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Mediating effects of active and distributed instruments on narrative activities

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ABSTRACT

This paper discusses the effects of introducing new distributed and active instruments on narrative activities in a school environment. We address the issue of how the Pogo instruments change children's activity when they invent stories. The results enable us to compare the way the activity is carried out, both in its conventional context and with the Pogo instruments, mainly along three main lines of investigation: the collective dimension, the use of space and the structure of the narrative. The results also show that using the instruments increase the collective or group dimension of the creative process, particularly the role diversification and participation of the children. These instruments support children's efforts to structure narratives and thereby produce richer stories.

This research was carried out within the Pogo Project by a multidisciplinary team that included interactive design and user-centred approaches within the EC I3 programme on "Exploring New Learning Futures for Children".

KEYWORDS : distributed instruments, mediation, narrative activity, collective creation.

1. INTRODUCTION

The development of new information and communication technologies is laying the foundations for new forms of building and sharing knowledge, and is leading to a reassessment of the concept of an instrument and the need to understand the effects of the use of an instrument on activity. According Vygotsky's law of semiotic mediation (1997, 1973); group and mental processes cannot be understood without taking into account the tools and signs that organize those processes. Vygostky's approach posits a complete renewal of the composition of a subject's activity in and through the act of using an instrument. This position leads to the question of the effects experienced by the subject when instruments derived from new technology are introduced. The question has already been addressed in a number of work situations. This paper explores another context, namely the educational environment and instruments used to support narrative activity.

Our objective here is to present the results of research on the design and evaluation of new distributed and active instruments intended for children age six to eight. In particular, we

intend to show how such instruments transform narrative activity. First, we examine questions of the mediating roles of new technology on activity, and formulate our approach to these roles in the context of narrative activity. Next, we present our methods, and the results obtained.

1.1. The structuring effects of new instruments

A number of authors posit the structuring effects of activity and human development in connection with the use of artifacts (Cole, 1996; Engeström, 1999; Kaptelinin, 1996; Rabardel, 1995; Wertsch, 1997). Problem space, work procedures, subject strategies and also group dynamics (Payne, 1991; Hutchins, 1990, Norman, 1991) vary on the basis of the instruments used. Characteristics of artifacts, such as their degree of openness and their horizon of observation, have an impact on the activity patterns of groups.

How technology can enhance user interactions has been explored in Computer-Supported Collaborative Work (CSCW) and Computer-Supported Collaborative Learning (CSCL) approaches (Gutwin et al. 1996, Dillenbourg, 1999). CSCL environments aim to support synchronous and asynchronous collaboration: support sense-making, facilitate external memory functions, enable communication and support implementation of collaborative activities (Kolodner and Guzdial, 1996; van Bruggen et al. 2002). Most groupware research assumes that face-to-face collaboration provides a richer experience, and distributed groupware systems are often designed to recreate the feeling of "being there". Scott et al. (2002) analyze how a shared workspace facilitates the development of a shared understanding during a computer-based collaborative activity. Given that children are very good in face-to-face social interactions, they become more motivated and successful when these interactions are supported (Inkpen et al. 1999). For instance, their results indicate that in synchronous shared environments, the physical proximity of participants, the possibility to better understand the partner, the ability to use gestures and the use of a shared physical space positively influence the students' collaborative experiences.

In spite of recent progress in the area of educational technologies - partially stimulated by CSCL approaches - we feel it is essential to examine new patterns of interaction that go beyond current computer-based technologies. Indeed in many educational computer systems, children control and manipulate knowledge and contents in the computer (for instance children can manipulate simulated urban environments, build houses and roads, etc). These systems place students in a circumscribed space. Their movements are reduced to mouse shifts and clicks, and their sensory interactions are limited to passive visual and auditory stimulation. The question we ask is "Why not use computers in the real world, and in a distributed way in the student's personal environment?" This question is now being investigated in an area of research called "ubiquitous computing", which aims to integrate computers seamlessly into the world at large (Weiser, 1991). In ubiquitous computing, computers disappear, becoming totally integrated into everyday objects. Computation is distributed throughout the environment, embedding computation in all types of objects and artifacts, or creating handheld instruments that enable people to access and exchange information wherever they are. Yet, mediation of activity by these instruments is still relatively unexplored and opens a new and innovative field of research.

1.2. Mediation of activity by instruments

The structuring effect of new instruments on either individual or group tasks can be analyzed in terms of the basic question of mediation by artifacts and mediation as the main factor in transformations of psychological functions as demonstrated by Vygotsky. It is important to note that our approach to mediation gives a pivotal role to activity mediated by artifacts. As theorized by a number of authors (Bannon and Bodker, 1991; Rabardel, 1995), the tool is in an intermediate position between the subject and the object. The activity of the subject towards the object is mediated by tools. This means that tools shape the way the activity is performed, and are themselves changed by the activity. There are a number of dimensions to this mediation, the main one being mediation of activity between subject and object.

There may be a number of patterns for structuring activity through the use of artifact. *Simple passive structuring* may be observed in relation to the form of the instrument. On the other hand, when the procedural organization of the activity is modified, the result can be described as *organized passive structuring*, which touches on the temporal dimension (time constraints), spatial dimension (inferring the place where the subject performs the action), and operational dimension (the types of actions and organization of the sequences of those actions) (Rabardel, 1995).

In group activities, interpersonal mediation comes into play. It takes into account the interactions between subjects, namely collaboration and cooperation. For instance, Engeström (1999) posits that a collective activity system is the relevant unit of analysis in order to explain the collaborative nature of actions. His view of activity involving mediation adds some dimensions related to the community and division of work.

During his activity, the subject is also in relation with himself. This third dimension of mediation, called "heuristic" (Rabardel, 1995), or "reflexive" is also mediated by the instrument. This is an example of the "forget-me-not" reminder.

The last dimension of mediation that appears relevant in our context is mediation of space. Barker (1968) pointed out the relevance of the environment for studying behaviour and recommended observation of the use of space surrounding people and their behaviour. According to Barker, a "behaviour setting" is a "pre-perceptual ecological entity", i.e. it exists independently of its observers and actors, it is constant and permanent and it exists over time. Therefore it has a space-time locus, i.e. it occurs at a specific geographic location and it may occur serially and have duration. A behaviour setting also has a milieu and a standing pattern of behaviour that are similar in structure. They are therefore in a "synomorphic relation". For example chairs are arranged in a classroom to face the desk, obliging children to face the teacher. A behaviour setting has internal unity and coerciveness, which implies that the standing patterns of behaviour are not transposable. When any principle part of a setting is changed, the setting as a whole is changed. For example if a classroom is changed, including different decorations or tools, it becomes a new setting and the patterns of behaviour could be changed. According to Barker, the settings are a means to convey patterns of behaviour from person to person – behaviour objects are artifacts which afford particular actions, a ladder have physical properties and associated behaviour. An environment and its objects are important in achieving congruency in group activities. The environment and the instruments in the environment stimulate situated behavior and produce a common action environment for a number of cooperating participants. When several people are present in the same place, joint action is enabled. This is because they perceive each other in the environment and are included in the action situation (Pankoke-Babatz, 2000).

