The contribution of non-verbal graphic texts to children's early literacy development

La contribución de los textos gráficos no verbales a la alfabetización temprana

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Abstract

This paper argues that non-verbal graphic texts constitute a bridge between spoken and written language at an age in which there is a gap in children's ability to produce and understand spoken compared to written language. Non-verbal graphic texts are tools which may enable young children to build the concepts and skills relevant for early literacy development if, and only if (in my view), they are actively used by the children in relevant contexts. This claim is based on several studies carried out in the last decade by my colleagues and I on the use of non-verbal graphic texts by kindergarten and preschool children in Israel and England; calendars, icons, mathematical notation and scientific illustrations.
Several studies support the claim that young children: 1) have considerable ability to "follow the rules" involved in using a weekly paper calendar; 2) are able to produce "scientific illustrations" suited for data recording in science problem solving and for communicating findings which they cannot readily express verbally; 3) are able to discriminate between the use of numerical and "writing" notation and their relations with functional contexts; 4) produce more extended and coherent spatial descriptions when these descriptions are supported by simple maps produced by them.

Keywords: Non-verbal graphic texts, notation, scientific illustration

Resumen

Este trabajo sostiene que los textos gráficos no verbales constituyen un puente entre el lenguaje hablado y el escrito a una edad en la que existe una distancia entre la habilidad de los niños para producir y comprender el lenguaje hablado en comparación con el escrito. Los textos gráficos no verbales son herramientas que permiten a los niños pequeños construir conceptos y habilidades relevantes para el desarrollo de la alfabetización temprana si, y sólo si (desde mi punto de vista), son activamente utilizados por los niños en contextos relevantes. Esta afirmación está basada en numerosos estudios que en la última década llevé a cabo conjuntamente con mis colegas sobre el uso de gráficos no-verbales por parte de niños de jardines de infantes y preescolares en Israel e Inglaterra. Varios estudios apoyan la propuesta que los niños pequeños: 1) tienen una habilidad considerable para "seguir las reglas" involucradas en el uso de un calendario semanal; 2) son capaces de producir "ilustraciones científicas" apropiadas al registro de datos en la resolución de problemas en ciencia y a la comunicación de hallazgos que no pueden expresar verbalmente; 3) son capaces de discriminar entre el uso de notaciones numéricas y "escritas" y sus relaciones en contextos funcionales; 4) producen descripciones espaciales más extensas y coherentes cuando esas descripciones están apoyadas por mapas simples producidos por ellos.

Palabras clave: Textos gráficos no-verbales, notación, ilustración científica.

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The term "literacy" brings to mind written words. Literacy is currently perceived as intelligent use of verbal texts (see, for example, Ravid & Tolchinsky, 2002). However, during the last 30 years, literacy has acquired a broader meaning which includes non-verbal graphic texts such as written mathematical language, sketches of all types, graphs, diagrams, illustrations in general and scientific illustrations in particular, maps, calendars and more (see, for example, Harris, 1995; Kress & van Leeuwen, 1996; Lemke, 1998, 2002; Olson, 1994; Teubal, 2002).

In the present paper I intend to argue that graphic non-verbal texts have a unique role in fostering children's literacy in the early stages of their exposure to written and to literate discourse. The capabilities and skills most relevant to literacy at a young age can be fostered through strengthening children's ability to use a wide variety of non-verbal graphic texts in situations where these tools are used in activities that the children find meaningful.

I will attempt to unfold this argument as follows: 1) by presenting issues that may hinder (thwart) the development of literacy in its early stages; 2) by presenting non-verbal graphic texts as a special case of "written language in a wider sense" (Olson, 1994) and demonstrating the role of this system in the "cognitive toolbox" of people in general, and young children in particular; 3) by presenting examples of useful non-verbal graphic text, especially in the early stages of the development of literacy, and research findings or observations about them: A weekly calendar (Teubal, 2000), Scientific Illustration (Gross & Teubal, 2001), Narrative Illustration (Teubal & Guberman, 2007), Numerical Notation (Dockrell & Teubal, 2007), and maps (Uttal, Fisher, & Taylor, 2006). To conclude, the paper I will briefly discuss the contribution of non-verbal graphic texts to the early stages of children's literacy development and the implications for the training of preschool educators.

