities, and mathematical affordances. In L. Edwards, F. Ferrara, & D. Moore-Russo (Eds.), Emerging perspectives on gesture and embodiment in mathematics. Charlotte, NC: Information Age Publishing.

Fandiño Pinilla, M.I. (2008). Molteplici aspetti dell'apprendimento della matematica. Trento: Erickson.

Lowenfeld, B. (1947). Psychological aspects of blindness. In Outlook for the blind and the teachers forum (Vol. 41, No. 2, p. 31).

Luquet, G. H. (2001) Children's Drawings (translated by A. Costall), London: Free Association Books (original book published 1927- Le dessin enfantin)

Mcneill, D. (1992). Hand and mind: what gestures reveal about thought. Chicago: University of Chicago Press.

MIUR (2012). Indicazioni nazionali per il curricolo della scuola dell'infanzia e del primo ciclo d'istruzione. Roma.http://hubmiur.pubblica.istruzione.it/web/istruzione/prot7734_12

Nemirovsky, R. & Ferrara, F. (2009). Mathematical Imagination and Embodied Cognition. Gestures and multimodality in the construction of mathematical meaning. Educational Studies in Mathematics, 70(2), 159-174.

Pontecorvo, C. (1992). Un curricolo per la continuità educativa dai quattro agli otto anni. Firenze: La Nuova Italia.

Radford, L., Edwards, L. & Arzarello, F. (2009). Beyond words. Educational Studies in Mathematics, 70(3), 91 - 95.

Van Hiele, P. (1986). Structures and Insight. A theory of Mathematics Education. London: Academic