1.3. Distributed and active instruments

The development of a distributed technology is the anchoring point of a research project on which we[1] are currently working. We designed a fully distributed environment where children can build stories, and gain knowledge of the world, reflect upon that knowledge and share it with others. The challenge we faced in designing this new system for interactive story building, was the need to envision a new form of interaction that encourages creativity and cooperation. We targeted children age six to eight as intended users of instruments intended for collaborative creation of stories. POGO was designed as an open environment, a "space" for possible activities and experiences that complement conventional learning practices and tools.

This technological orientation is based on a set of complementary concepts: the concept of perceived "affordances" of objects (Gibson, 1977), which extends into the information appliances proposed by Norman (1999), and the concepts of distributed and active tools.

Within the framework of Pogo, simple active instruments were designed. The instruments are described as distributed because the various units of the system are distributed throughout available space, and because they have different functions that are conventionally united in a single unit. For instance, the Beamer (see instrument descriptions below) is used to visualize and capture data, whereas the Basket is used to read data.

The instruments also provide for distributing contents in physical objects that are distributed throughout the space (i.e. a setting or scene is recorded on a card, while another card contains the characters involved in a story, the first read by the Basket and the latter by the Torch - see instrument descriptions below). The POGO system provides rich active connections to the world. We were interested in connecting computation to physical objects, enabling children to sense their immediate environment and to react by performing actions. The system has a rich assortment of input-output capabilities including ports for motors and sensors.

The instruments that make up Pogo were designed to support the children's invention of a story. In the school context, narration is a tool for learning subjectivity. The child learns to describe his/her own experience and to differentiate it from the experiences of others. Our approach is to analyze the structuring patterns of narrative activities in the context where they are created. We do this by introducing new active, distributed instruments. What sorts of structuring effects can we expect from introducing Pogo's active and distributed instruments into the educational environment? In the case of the activity that concerns us, namely construction of narratives, we want to know if the structuring is specific and what components of the activity are transformed.

1.4. Instruments that support classroom narratives

In the school environment, a number of instruments are used by teachers and children to construct narratives. Typical examples are notebooks, blackboard and materials such as plasticine clay, pencils, etc. The *Observations Notebook* is used by the child to express his own impressions of each type of environment that he experiences (e.g. in class, in his

[1] Within a project named POGO, carried out by a European consortium composed of designers and specialists in user-centered approaches (Domus Academy, Philips Design, Universita di Siena, Université de Liège), European Programme I3 – Intelligent Information Interfaces, "Exploring New Learning Futures for Children".

everyday existence, during visits to museums). The *Story Notebook* consists of an illustration and a story made up by the child when he gives free rein to his imagination. The teacher records the story dictated by the child in the *Rough Draft Notebook*, and the child copies the story in his/her *Story Notebook*. Sometimes the blackboard is used to pin up children's stories, and consequently share them with the whole class. While the Notebooks are personal, the blackboard is a group instrument.

Five instruments (fig. 1) make up the first generation of Pogo. The **Beamer** is a threshold tool, which connects the real and the virtual environment by allowing the passage (storage) of physical things into the virtual story world. It is a base unit integrating a video camera laid over a Basket and a card reader. The Beamer allows the real-time projection (on the Screen) of any kind of physical object placed in the basin. Children can also place their body under the camera and have their hands or face projected on the Screen. The combined use of Beamer and **cards** allows users to capture and store (on the cards) the physical objects placed in the basin.

The Pogo tools: Beamer (a), Basket (b), Token (c), Screen (d) and Torch (e).

Cards are based on tag technology and contain a unique ID tag. They contain data captured by the Beamer, which provides for storage, transport and exchange story elements. Indeed everyday objects can be defined and associated with corresponding virtual objects by storing the image of an object on the Card. The storage is performed on the Beamer while the reading is activated through the Beamer, Bucket or the Torch.

Pogo Screen displays the objects placed in the Beamer Basin or stored on Tokens or imported from the real world via the Beamer. The Screen can be used to display drawings or other materials produced by the children. ***Pogo Basket*** is used to read the contents of the cards, and display them in Screen background. The ***Pogo Torch*** is also used to read cards contents, displaying them in the foreground. The Pogo configuration also includes a central processing unit, invisible to the user.

1.5. Narrative activity within its context

Classroom observations enabled us to understand how narrative activity is organized, and to identify a set of pertinent dimensions that correspond to this organization. We classify these dimensions in four main categories: the narrative activity phases, the role played by the group, by the workspace and the structure of the narrative. The group dimension involves the distribution of roles among the children, forming a team and sharing the narrative content during and after its production. The space and physical setting variable includes the identification of the environment where the activity occurs: children, teacher and tool configuration within the environment, the way the classroom is adapted and the attention focussed on the tools.

In the perspective of a global analysis of narrative activity, we looked into the products of this activity, into the narrative as a result of the narrative process. Among the numerous approaches used to study the formal organization of the narrative, we selected the approach taken by Labov (1972) and Labov and Waletzky (1967) that was suitable for analyzing the main structuring effects of Pogo tools on stories produced by children.

1.6. Structuring effects of POGO instruments on narrative activity

To what extent is the organization of narrative activity modified in its group dimension, to what extent is the use of space changed and the product of the narrative activity modified? These are the three paths that we want to explore in this article. We posit a big change in activity, on the level of interpersonal mediation, on interactions between children and on the nature of cooperative narrative activity. We also assume that the instrument's mediation of the object generates specific use of space in relation to the conventional classroom setting. POGO instruments modify the space in its totality ("classroom"), and create a new space. POGO instruments imply a different occupation of space and activity is modified both in terms of creative work involved in the construction of narratives, as well as in group activity. Taking into account the affordance of the instruments, their ease of use, their distribution in space and their interactivity, we can anticipate that their use in no way hinders the production of the narrative, but rather that they enrich the narrative. It is also conceivable that the new means of narrative expression that the system offers children would have an impact on the way narratives are constructed and structured, certainly on the verbal level, in conformity with the Labov model, but also on the visual level. On the other hand, taking into account the characteristics based on the form of the instruments and their uses, we would expect to see multiple patterns of structuring, whether simple or organized, as shown by Rabardel (1995).

Before presenting the results obtained, our methodological approach is described below.

2. METHODOLOGY

In this section we will not describe the methodology of the whole design process but we will mainly concentrate on the procedure used for the testing period. This period consisted of three main phases: preparation with and without the teachers, performing activities with the children (or data collection) and data analysis with and without the teachers.

2.1. Preparation

The preparation phase is divided into two parts. The first, among the researchers, aimed to define objectives and observation criteria for the testing. The second prepared the teachers and got them ready to use the instruments, and involved working with them to select activities to be performed with the children.

We defined the testing objective as the evaluation of changes brought about by instruments designed for the activity. While we do not want to enter into the details of the initial activity analysis that produced design concepts and defined requirements for the purpose of our testing, we need to recall some aspects of this phase of the design process. Indeed, the observation criteria used for the testing derives from the variables we identified as particularly

relevant to the conventional narrative activity observed. This activity analysis and the model derived took into account the main mediating resources shaping children narrative activity at school: artefacts used during the activities, the space in which the activities took place, the physical setting of desks and chairs, the individual/collective/cooperative character of the activity, the interaction that took place between the various participants. The basic assumption is that any narrative process is always defined by a specific combination of these resources. We believe that the mediating elements identified as significant have a combined effect on the activity. It is this combination and its synergy that transforms the narrative activity.