Factors that could hinder literacy development

In the early stages of literacy development children have a considerable amount of understanding for oral texts (Nelson, 1996). However, the last three decades in research indicate the existence of factors that might hinder the development of literacy (Snow, Burns, & Griffin, 1998; Snow & Guberman, 2008).

These factors are: lack of acquaintance with the roles of written language, lack of ability to transfer understanding from oral text to written text, lack of motivation to read, and difficulties in understanding the alphabetical principle and its implementation.

Verbal and non-verbal graphic texts as written language in a wide sense

Graphic texts (see Olson, 1994) include written verbal language, written mathematical language, maps, charts, graphs, diagrams and other symbol systems that have the following in common: they are *external,* accessible on a bi-dimensional surface and *fixed* (not passing or fleeting, available for review, editing, memorizing and more). These features allow the texts to serve three major functions:

1. *Mind Extension* - enhancement of processing capacity and greater efficiency of mental functioning (Clark, 1997; Olson, 1994). Thanks to graphic representations people can break through the limitations of memory in terms of quantity of material stored, in terms of the length of time that the material is available, and the ability to precisely and quickly retrieve it. With the external representations at hand, the individual can execute mental actions that are not possible without them.

2. *Mind Sharing* – exists thanks to the exchange of information between people, and the delivery or retrieval of information through texts (Clark, 1997; Donald, 1991).

3. *Mind Regulation* - enhancing the individual's ability "to manage" (or "organize", or "regulate") her/himself: "enhancing the ability to deal with self" (Clark, 1997; Donald, 1991).

Thus, a literate person is a person capable of "consuming" and producing verbal and non-verbal graphic texts as communicative tools (mind sharing) and as epistemic tools (mind extension and mind regulation).

The more accessible these tools are to children, the more the children improve their ability to solve problems in various fields. Literacy as empowerment means making written language (in the wider sense) an accessible, available, usable tool for human beings in general and for children in particular (Teubal, 2002). People's ability (adults and children alike) to achieve their goals through the use of texts, is related to their ability to distinguish the affordances of the various types of texts. Awareness of the benefits as well as the disadvantages of the different available texts as related to content, addressee, and goal to be achieved is of critical importance. The ability to identify different affordances of various representations permits us to make optimal use of them.

Below I will give various examples of graphic texts that children use quite successfully, illustrating the three aspects mentioned above: mind expansion, mind sharing and mind regulation through the use of different kinds of texts.

Examples of non-verbal graphic texts which are especially useful in the early stages

The examples listed below include: A weekly calendar, Scientific and Narrative Illustration, Numerical Notation and Maps.

A Weekly Calendar

A weekly calendar is a cultural tool for mapping time in space. It lets us represent events in space according to their order of occurrence in time. In order to have this graphical representation serve children in the process of conceptualizing time, they have to be acquainted with the syntax and semantics of the non-verbal graphic language involved in this kind of text. This raises the following question: "Do children acquire – or are they capable of acquiring – the rules of the game involved in the process of mapping time in space in a tool such as a Weekly Calendar?" In order to check this question I carried out a study with Preschoolers and Kindergarteners (Teubal, 2000). Sixty-eight low socioeconomic status (SES) Israeli children, aged between 42-79 months were individually interviewed in a quiet room adjacent to their class. They were presented with two tasks in a weekly calendar (graphic representation charting the seven weekdays, morning and afternoon of each day) a recognition and a production task. The children were asked to read (interpret a calendar someone else had produced) and to list events in a weekly calendar. Here is an example – a calendar produced by a 5-year-old Kindergartener who was thus able to list her weekly activities (Fig. 1).

This being a Hebrew calendar, it is organized from right to left, and Sunday it the first day of the workweek. Saturday (first column at the reader's left) is the day of rest.

The child chose to show through numerals that on Sunday morning (top right corner) college students do math activities with the kindergartners. On Sunday afternoon she plays with a friend; on Monday, she watches television at 3 PM and on Wednesday too. On Saturday afternoon she rests at home.

The study's findings indicate that children are quite capable of applying the rules of mapping time in space, a requisite for creating a weekly calendar. We found that 63% of Kindergarteners and 31% of Preschoolers can read someone else's calendar; while 67% of Kindergarteners and 42% of Preschoolers succeed in using the calendar to record events meaningful for them.