While the concept design assessment was filtered through the pedagogical objectives, prototype testing was filtered through analytical and design criteria derived from classroom observations performed during the initial analysis. These criteria are described in the facing table:

Individual/group Dimension	**Space**	**Narrative structure**
Mechanisms of cooperation in the construction of the narrative Sharing the narrative contents Distribution of work Sharing tools	Activity environments Children, teacher and instruments configuration in the environment The way the classroom is adapted The attention directed toward the instruments	Structure of the narrative into categories Sequentiality and narrative effects Visual organisation of the narrative

Table 1
Analytical criteria of data – mediating dimension

During the preparation of the testing we also spent some time getting the teacher familiar with these new prototypes by presenting them the instruments in form of paper and video documents. These drawings, definitions of instruments and their functions were accompanied by examples of possible uses in conjunction with existing materials. This phase of familiarisation had two objectives: firstly to allow the teachers to better understand the functions of the system, so they could select the most appropriate activity for the testing; secondly, to insure a smooth interaction with the instruments during the testing, so that the activities could be performed naturally without excessive focus on their operation. But the instrument presentation also allowed teachers to comment on the potential value of these instruments in narrative activities. The teachers provided their criticism and raised points about implementation (i.e. tool nomenclature, database access and modification, animation, saving creations, accurate colour matching on the Screen, etc.). The teachers wanted to practice using the instruments before employing them in the context of children's narrative activity.

After this stage of familiarisation, we asked the teachers to select a set of activities in which the instruments could be used and performance improved. This phase of selection with the teacher validated the capability of the instrument to fit into real narrative activity. Indeed, teachers started thinking about their regular narrative activity they wanted to perform with the children in the future weeks, but also trying to imagine how to perform it with the new system and how this system would be an added value to the conventional activity. This phase allowed for the selection of several topics related to their current activities.

2.2. Testing

Eight activities guided by their teachers were carried out with groups of children age six to eight. As examples three typical activities are described below. This selection was motivated

by the fact that the other activities observed during the testing differ in term of theme but are comparable in terms of general organisation.

Goldfish in the sea. Following a several day trip to the sea, the children continued to use the theme in various class activities. The presence of Pogo instruments suggested the idea of creating a story using the material collected during their trip. For example, the Basin of the Beamer was used to reproduce the seafloor, and living goldfish were added. After a production phase where all of the children invented a story, one of them presented the whole story to the other classmates.

Castle invaded by witches. Everything began in class with the creation of a scene on a sheet of A4 paper and cardboard silhouettes, cut out and attached to straws. These elements became 2-dimensional puppets. The children took a little while to understand how the Beamer could be used to have their character play roles, and to improvise dialogues for their story. At the end of the story, it was already time to recount it to the half of the class that did not participate in the Pogo activity. As opposed to the other activities, this one left free rein to the children's improvisation with little intervention by the teacher.

Mushroom development: Believing that Pogo tools could be used for analytical activity, the teacher used the system to help the children reflect on a past experience. After having attended a meeting on the development of mushrooms, the children used Pogo to reconstruct and visualise the various stages of this process. The pictures made were then showed to the rest of the class.

Each of these activities was filmed in video. The observation and capture of video data was carried out by two observers. Two stationary digital cameras and one mobile digital camera were used. The stationary cameras were placed on tripods on either side of the Pogo instruments, to provide uninterrupted filming of the activity. The observer used the mobile camera to film selected dialogues, interactions between children or particular uses of instruments. The researchers did not intervene during the activity, except when a problem arose with instrument use, and then only to provide additional information on its use. The observers' presence in the experimental space does not seem to have disturbed the children, who rapidly ignored their presence.

The Pogo system was installed in a room normally used as the library. Half-groups 7 to 9 children were formed. The instruments were laid out as shown in the facing diagram (fig.2).

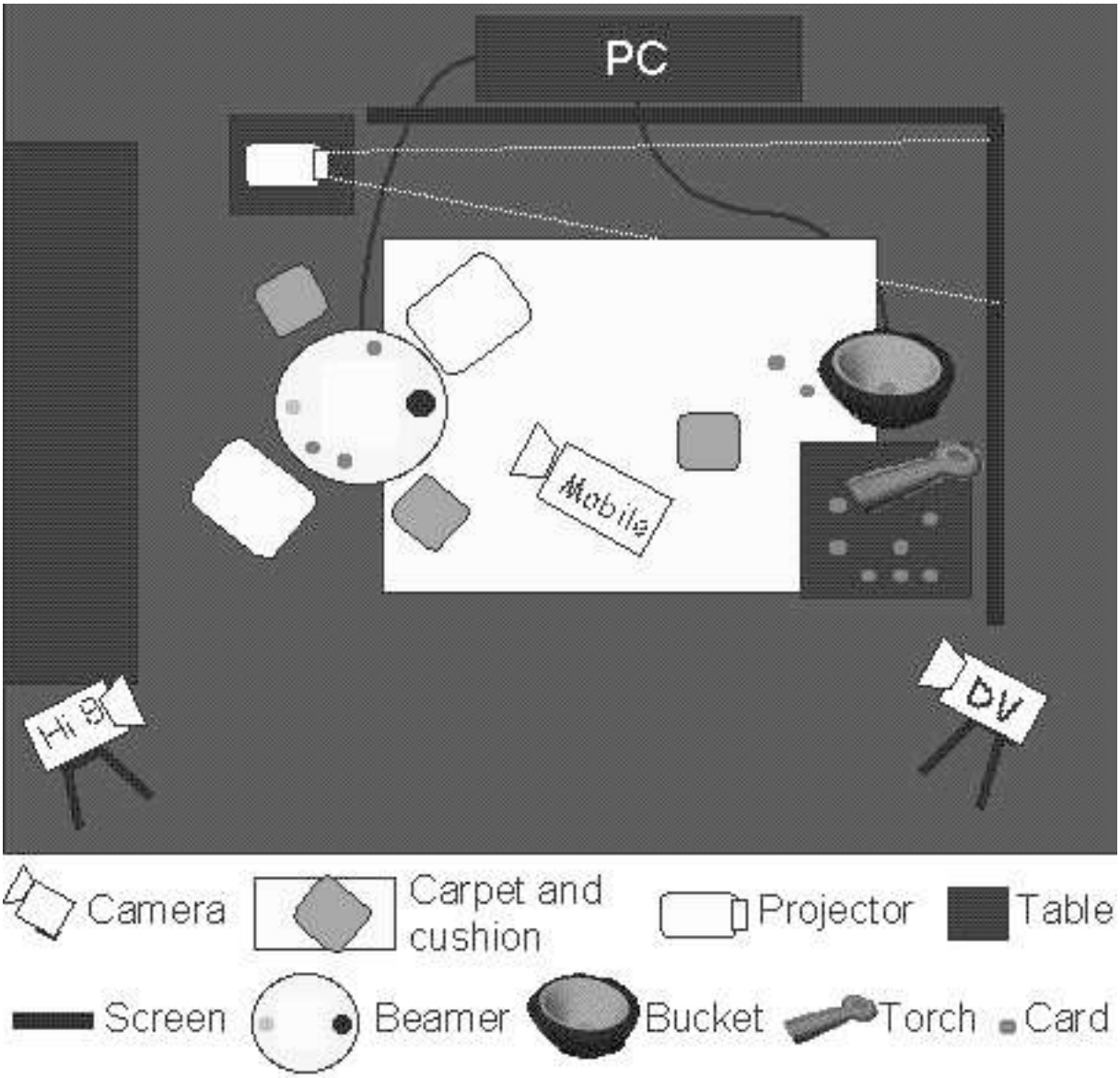

Figure 2. The Setting of the testing room

2.3. Post testing

Each observation was transcribed. The transcribed data reports particularly on the manner in which the activity was carried out by the teacher, the child's narrative production, the verbal interactions between children, the behaviour and movements of the children in the space, individual and group activities. The data also illustrates the types of instruments used at different stages of the activity. The transcription was guided by the table of criteria defined earlier in the evaluation process.

The results of these observations were compared and discussed with the teachers. When the narrative activities were finished and some data transcribed, a meeting was held with the teachers in order to gather their impressions, comments and criticism concerning the prototypes, their use and their impact on the activity, and particularly on the changes

introduced by the instruments in terms of teacher behaviour, group dynamics, and structural parameters.

The observations, transcriptions and teacher comments were also analysed in light of the observations and the analysis of conventional activities and discussed among members of the research team. The presentation of the results were structured according to the established criteria.

3. RESULTS

3.1. Narrative activity without Pogo instruments

The analysis of the narrative activity provides insight into how the activity takes place for each child, for groups of children and for structuring of the story.

3.1.1. Narrative activity phases

Narrative activities involve complex organization where the child is guided by the teacher. We have broken down this process into four stages: Exploration, Inspiration, Production and Sharing (fig.3).

Figure 3. Narrative activity without Pogo. Exploration (fig. a,b): children explore the garden and collect material for a narrative activity. Inspiration (fig. c): some examples of children reports on the Observation Notebook. Production (fig. d, e): while children work individually, the teacher passes through the tables and helps them to structure the content in a narrative form. Sharing (fig. f, g): teacher reads the stories produced by each child and shows the illustrations.

Exploration. All narrative activities that we observed are rooted in the child's experience (fig.3a, b). The narratives are things the child has seen, heard, touched or encountered in the museum, the forest or on the seashore… This means that the teacher initially focuses on the sensory experiences of the child, which subsequently constitute the starting point for the theme and for the ideas. At this stage, the child uses instruments appropriate for exploration (dip net, shovel, microscope, etc.) and handles various materials (earth, shells, sand, etc.).

Inspiration. Next, the child is encouraged to think about this experience, discuss it and sort out the elements that he/she gathered. The teacher accompanies the child in the analytic process and in the discussion of choices. This phase is usually supported by individual writing or group discussion. If the activity is individual, the children primarily use the Rough Draft Notebook and the Observation Notebook (fig. 3c) If group, the blackboard is used for the media for discussion.

Production. The following stage of the activity is focused on producing the narrative. All information that has been stored is combined and organized in the form of a narrative to produce a story. During this phase, the teacher's role is to supervise the organization of narrative content, as well as to insure conformity with standard rules of story construction, such as having a beginning in which characters and situations are presented, a middle where the problem is explained and an end that shows that the problem has been solved. The teacher also makes sure that the text is coherent and sufficiently rich. During this phase, the children mainly use their Story Notebook and pens for illustrations (fig. 3d, e).

Sharing. To conclude the activity, the teachers propose a moment of exchange and sharing of the narratives produced. In conventional activities, this is the phase when the teacher concentrates on the presentation of the final product created by the child. Sometimes the teacher reads the child's product and presents his drawing to the class (fig. 3f, g), in cases where reading skills are not yet acquired. Sometimes the child presents his production to his/her classmates or simply to the teacher. Once again, the most important document in this phase of the activity is the Story Notebook, which contains the final product: text and drawing.

3.1.2. Individual/group dimension

In most conventional activities observed the narrative is created individually by each child. The Exploration Phase is usually carried out in groups. Afterwards each child independently carries out the process of creating the narrative. The Inspiration stage usually involves use of the Observation Notebook, which is a personal and individual tool, in which each child expresses his own point of view on the experience, the sites visited and the observations that he/she made, etc. The actual story production is also a personal and individual process. The child does not know how to write. He/she is helped by the teacher, who guides and questions the child, and transcribes the story in the Rough Draft Notebook (fig. 4a). Next the child copies the text in the Story Notebook (fig. 4b). Some months later the child writes the story independently, and the teacher intervenes only when there are difficulties.

Figure 4. Individual /group dimension without Pogo. The teacher encourages and questions the child and transcribes the story in the Rough Draft Notebook (a). The child copies the story from the Rough Draft Notebook in the Story Notebook (b) and draws an illustration (c).

The graphic illustration of the story is also done individually, during or after the verbal description (fig. 4 c). In other words, in conventional activities story making is mainly an individual undertaking.

Nevertheless, we also observed some activities where all the children of the class or of sub-groups worked together to create a single story. These group creations generally end up being group presentations (plays) or they take place in a particular context, i.e. afternoon workshops. The patterns of cooperation vary on a case by case basis, but generally the phases of group activity (choice of story subject and story line, etc.) alternate with individual creation (drawing, inventing dialogs, etc.), where each child makes his/her personal contribution to the construction of the story.

3.1.3. Spaces and physical settings

Our analysis of the activities enabled us to identify three generals areas where story creation takes place: **classroom**, where the most consistent part of the story is constructed (writing, dialogue with the teacher, etc); **outside world**, where the children carry out their experiments (trip to the ocean, or to the woods, etc.) and collect elements (shells, leaves, etc) that will be brought back to the classroom and used for general educational purposes and more specifically for narrative activities; **dedicated spaces**, used for specific activities connected with the narrative process, e.g. performance (theatre), search for information (library), and socially mediated experiences (museum), etc.

Classroom activities usually take place in the conventional spatial configuration: each child sits at his or her desk, facing the teacher. The teacher sits at her desk or moves around the class approaching various children. During activities, children also go to the desk, one at a time. However, this does not involve any changes in the spatial configuration of the class: there is no change in the furniture layout. Nevertheless, we observed some rearrangements of the normal classroom layout when the children work in groups. During these group sessions,

the teachers like to rearrange the children's desks (provided room size is suitable), turning the desks so they face one another and thereby facilitate communication between the children.

Figure 5. Spaces and physical settings

We also recorded a circular arrangement during storytelling (in the classroom, but more often in dedicated spaces). Likewise, we noted situations where the children sat in a circle on the floor while the teacher presented a story. There is no structured physical arrangement in activities outside the class. The teacher simply makes the best use of the particular environment.

3.1.4. Narrative structure

Stories produced by children using conventional procedures mainly consist of a brief written text, occasionally combined with a drawing. This product represents a more or less descriptive episode of the story, the characters or may be more or less abstract and decorative. It is uncommon for first year children to be able to construct a complete story, in Labov's sense of the term. According to the teachers, narrative production in this age group consists of the "beginning of the story, describing the situation, characters and action". Aided by the teacher, the child gradually learns to better structure the narrative. In higher classes he/she will learn to build better structured narratives and "properly formed stories, with a beginning, middle and end".