This example illustrates the way in which the tool enables mind expansion, mind sharing and mind regulation: by using it, children can remember what they have to do each day (mind expansion); the tool is communicative as well: by showing the calendar to someone else the child can let the other person know about the events occurring during the relevant week and their sequence (mind sharing); with the calendar's help, the children can make plans (mind regulation). A common use of the calendar in Kindergartens is at holiday time or vacation time. Before Hanukkah, for example, the calendar was used in many kindergartens to indicate the day set for the Hanukkah party and to plan the necessary preparations for the party. Every boy and girl received a further calendar to take home, on which they would

Fig. 1: Example of a Weekly Calendar produced by a 5-year-old child.

mark the special activities they engaged in during the 8-day holiday. On their return after the vacation, the children used the calendar as a support to reporting their special experiences to the group. There is a noticeable difference between a calendar-supported report and one that was unsupported. As a rule, the first is much more organized and coherent, i.e. children's reporting supported by a calendar increases the cohesiveness of their discourse and improves their organization of time relations between the reported events. It is likely that the phenomenon is not only one of expression and reporting but that the calendar may allow various, more effective strategies, for processing and storage.

Scientific and narrative illustrations

The term “scientific illustration” is used here to refer to an illustration intended to be an accurate representation of specific information about a certain subject. For instance, a scientific illustration of a fish will show the typical number of scales on the kind of fish preserved for study, which the illustrator is observing. Although scientific illustration looks in general quite realistic, it is different from other media of representation, such as photography, since its main purpose is to provide specific information. Therefore, depending on the relevant aspects of the information to be conveyed, the result can either look realistic or not. Scientific illustrations include maps, diagrams and illustrations of things have never been seen, nor could have been seen by the illustrator, such as black holes, quantum particles, etc. (Mikel, 1996).

Figures 2 and 3 below show illustrations made by children with the purpose of providing specific information about the objects represented.

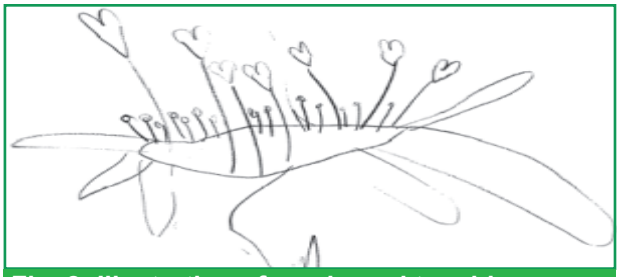

Fig. 2: Illustration of an almond tree bloom as seen in a binocular microscope (x60) made by a kindergartener (female).

These examples come from two different studies (Gross & Teubal, 2001; Teubal & Guberman, 2007). In both studies the kindergartners were told to "draw what you see", as opposed to the prevalent instruction in kindergartens to "draw whatever you want". In other words, when children draw in kindergarten, the prevalent instruction is characterized by a lack of constraints – they are invited to produce a "free style creation". This means that the creation of pictorial graphic texts is guided by very different rules from those guiding the production of verbal text: When children are invited to give an oral report on their experiences, they learn they are expected to give a "realistic report". In contrast, when they are invited to make up imaginary situations and report them, they are expected to create a "fictional text". Typically, there is a clear distinction in kindergarten activities between dealing with imaginary verbal texts and dealing with informational texts. However, a similar distinction concerning pictorial graphic texts is rather difficult to find. Below, I shall present the results of two studies. The first concerns kindergartener's ability to produce two genres of illustrations: Narrative illustrations and "Scientific" Illustrations; the second concerns kindergartener's ability to use scientific illustration in order to answer questions about an experienced

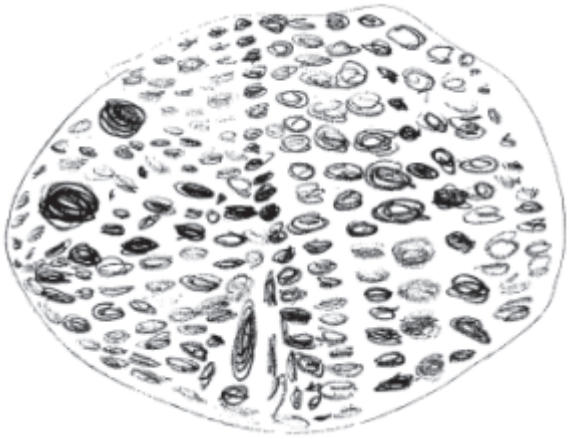

Fig. 3: A butterfly egg, 60x enlarged, illustrated by a kindergartner (male).

1. Kindergarteners producing differentiated "Scientific Illustrations" and "Narrative Illustrations".

Before discussing the example, let me examine what a "narrative illustration" is. Traditionally, "narrative illustration" referred to paintings or drawings whose purpose was to support verbal text. Nowadays, there is an abundance of sub-genres of this general genre which tell the story independently, not needing verbal text to accompany them: Comics, graphic novellas, caricatures and animations. Thus nowadays, we encounter "narrative illustration" both accompanied and unaccompanied by verbal text. The study discussed below refers to the first type of narrative illustration. The study took place in Jerusalem Preschools and Kindergartens (Teubal & Guberman 2007). Forty children, aged 48 to 70 months, from heterogeneous socioeconomic backgrounds, were individually interviewed, and were asked to perform two tasks:

i. They were asked to draw *according to their imagination* the ant from Aesop's fable “The Ant and the Grasshopper”, after having heard the story read to them by their teacher.

ii. They were asked to draw an ant *they were observing* – an ant they had brought in from the yard in a transparent plastic container.

Fig. 4: An example of a "Narrative Illustration" (left) and a "Scientific Illustration" (right), drawn by the same 5-year-old girl.

The children were told to draw the ant taking into account its color, its size, and the number of parts in its body. Our findings show that the children distinguish the two genres of non-verbal graphic texts. They produce differentiated products, fitting the task's context: a narrative illustration following the story (larger and more colorful, with facial expressions, less accurate than the scientific illustration- see Figure 4) and a scientific illustration "for learning about the ant". These results indicate that encouraging children to create different genres of non-verbal graphic texts may enrich their cognitive toolbox and enhance their representational capabilities.

2. Kindergarteners using "Scientific Illustration" to solve problems in "Science".

In a study done by Gross and Teubal (Gross & Teubal, 2001 (a group of 60 children, aged 36 to 65 months, from heterogeneous socioeconomic backgrounds, faced two tasks that required pictorial notation. The children were presented with a problem of water permeability in two different types of soil. The children were asked to solve the problem at first through naked eye observation (without a magnification tool) and to both orally describe and draw what they had observed. The children's answers are thus expressed both verbally and pictorially. In the second stage, in order to confirm or refute their first answer, the children were instructed to carry out the observation with the aid of a microscope or a magnifying glass, give their opinion, and *"*draw precisely*" what they saw*. It was found that the scientific illustration served the children effectively for reporting the solutions they found to the question they had investigated. It was also found that the *pictorial responses* were more appropriate for description of visual data, while the *oral responses* were more appropriate for reporting the children's conclusions. These findings illustrate the contribution of scientific illustration as a tool for external representation that helps the children record (remember – mind expansion) and communicate (the tool provides a way of conveying a message that they may not be capable of verbalizing at that point – mind sharing).

Figure 5, below, presents an example of "pictorial responses" by a 5-year-old girl to the question: "Why did the water disappear faster when it was poured on sand that when it was poured on soil?". The illustrations in the top row were made following the naked eye observation, whereas those on the second row, were produced after observation through a microscope (x40).

Comparing verbal texts and their accompanying illustrations as a tool for fostering critical reading

Children's familiarity with the genre of narrative illustration is also exhibited when they "read". When a story is accompanied by an illustration, there are three main types of relation between the two types of texts (verbal and pictorial):

a) overlap (the information in the texts overlaps);

b) contradiction (the information in the texts is contradictory);