3.2. Narrative activity with Pogo tools

Taking into account the observations and interviews with teachers, it is possible to analyze the recomposition of narrative activity and to identify a number of structuring effects that can be regrouped according to our analytical criteria: the group dimension, the use of space and story structure.

3.2.1. Effects on the narrative activity

Data gathered enables us to identify the structuring effects of instruments in terms of the way the activity is organized. Can we repeatedly find the same phases? What is the role of the instruments in particular phases?

Exploration. Pogo instruments do not affect this exploration phase. Even if proposed during the activity, Pogo instruments are not used by the teachers. The teachers feel that "the Exploration Phase does not need Pogo instruments", because nothing can replace direct, unmediated experience for entering into contact with one's environment. Nevertheless, the Beamer, which enables the user to import a virtual version of various sorts of objects, would stimulate both child and teacher to make a record of a direct, unmediated experience. Teachers encouraged the children to tell their stories by using the Beamer, and projecting images onto the Screen (seashells gathered on the beach in fig. 6a and mushrooms gathered in the woods in fig. 6b). In conventional activities, they could only reproduce these objects in the form of a drawing.

Figure 6. Exploration with Pogo. Use o the Beamer of seashells (fig.a), mushroom and leaves (fig.b) respectively in the "Goldfishes in the sea" and "Mushroom development" activities.

Even though the instruments are not used directly in this Exploration Phase, they do not limit it. In fact, they encourage exploration through the primary function of the Beamer. On the other hand, there are two principal reasons why the instruments play no determining role during this phase. The first is that it is only possible to use Pogo instruments where they are installed. The only objects that can be reused in the Pogo system are those that are can be brought to school. As the teachers pointed out, the current system can not be used to enrich the narrative with a picture of a tree or a landscape or many other elements encountered and captured on the spot during exploration. In connection with this limitation, there is another problem concerning the types of experience that the instruments can capture. While the Exploration Phase involves all of the child's senses, the current system can only record static images. Pogo technology cannot yet integrate moving pictures and sound into narratives, with the resulting loss of experiential parameters that are important for children.

Inspiration. As with conventional activities, in all activities analyzed, the teachers encourage children to rethink the original experience, to list its constituent parts and to express them verbally or graphically, selecting the most important components in terms of either content or the child's personal experience. The change here, is in the resources available to encourage thought and choice. In comparison with conventional activities, Pogo instruments seem to offer greater support for the teacher's efforts. The possibility to combine and recombine elements on the Beamer table, and to display the result on the Screen in real time facilitates experimentation and comparison of different solutions. In addition, Screen displays have an amplifying effect that facilitates perception and information sharing. The instruments support both personal reflection and intersubjective comparison. This is particularly evident in the

activity “Mushroom Development”, where the children spend nearly all the Pogo session in the Inspiration Phase. The children gather around the Beamer and the teacher encourages them to use the material placed at their disposition to reconstruct the developmental phases of the mushroom. The Beamer acts as a support for handling the material, and for producing a drawing (fig. 7a). The teacher encourages each child, in turn, to suggest ideas by modifying the way the material is laid out on the Beamer table (fig. 7b). The Screen enables them to monitor their own production, as well as the productions of other children (fig.7c), and becomes a support for their discussion and group decisions.

Figure 7. Inspiration with Pogo. During the “Mushroom development” activity, the Beamer is used as a support for drawing (fig. a) and for experimenting various compositions (fig. b). The screen allows to monitor the results (fig. c).

This means the second phase, Inspiration, appears to be supported by Pogo. It appears that the instruments help the children to think and analyze their own experience.

Production. In relation to conventional activities, Pogo instruments do not detract from the teacher’s guidance and encouragement, which continues to serve as support for the construction and organization of the narrative. Nevertheless they provide the child with some independence in his/her organization of the contents (see “Narrative structure”): according to the teachers the tokens encourage the child to construct the narrative in a coherent and well-structured manner.

We also note that the instruments proposed, particularly the Tokens and the Beamer, led the teachers to structure the activity in a very specific manner. These activities mainly followed a specific sequence of events. In their constant interaction with the children, the teacher first guides the children towards a verbal construction of the scene (fig. 8a) Next, she suggests that the children use available material to make a graphic illustration (fig. 8b and 8c) of what they have just described verbally. And finally, she asks the children to memorize the image created on a token (fig. 8d) and to number it with a sticker (fig. 8e), in order to keep track of its order in the sequence. These various tasks are repeated throughout the construction of the story. This verbal and graphic creation is supported by the instruments. On one hand, the circular form of the Beamer adapts well to the spatial organization of the children. They gather around the periphery, a physical arrangement that lends itself to verbal exchanges. This circular arrangement is often used for telling stories or reading them during conventional activities. During most testing activities the teachers also ask the children to sit around the Beamer when they are inventing their story. The Beamer not only offers an opportunity to produce graphic representations of what is said, but also to save tangible traces on the Tokens. The teachers make use of these opportunities. It appears that the rectangular form of the Beamer’s basin, which resembles the page of a book, strongly encourages the teacher and children to construct graphic representations of the narrated scene. This combination of verbal and graphic expression organized and saved in a precise sequential order closely resembles the creation of

an illustrated book. The metaphor of the book, which seems to have been proposed by the teacher, is even more strikingly evident during the Sharing Phase. The transition from one illustration to the next guides the narrative, just as though the children were paging through an illustrated book, and telling the story as they looked at the pictures.

Figure 8. Production with Pogo. After creating a text orally (fig. a), children build its graphical representation (fig. b , c), record the scene on a token (fig.d) and the label it (fig. e).

On the other hand, when the teacher provides less guidance, the children produce their story with greater independence – as occurred in two activities ("Castle invaded by witches" and "Story of sound") - the metaphor of the puppet show is employed. During these two activities, the children spontaneously sat down behind the Beamer, facing the Screen. As soon as the activity began, the children started moving the silhouettes on the glass plate of the Beamer and kept track of the results projected on the Screen. Their characters were animated against

background scenery, like a Chinese shadow puppet show. The teacher then suggested that they improvise dialogues, giving voice to their characters, rather than describing the action, as they do in other activities. We can conclude that with Pogo's Beamer the child is the actor, and when looking at the Screen he/she is the public.

In short, Pogo supports the story's production phase, as organized and directed by the teacher, as well as the more spontaneous and improvised operating mode of the child. Nevertheless, this phase still has important failings in the eyes of both teachers and the children. The problem is that the dialogues, sound effects, animation and other creative narrative effects suggested by the teacher or proposed by the child could not be recorded.

Sharing. The instruments that the Pogo system places at the disposal of the teacher can be used to amplify and enhance the moment when narrative products are combined. Using Pogo instruments, not only is the creative process shared by the class, but sharing the final product becomes a fundamental part of the process. The children insisted on "redoing" the story for themselves during all testing activities, and also wanted to present the story to children who had not participated in the production.

This need for sharing can be explained essentially by understanding that during the creative process the children are concentrating mainly on creating a scene, and have difficulty formulating a global view. In conventional activities everything is located on one or two pages of a notebook. With Pogo the data is stored on chips, and so Tokens, Basket, Screen and sometimes the Torch have to be used to display it.

In addition, this Sharing Phase favorably supports the amplifying of contents on the Screen, which constitutes a net improvement over current personal tools (i.e. Story Notebook). The teachers claim that the children like to show what they produce, that seeing it enlarged and presenting it to a larger public makes the child feel important. There are differences between conventional and Pogo activities in enabling the child to achieve this importance. Theater – an annual activity – is the conventional opportunity to achieve importance in front of the group, whereas Pogo offers that same opportunity for all narrative activities.

3.2.2. Mediating effects of the individual/group dimension

Contrary to conventional activities, Pogo narratives specifically have a group dimension. Children participating in the activities contribute to the production of the same story. This group dimension seems to be motivated mainly by the multiple components that make up the Pogo system, and by certain specific characteristics of the instruments. The presence of a number of functionally diversified instruments distributed throughout the activity space implies the participation of a number of children to operate the system. It would be difficult for a single child to utilize the system's full potential.

In addition, the physical and functional characteristics of Pogo instruments produce affordances to group use: the Beamer 's circular base enables a number of children and the teacher to sit around the perimeter and encourages them to work together. The Beamer provides a common and sharable work surface for groups. This surface can be used to create characters, spread out and combine different parts of the story.

The Screen offers an instrument for sharing the narrative content that is being constructed. All children can see it. It focuses their attention, which is impossible with the conventional tools currently used to create a story (Story Notebook, Observation Notebook, etc.)
However, the patterns of cooperation between children during the creative process reveal some special mechanism that should be analyzed in greater detail.

Effects of role diversification. During the evaluation we observed a division of labor during the creation of scenes, namely "producers of contents" and "technicians": certain children produced the story line (fig. 9a and 9b), whereas others were mainly occupied with the use of Pogo instruments (fig. 9c to 9d), although the roles did change. The participation of the first group is the core of activity aimed at producing the story, and the second, more technical component is both active and oriented towards implementing the activity. This diversification during creation can be explained by the distribution of the instrument functions: the Beamer is the only instrument that can be used to create content, whereas the other instruments serve to memorize (Tokens) or reproduce (Basket, Torch and Screen) the results achieved with the Beamer. In addition, we noted that the sequential organization of the scenes requires a special sort of investment. Since the content of the Tokens is not easy to read, external media must be used to keep track of their order. The Tokens are labeled with stickers and checked using the Basket. The complexity of the operations involved in memorizing the sequences encourages some children to occupy themselves continuously and exclusively with this task, thereby becoming technicians.

Figure 9. Individual/group dimension with Pogo. Children are distributed in the classroom's space (fig. a). While some of them create the story content with the Beamer (fig. b), others take care of labelling and ordering the tokens (fig. c, d).

Effects on participation. Following the testing, the teachers confirmed that this new role of "technician" enabled children who generally participated the least in conventional activities to better follow the activity, even if they were not directly involved in the story: they listen to, follow and memorize the story more easily than normal. This enhanced possibility of participation appears to stem from two sources. On one hand, the Screen enables all children to share graphic creations of individuals or sub-groups, to create a common reference, to facilitate participation and story memorization. On the other hand, the tasks of recording and managing the sequences of Tokens requires the children-technicians to pay continuous attention to what is happening during the activity of constructing the narrative. This encourages them to follow the creation of the story line and memorization.

3.2.3. Mediating effects on spaces and physical settings

During testing, the Pogo instruments were placed in the library. The first interesting aspect to be analyzed is the role played by this new dedicated space. We call it the "Pogo space" to differentiate it from the three other types of spaces used in conventional narrative activities. The other important spatial change introduced by Pogo is the the integration of virtual space in school children's narrative activity. By offering the possibility of digitalizing material objects and visualizing the resulting images in physical space, Pogo creates a two-way relationship between the material and immaterial that did not exist in conventional narrative approaches nor in existing computer-based products. We will therefore analyze the relationships between the Pogo space and the three sorts of spaces (virtual, classroom and outside world) in terms of the structuring effects that result from the integration of Pogo instruments in narrative activity.

Pogo-classroom space

While the Pogo environment is designed to be integrated into normal practices and the normal environment of the school, the initial reaction of the teachers was to view Pogo spatially as a sort of laboratory functionally separated from the normal classroom. This reaction can be attributed mainly to transitory limitations connected with the difficulty of moving the Pogo system around, and the space occupied by the components, which makes it difficult to integrate the system into a normal classroom. Another, more profound, explanation is related to the important changes in the use of space: the introduction of Pogo implies extensive revamping of normal school practices. Further explanation of this aspect can be found below.
During the testing period, we observed that the spatial arrangement of the tools and the children was radically different than found in a normal classroom (fig. 10).

Figure 10 (a, b,c). Spaces and physical settings. The children are divided in spaces in several groups according to the elements they have to construct.

Testing also revealed three types of spatial distribution of the children in the Pogo space.
In the beginning, when the children are using conventional material (drawings of landscapes, plasticine story characters), they arrange themselves in groups of two or three in the various areas of the Pogo environment, working on the floor or on a table (fig. 10 a, b, c). It is interesting to note that at this point the children are not using Pogo. Some children turn away from the Beamer and concentrate completely on the elements used in their construction. This shows that the children view the Pogo instruments as a means and a mediator of activity, not as a finality in itself. When the story elements are put together, the children sit on the floor around the Pogo instruments. The "creators" of the content gather around the Beamer, whereas the "technicians" of the production gather around the Basket, though they go over to the Beamer several times.

Once the story is completed, it is shown to the public. The "actors" or "creators" leave the Beamer and go to the Basket. The audience forms a semicircle, facing the Screen, at a distance that allows them to visualize the whole Screen (fig. 11). Some of these spectators are children who took part in the creation, but who do not help to present the production. A small group of narrators occupies an area near the Basket, between the Screen and the audience. This position provides them with easy access for inserting Tokens into the Basket, while monitoring the projection of scenes on the Screen.

Each of these three configurations has a particular function in the Pogo space, depending on the task being performed by the children. According to the teachers, this variety of configurations and the mobility implied are not compatible with the conventional arrangement of desks in the class. We therefore conclude that the current spatial arrangements required for working with Pogo instruments apparently implies the need for a dedicated area for Pogo.

Figure 11. Scenes creation : children form a semicircle around the beamer facing the Screen at a distance that allows them to visualize the whole Screen and to check the result of their production before recording. Some children are also standing up nearby the screen pointing elements and calling the children attention on specific contents.

The teacher is also obliged to reposition herself in the new spatial configuration. She leaves the front of the class and sits on the floor with the children. This new use of space is explained in part by the fact that the Pogo instruments are placed on the floor. The system was designed

as a game environment, providing recreation and a break from conventional learning. It aims to loosen the reins on the child's imagination and fantasy. The child is encouraged to sit on cushions on the floor, his or her attention no longer directed towards the teacher, but rather towards the contents of the activity. In addition, the spatial distribution of the instruments and their function varies, forcing the children to move from one instrument to another, on the basis of the task at hand.

Pogo-outside world space

Most testing activities took place exclusively in the Pogo space. The children went outside the school only once. They wanted to make a forest scene, so they went into the garden to collect branches and leaves. During the other parts of the testing activities, the children used a rich and varied assortment of objects recovered prior to the arrival of Pogo. These included mushrooms ("Development of a mushroom" and "Magic forest"); living fish and seashells (Goldfish in the Sea); and a dead mole (the Mole). These elements served as characters or scenic elements in the story.