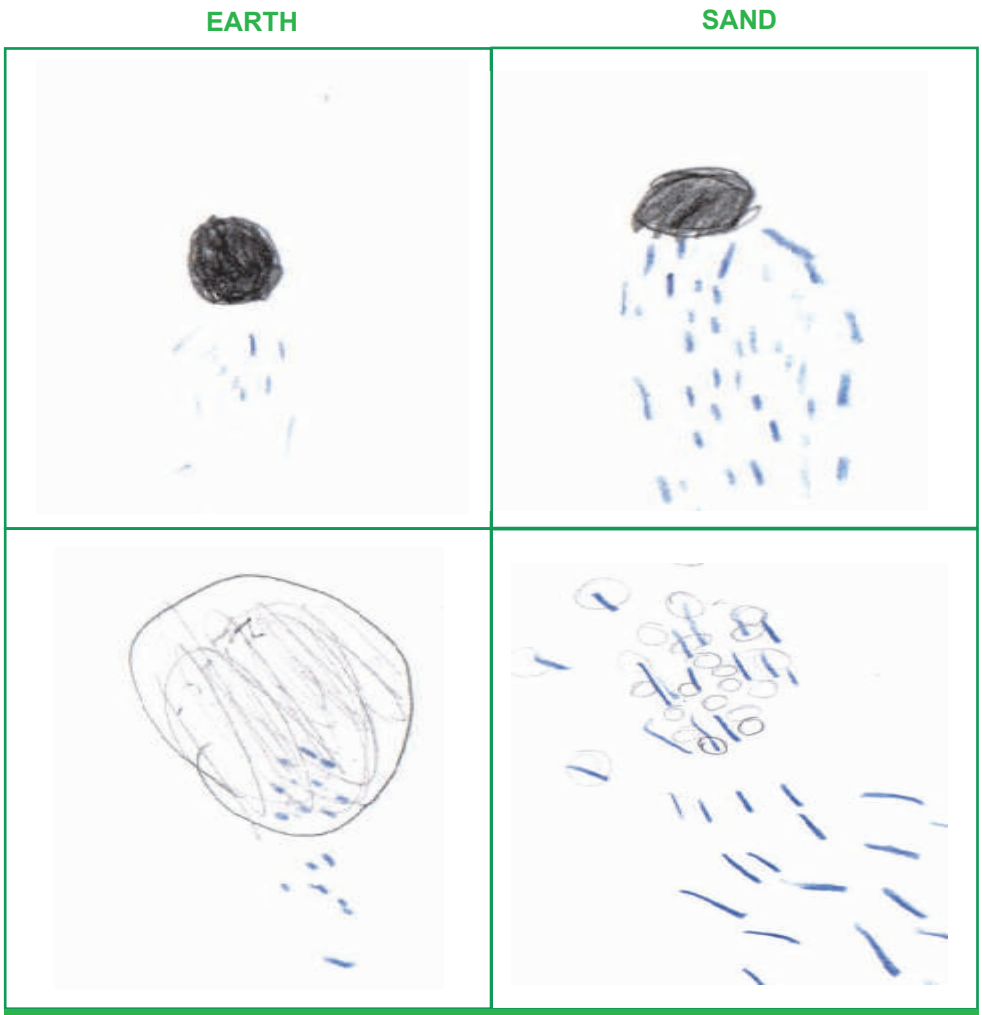

Fig. 5 : Five-year-old girl "pictorial responses" to the differential water seepage in sand and in soil.

c) complementary (the information in each of the two texts informs on different aspects of the same topic so that a new combined mixed text is thus produced).

An example of activity that fosters critical reading is comparing the types of information obtained from these two types of texts when reading with children. For example, during a discussion that took place after their teacher had trad to them the book "One fine morning",[1] children in the "Dror" kindergarten in Rehovot noticed that the illustration accompanying one of the episodes depicts a grandmother welcoming her grandchildren – whom she does not see because the door is hiding them and crushing them against the wall (see Figure 6). They suggested changing the side the door opens to, or the location of the doorbell. They accompanied their proposals with their "edited" version of the original illustration, which they achieved by cutting and pasting parts of a photocopy of the original illustration.

Discussing the illustration provided an opportunity for dealing with spatial issues. The comparison between the written text and the pictorial text enabled a critical discussion of the mismatch between them. The photocopy and its cutting provided a way of editing and correcting the graphic text without the need to resort to writing words.