Therefore, the instruments do not intrude the natural exploration of the environment, i.e. the unmediated experience of entering into contact with physical objects. In particular, the Beamer, which enables the user to import a virtual version of various sorts of objects, stimulates the children and the teacher to record a direct, unmediated experience. Indeed POGO has a special feature. It is seamlessly "compatible" with any existing and consolidated educational technology available in the classroom.

In relation to conventional activities, the Pogo environment enables users to extensively integrate the outside world into their narrative activity. This integration takes the form of inserting real elements and products of the children's experience in the outside world. The material gathered in conventional activities serves as a source of inspiration for creating drawings and texts. For instance, Pogo makes it possible to use these elements directly in making scenery for the story. During the testing, the teachers encouraged the children to tell their stories by using the Beamer to project images on the Screen: seashells gathered on the beach (fig. 6a) and mushrooms picked in the woods (fig. 6b). Conventional activities would limit the children to making drawings of these objects.

The structuring effect that we attribute to Pogo is based primarily on the function and form of the Beamer. The Beamer's Basin is an open invitation to place numerous sorts of elements in the Beamer, and to visualize them on the Screen, thereby creating a rich repository of different elements useful for the story. From the outset of the testing, the children found it simple and natural to use two and three-dimensional objects as story elements. The Beamer offered opportunities that stimulated the imaginations of teacher and children. They did not hesitate to use the tool to its full capacity, including transforming the Basin into an aquarium with live fish.

The availability of a Screen display of scenery currently under construction provided the children with immediate feedback on the effects of their actions and modifications.
At the same time the testing also identified a number of limits on the integration of outside space into the Pogo environment. The first and most important of these was the impossibility of capturing narrative elements directly in the outside world. All objects to be used in the children's stories have to be brought back to the Pogo space. This creates no problem for elements that are easy to transport, like leaves and seashells, but as pointed out by the users,

the current system does not enable them to integrate, for instance, a tree, a landscape or other potentially useful visual elements into their stories. In addition, both children and teachers wanted to capture sound and movement, which are also part of the recording of experience in the outside world, and constitute rich narrative elements. Of course the potential of the system could be even more extended. Even if the connection is not visible, the Beamer is a wired tool that cannot be transported around. A portable tool would support exploration of external open spaces, expanding and enhancing the realm of experience.

Pogo-virtual space

The Pogo space plays a mediating role between all of the physical spaces implied in constructing a narrative and the virtual realm. Using Pogo instruments, physical objects constructed or gathered by the children - in class, on the seashore or in a dedicated space - are transferred into a virtual dimension. The Pogo Screen reintroduces virtual images of these objects back into the physical world. Not overlooking their ephemeral nature, *de facto* these projections become constituent elements of the Pogo space: they occupy a place in the room and constitute a pole of attraction for the children. This space is the focus of the children's attention when the story is being constructed, but also when it is being presented. This shared virtual space offers a horizon of observation common to all the children. It enables children who cannot find a place around the Beamer to also follow the development of the narration. By sharing the same physical space, all the children hear the verbal construction of the story. By sharing the same virtual space on the Screen, they follow the graphic construction of the story, as it is being constructed on the Beamer. The teachers called our attention to the importance of this shared virtual space, particularly the fact that it resulted in all the children showing increased attention to the narrative content. All could follow each moment of the development of the story, and could consequently participate more easily in the construction.

During group construction of conventional stories, everything takes place on the verbal level. There is no shared space where the child can follow the development of the storyline. Normally the teacher notes the storyline on a sheet of paper. Teachers feel that this sort of situation does not always allow them to maintain the sustained attention of all children. Timid children who participate less in production of contents may lose track of the story.
The attraction of the projection captures everyone's attention, even the least actively involved. In addition, the advent of Pogo provides these particular children with a new role (as explained above).

3.2.4. Effects on structuring the narrative

In terms of the products of narrative activity, we established a number of structural dimensions that the instruments seem to influence.

Organization by scenes. The most evident characteristic of the stories produced by the children is their segmentation into scenes. We use the term "scene" as a pragmatic definition of the minimal narrative units of stories produced with Pogo: a scene corresponds to an image accompanied by a verbal text. In most cases, a scene represents an event, and more specifically, an action or a dialogue. The first scene in all stories is used as an introduction or "abstract", or to describe the context of the story, using what Labov calls the "Orientation. In one story, we find an example of a formal conclusion of the story, or "coda". The actual narrative scenes (between 8 and 10 in each production) can also be classified, according to

Labov's categories, as scenes that represent the complication of the action and scenes that represent the solution. The evaluation is generally included within the scenes of action.

Adherence to the Labov model corresponds to a conventional type of story. As the teachers point out, these are well-formed, coherent stories with a clearly defined beginning, middle and end. The teachers also feel that in structural terms, story quality is better than usual. Pogo instruments enable children to structure the stories better and more rapidly than normal. According to the teachers, these structuring effects would be the consequences of "affordances" offered by Pogo instruments for the organization of the narrative by scenes.

The mechanisms that enable Pogo functions to influence the structural organization of the narrative are:

- The use of Tokens. Children must breakdown the story into parts and identify the significant units of the narrative. This explains why the stories are "well-formed";
- The recording function. The need to record a picture facilitates the memorization of sequences and consequently helps to maintain a coherent story;
- The possibility of visual representation of a scene. Visual representation stimulates the children's imagination and facilitates progress on construction of the story line. This makes for longer and more complex stories than normal.

Sequentiality of narrative effects. The instruments also reinforced the sequential nature of the stories produced. The use of Tokens imposes sequentiality in the activity (one token at a time is recorded on the Beamer and one token at a time is projected by the Basket), and sequentiality in the narration, meaning that in most children's stories the order of production reflects the chronological order of events. Nevertheless, the Pogo system also supports nonlinear representation of time in the construction of scenes. During one activity ("Magic Forest") the teacher helped the children to use the potential of the Torch to manipulate the narrative sequence. They created flashbacks and flashforwards by superimposing smaller sized projections of past or future events on the main scene.

Foreground/background. Story construction is based on the systematic distinction between foreground and background. Each scene is created on the basis of these two components of the story. The background is the scenery, the place where each scene takes place. The foreground consists of characters and other elements that play a role in the story. Even if this distinction is taught as a part of everyday instruction, the principle becomes evident when using the Beamer. The glass-covered, basin-like configuration of the Beamer clearly distinguishes these two levels of narrative content. The children fill the bottom of the Basin with drawings and/or objects, which make up the background, or scenery. This may or may not change during the story. Next, the glass plate is placed on the basin, providing the foreground level where the children place and play with characters and objects.