Numerical notation systems

Dockrell and Teubal (2007) interviewed 80 Kindergarten and Preschool children (between the ages of 36 to 65 months) in order to address the question of when children begin to distinguish between numerical and writing notation systems. The children faced a production task: Filling out an ID card which requested numeric information (age, number of brothers and their age, number of sisters and their age, phone number, date of birth, weight, height) and non-numeric information (name, address, city, eye color, hair color, brothers' names, sisters' names). A significant difference was found in children's answers to the numeric and non-numeric items in all age

1. "One fine day" (Ayal, O. 1985) (In Hebrew: Boker bahir echad) Tel Aviv: Sifriyat Hapoalim.

Fig. 6: The original picture from the book "One fine day" (Eyal, 1985) which the children in "Dror" kindergarten suggested to correct.

groups. Some items revealed a special response pattern: the items referring to eye color and hair color elicited iconic responses (using marks on the page that are similar to or hint at the referent they represent) in all age groups.

Apparently, children find the use of iconic representation more adequate for some types of contents. This finding indicates that children do not move from graphic representation to alternative notation systems, but rather, several systems exist concurrently. It was found that some children were capable of using different notation systems for representing different domains already at 3 years of age.

The example in figure 7 below demonstrates that children can successfully use different notation systems functionally, depending on the task's content. For example: A writing notation for a name, a numeric notation for a telephone number, an iconic one for hair color and eye color.

Maps

A map is a two-dimensional representation of a three – dimensional space. In most cases, a map is a small-scale model of a specific spatial reality. The model guides spatial orientation and helps to perceive the spatial relations between entities in that space. Most maps are sketched according to a scale: the size of the real area is represented by each surface unit on the map. The larger the map's scale, the same area in reality will be represented by a larger map. The scale is determined by the map's purpose: the more details necessary, the larger the scale used. The aim is to have a uniform scale for each map, but this often conflicts with the desire to represent some aspects of reality more prominently – aspects that are particularly relevant for the map's use, such as: roads, rivers, railways and a long list of other details frequently marked on maps, which often exceed the map's general scale.

There is a type of map called "topological map" that are not accurate at all insofar as scale is concerned. Classical examples of this type are the maps of bus routes, railway tracks and the like. The purpose of these maps is to represent non-quantitative spatial relations between different points on the map: when traveling from Beer-Sheba to Haifa, Binyamina station comes before Haifa, and after Tel Aviv. That

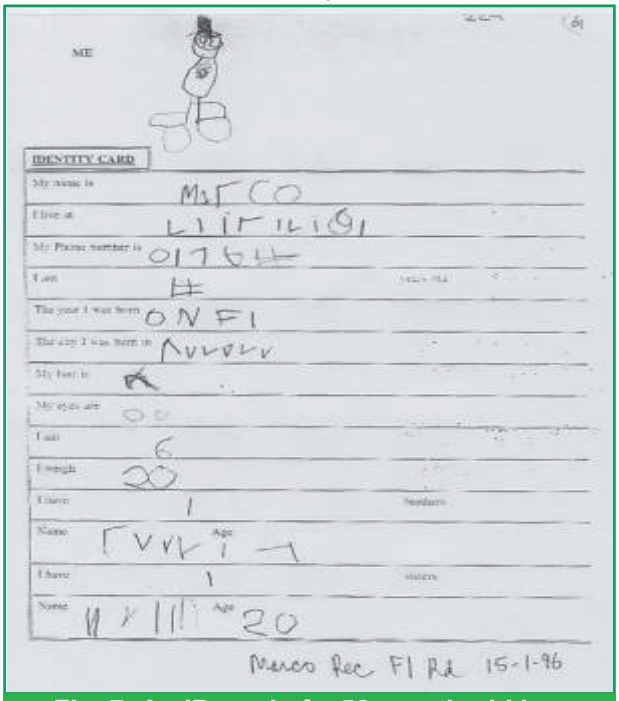

Fig. 7: An ID card of a 52-month-old boy showing various notation systems depending on the item type- referring to numeric o verbal non-numeric.

information is important for the passenger on the train; the distance in this case is irrelevant to the purpose of keeping track of the stations. Developmentally, the ability to produce and read topological maps precedes the ability to cope with the scale (Blades & Spencer, 1994).

As stated above, a map is a typical source of spatial information; however, it must be noted that one can also get information from other sources: verbal descriptions, cruising the environment (Uttal, Fisher, & Taylor, 2006). The different sources present the information in different ways which have different affordances, for instance, maps can show many different spatial relations concurrently whereas a verbal description specifies the various spatial relations sequentially, one by one. Uttal *et al.* (2006) investigated the effect of various sources of information on the mental models of children and adults about spatial relations. They concluded that maps and graphic representations such as sketches can facilitate children's spatial thinking by helping them overcome the sequential nature of verbal expression.

Kindergartens use quite a wide variety of types of maps: topological maps in which the children mark the way from the kindergarten to their homes; maps of sites, such as national parks, used to plan a visit to the site or to reconstruct it. A map of the kindergarten may be used to plan events - indicate the special arrangement of seats at a party to which guests are invited; suggest a new arrangement of the various activity centers, etc.

The following example was produced by a child with language difficulties (Fig. 8). It shows the way from her home to the homes of some friends. It is worth noting the significant contribution of the map to the girl's level of reporting: when consulting the map that she herself produced the level of her discourse was much higher than that which characterized her reporting without the support of the map.

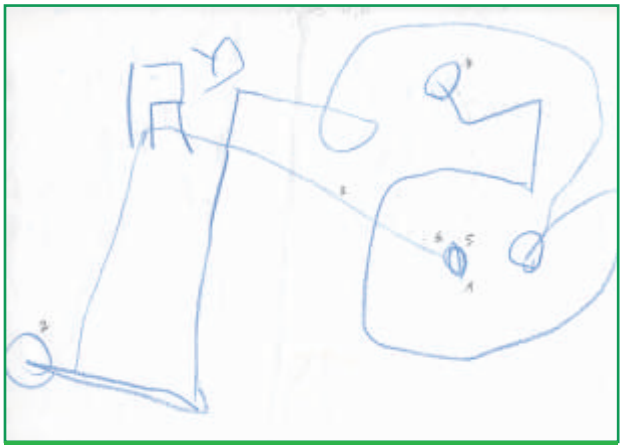

Fig. 8:A map drawn by a girl aged 60 months, in a kindergarten for children with language difficulties.

The literacy-enhancing role of non-verbal graphic texts

Following the above examples brings our attention to the special role of non-verbal graphic texts in the development of literacy in young children. Their use enhances children's ability to give spatial instructions (Figures 6 and 8), to notate data and observed qualities (Figures 2, 3, and 5), to report things that happened, track timetables and plan events (Figure 1). Additionally, sometimes when children use different notation systems, they do it according to their own choice and convenience (Figure 7).

This raises the question whether children's usage of non-verbal graphic systems changes after they acquire written language. Is there a discernable development in the way these representations are used? To the best of my knowledge, there have been no systematic studies of this subject. I think it is probable that the answer to this question is not uniform; rather, it depends on the differences between types of texts, and on individual and cultural differences. The use of some types of texts is temporary and fleeting: they serve the users at the stage when written language is not available and are discarded at a later stage (for example: drawing an object instead of writing its name). Conversely there are non-verbal graphic texts -such as maps and scientific illustrations- for which its use continues despite the fact that users can also avail themselves of verbal texts.

In the early stages, mind expansion, mind sharing and mind regulation through written language, has to be done by drawing non-verbal graphic texts - because the verbal written language is not yet available for children's use. It would be interesting to study this issue with adult users for whom verbal written language is unavailable. Later on, when the repertoire of the user's toolbox grows richer, a variety of graphic and verbal tools is used, their choice depending on content, interlocutor, user, and local resources at the user's disposal.

In some cases, there is a gradual replacement of non-verbal graphic texts by verbal graphic texts, for instance in stories. But it is not always so. There are circumstances in which the communicator (artist, journalist, graphic designer) makes exclusive use of a non-verbal graphic text, such as pictures or photos.

The use of mixed texts, i.e. texts in which the verbal and the non-verbal graphic elements complement each other, is common. Examples of widespread use of mixed texts are found in newspaper articles and in textbooks in science, architecture, geography etc. Non-verbal visual texts have a distinct advantage for representing certain content, such as math formulas, and spatial information. However, the common assumption that non-verbal graphic texts have greater transparency must be considered an over-generalization. There are non-verbal graphic representations, which represent thoroughly abstract

concepts and ideas, whose meaning cannot be perceived without prior background. See for example the graphical representation of the molecular structure of METHANE in the following image.