Plans and viewpoints. We had no a priori about how the children would compose pictures with Pogo. However, we detected some consistent patterns. All pictures can be defined as full frame shots: the whole character is visible, and we can recognize the environment where they are placed. This characteristic is one of the structuring effects of the instruments, and is the reason why it is impossible to zoom or modify the distance from camera to "stage". Each story has the same camera view of the action. In most cases the pictures are constructed for front views, as in a theater. In other cases, story scenes seem to have an overhead view (bird's eye view). The children create their own system of spatial relationships between objects: some are seen from above, and others from the side, with an ambiguous relationship between

character position and background scenery. Independently of the more or less realistic pictures used in these representations, we want to emphasize the importance of the not being able to modify the camera angle, and consequently the viewpoints of the characters in the story. This also tends to "flatten out" otherwise three-dimensional narrative elements. In order to adapt their efforts to the camera's limitations, some children create two-dimensional backgrounds and foregrounds, while others lay their three-dimensional characters down so the characters better correspond to the two dimensional scenery.

4. DISCUSSION

This paper attempts to elucidate the mediating effects of a system of active and distributed instruments on narrative activities. We showed that POGO instruments transform narrative activity in a number of ways and at various levels, i.e. the nature of the narrative activity, its phases of exploration, inspiration, production and sharing, interactions and the group aspects of creating a story, use of space and narrative structure. In terms of narrative activity, we showed that the instruments encourage exploration primarily through the Beamer which stimulates children to record and explore previous experiences. Pogo instruments offer new resources to encourage thought and choice. The instruments support both personal reflection and intersubjective comparison, and help children to think about and analyze their own experience. This confers a role of *heuristic or reflexive mediation* to instruments, as shown by Rabardel (1995). The possibility to combine and recombine elements on the Beamer table, and to display the results on the Screen in real time, facilitates experimentation and comparison of different solutions. In addition, Screen displays, like external representations, have an amplifying effect that facilitates perception, information sharing and supports children's discussions and group decisions therefore increasing a shared creative process for the group of children. As shown by Scott et al. (2002), shared display has numerous advantages over a side-by-side environment, in particular it can help foster a shared understanding. This result goes in the direction of the ones found by Järvelä (1995, reported by Littleton and Häkkinen, 1999) that instructional technology can play a vital role in supporting the student's collaboration as the cognitive work is externalised and made jointly available in the interaction.

In this line of thought, an initial conclusion of our research is that POGO instruments such as the Beamer and the Screen encourage a shared creative process, and that this is supported by an increase in mechanisms of exploration, inspiration, production and sharing, leading children working in groups to invent richer, better constructed and better developed stories.

One remarkable result, as opposed to conventional activity, is that the narratives produced using POGO instruments have a group dimension. This is motivated by the multiple elements of the POGO system distributed throughout the activity space. In particular we have shown that the instruments produce affordances to group use, a way to occupy differently the space and the production of a common and sharable work surface for groups. We have also shown that just as Engeström found in working environments, Pogo instruments transform the roles of participants and generate a different division of labour during the creative process. They create new tasks, enabling generally non participating children to be active in the construction of the group process. According to the teachers this increases the attentiveness and memorization of these children. Our results indicate that the enhanced possibility of participation appears to stem from two sources: the use of the Screen, which enables all children to share graphic creations, to create a common reference, to facilitate participation

and story memorization; and the tasks of recording and managing the sequences of Tokens, which requires the children-technicians to pay continuous attention to what is happening during the activity of constructing the narrative. This encourages them to follow the development of the story line and to memorize it.

Our results show that the instruments radically transform the conventional spatial configuration of the classroom. By placing Pogo instruments on the floor, Pogo provides a less rigid and more mobile environment than that found in a conventional classroom, where desks face the teacher and the blackboard. This new environment, induced by the nature of the tools and their layout transforms the patterns of behaviour (Barker, 1968) of the users. Rapidly and actively the children appropriate the instruments and the environment. Rather than sitting at their desks, they are on the floor where they can easily handle the equipment. They are distributed throughout the space, organized according to their roles in the activity. Those who produce the contents are gathered around the Beamer, while the "technicians" are near the Basket, with the cards. The teacher assigns no specific roles, and the children are mobile. In a conventional environment, children move around very little. Sitting at desks does not spontaneously encourage this sort of diversification of roles.

The environment not only encourages changes in the behaviour of the children, but also has an impact on the behaviour of the teacher. She has to place herself at the same level as the child, has to move from one spontaneously created subgroup to another and has to assume a different role than in the conventional setting where she faces children seated at desks. The spatial configuration of the tools tends to transform the teacher into a facilitator or regulator rather than a source of knowledge.

We also noted that the children rapidly appropriated the Pogo instruments, that there were no particular learning problems and that they generated new utilization schemes (e.g. using Tokens to record scenes, settings and character actions, and toying with the sequential aspects of events in the storyline, using methods like flashforwards).

Nevertheless, we must point out that the results show that the instrument used by children could be improved. Portable and wireless tools would make it possible to capture moving pictures and sound outside the class. The children's experience would be enriched in both quality and quantity if they could record and use such sound and movement in their narrative creations. In terms of the group, the distribution of children's roles could be improved by diversifying the instruments used to create content. The introduction of a number of instruments for simultaneously capturing, manipulating and combining pictures and sounds would increase the participation of all children in the construction of story content. Simultaneous use of instruments would also permit the introduction of a more personal dimension into the narrative: each child could simultaneously take part in the group creation and make his/her personal contribution, as desired. In terms of structuring the narrative, the system seems to support and even improve the organization of the story, according to the Labov model. We esteem that developing instruments in the sense of more open patterns of use could enrich the children's potential for expression. In practical terms, factors needed to contribute to this line of development would be:

- a mobile camera with zoom, with the possibility to zoom in for close-ups on parts of the scene, and a mobile camera that could take photos from different viewpoints. These improvements would offer the children the opportunity to develop visually richer and more varied narrations. For instance, they could focus on a character's face or change the camera angle so it corresponds to the viewpoint of a character, etc.

- the introduction of sound into narratives would enhance the potential expression achieved with Pogo: the children's characters could have voices, dialogues could be improvised, soundscapes reproduced, etc.

Our results also indicate that use of these instruments appears not to interfere with the activity, and that they integrate into existing instruments. The Beamer, for example, becomes a workbench. Objects gathered outside the class or produced by children can be integrated into the system, and thereby can be effectively used and developed. In addition, the instruments are easy to use. Each action engenders an immediately visible effect (e.g. objects created on the Beamer are immediately visible on the Screen). The interactions are mediated by physical objects. This makes it possible to simplify actions in the operating environment (e.g. avoiding Screen menus). These results recall Norman's concept of the "information appliances", and the fact that the instrument is designed to support the task in such a way that it becomes an integral part of that task, like an extension of the person and his/her work. This implies that the instrument's function is specialized to the point of being in perfect harmony with the real needs of user, and that it offers great simplicity and user-friendliness. Each instrument is simple and has its own means of operation. Each enables the user to perform the specialized task for which it was designed. This is approaching the idea that eventually instruments will be so well integrated into the task that they will longer be recognizable. They will disappear from view and from the user's awareness.

As already mentioned we also found the spatial distribution of these instruments interesting. The use of Tokens goes in the direction of possible incorporation of mnemonic units into physical objects, and using them in a spatial dimension (possibility to transport them and reuse them in another space-time frame). Information handling is expanded in spatial terms and is consequently no longer limited to a central processing unit. The instruments seem to us to be headed in the same direction of distributed creation, the creation and recording space being integrated into the context of handling and constructing natural objects from the children's physical world. These points seemingly indicate a movement towards invisible technology, where any central processing unit stays out of sight and out of mind for its users.

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