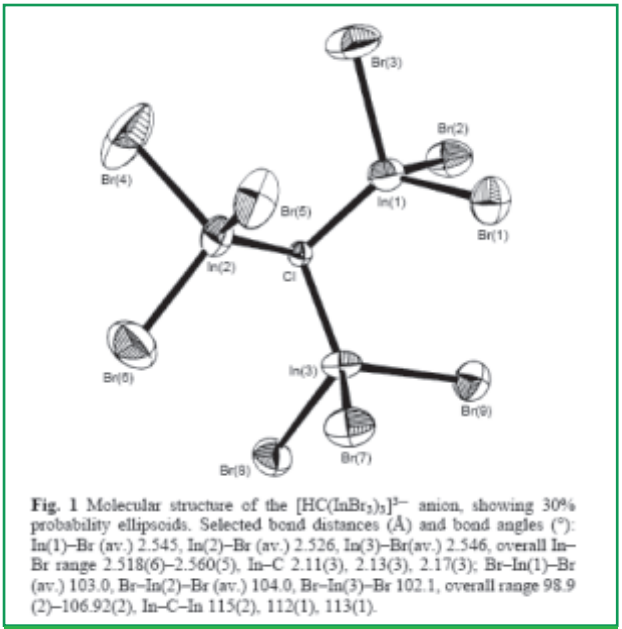

Fig. 1 Molecular structure of the $[HC(InBr_3)_3]^{2-}$ anion, showing 30% probability ellipsoids. Selected bond distances (Å) and bond angles (°): In(1)–Br (av.) 2.545, In(2)–Br (av.) 2.526, In(3)–Br(av.) 2.546, overall In–Br range 2.518(6)–2.560(5), In–C 2.11(3), 2.13(3), 2.17(3); Br–In(1)–Br (av.) 103.0, Br–In(2)–Br (av.) 104.0, Br–In(3)–Br 102.1, overall range 98.9 (2)–106.92(2), In–C–In 115(2), 112(1), 113(1).

Fig. 9: Graphical representation of the molecular structure of METHANE

Summary and conclusions

Symbolic systems are tools for enhancing cognition (Clark, 1997). Non-verbal graphic texts are a particular class of permanent external symbol systems - an external artifact suitable for enhancing emotional functioning, cognitive functioning, and social functioning. There are many aspects to the contribution of non-verbal graphic texts to children's development of literacy. The most important ones are:

1) support for bridging the gap between oral capabilities and writing abilities for preschool children. When these texts are accessible for children, they give them access to literacy events and generalizations within them in a variety of socio-cultural contexts – at a stage when written verbal texts are not yet included in the children's toolbox. In the examples presented above one could see how children manage to perform, using written language in its broadest sense, even before written language in the narrow sense of the word, becomes available; an ability that prevents frustration and increases motivation to acquire written language.

2) Enabling familiarity with different roles of written language. The children manage to record, communicate and process information at an early stage thanks to a variety of graphic representations available to them before they are capable of producing written verbal language (see, for example, Figures 2, 3, 5). These representations also underpin the development of literate discourse: thus the children have an opportunity to edit their symbolic expressions, organize them, and arrange them in a sequence when they are produced with the support of a graphical representation such as a calendar, a map, or a sketch (example: Figures 1 and 8). Early use of a variety of representations introduces the children to the differing affordances of various types of texts: it allows them determine the features of one representation versus another, their suitability for different purposes depending on the circumstances (example: Figure 4).

3) Exposure to different mapping rules (principles of representation) and experiencing them. Representing time in space (Figure 1) is done according to a principle different from the one guiding the representation of three-dimensional space in a two-dimensional one (Figure 8); the representation principle in an illustration is iconic, whereas the representation principle of a spoken word by a written word is an alphabetical one (grapho-phonemic representation using the letters of the alphabet)

These three aspects form an infrastructure that promotes young children's intelligent engagement with texts – both verbal and non-verbal.

Those involved in the training of teachers must recognize the importance of non-verbal graphic texts and ensure the students are aware of them, and capable of adding them to their toolbox and to the inventory of activities they offer children in their educational work.

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