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Young Children Collaborating to use Maps during Technology based Distributed Learning Activities

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ABSTRACT: How very young children of 6 years old reach to accomplish activities related to map use (reading, navigation); activities so cognitive demanding even for adults? This paper presents certain analysis aspects on a complex cognitive system that is formed by two groups of children collaborating by distance so as to navigate each other, through the use of technological tools of motion representation, cartography and oral communication. The analysis presented in this paper is focused mainly on cognitive processes during intra-group interactions as well as inter-group interactions involving relations and interactions among individuals and artifacts and examines which cognitive activities are emerged or activated by the children in their effort to read a map and navigate others to move in space facilitating learning related to spatial knowledge.

KEYWORDS: Map related learning activities, technology based collaborative learning environment, pre-school education, distributed cognition, spatial abilities

INTRODUCTION- PURPOSE OF THE STUDY

Researchers with interest in the education of mathematics and geography have given emphasis on the importance of comprehension of map, as tool that contributes in the spatial/geographic comprehension (Walker 1980). According to Uttal (2000) the relation between maps and the development of spatial cognition is reciprocal in nature (Liben & Downs, 1989, 1991; Gauvain, 1993, 1995; Liben 1999, in press). As children acquire new more sophisticated ways of mentally representing and using spatial information their understanding of maps improves. However, researches in the past have disputed the possibility of introducing mapping activities in small age. For example Satterley's study (1964) concerning children's perception about maps showed that "*is overwhelmed small effort in any work with maps up to the years of secondary education (high school, 13 +)*", while, in reverse, Blaut and Stea (1974) and Dale (1971) have reported successes of very small children in regard to work of representations with the form of map.

However, new visions of the learning process have emerged and have significantly influenced research. Thus, Distributed Cognition theory (Hutchins, 1995; Pea, 1995; Salomon, 1995), developed mostly during the last decade, can allow analysis of existing learning or working activities as distributed ones, and also to inspire the design of new learning settings and activities

not possible previously. More specifically, it emphasizes the distributed nature of cognitive phenomena across individuals, artifacts and internal and external representations in terms of a common language of 'representational states' and 'media' (Rogers, 1997).

In the context of the particular research the distributed cognition approach expands the map use activity from a cognitive activity of one person to a communicative activity distributed over interrelated groups of children 5,5 –6 year olds, and contributes to analyse how the systems of groups works in order to occur learning related to spatial knowledge. The design rationale of the proposed learning activities is around the idea of "Signifié- Signifiant Collaborative Play" Script that apply on the assumption that the cognitive operation of an individual for instance to read a map (2D symbolic representation) and use it to 'move' in the real space (3D representation), could be distributed over two group of individuals communicating each other while working in one of the two representational mode (Ioannidou & Dimitracopoulou, 2003). For this purpose a technology based learning environment was designed, permitting children 6 years old to be implicated in collaborative settings as distributed cognitive activities related to maps.

This paper is focused on the analysis on cognitive processes during intra-group interactions as well as inter-group interactions involving relations and interactions among individuals and artefacts. Phenomena raised and alternative strategies are commented. More precisely, aim of the research results presented in this paper are to show the cognitive activities that emerged or activated by the children in their effort to read a map and navigate others to move in space and also to discuss how learning may be occurred during distributed learning activities supported by technology.

THE TECHNOLOGY BASED LEARNING ENVIRONMENT AND THE LEARNING ACTIVITIES

Hardware and software specifications stem directly from the nature of the envisaged educational activities. In order to have distribution of activity of a map use or map construction, we needed a technological environment that allows settings of two teams of children. The technologies engaged involve mainly: (a) Geographical Positioning Systems (GPS), of high accuracy (1meter) and wireless data-links (based on GSM mobile networks). (b) A component based, end-user software environments providing cartography tools, which enable map use and map creation about places that are not in the immediate vicinity of cartographers. (c) Walky-Talkies for the oral/verbal communication between two groups of children.

Concretely, this technological environment permits basic activities as: (a) reading of existing maps included in the software environment where the base team can see the traces (in form of dots, footprints or sequent line) of field team's movement in real space carrying the GPS, (b) creation of

their own map based on the given traces of filed teams' movement according to significant information provided by them via walkie-talkie, (c) benefit of tools and functions that facilitate children to take the point of view of another and adopt his / her perspective.

Thereby, three are the main categories of activities that involve the technological collaborative environment and these concerns activities related to map uses/ navigation and activities related to map construction. Here we refer only to activities of map using/ reading and these are: *1. Labyrinth set of activities:* the base team having a 2D map and being in front of the workstation, finds a possible path and guides field team to find the exit of a real labyrinth suitable created in a schoolyard, while the field team confirms the directives via walkie-talkies. *2. Pattern set of activities:* These activities are take place also in a schoolyard and in which are created big scale drawings (patterns). For instance, during "*Pattern 1*", a set of numbered cones is placed on the computer screen and represents the position and the arrangement of cones placed in the courtyard in real time. The base team is asked to navigate field team to move from one cone to another, tying them up successively with a red tape and at the end a drawing will be shaped (a boat) so much in the external environment and digitally on the screen.

RESEARCH METHODOLOGY- EXPERIMENTAL CONDITIONS

The particular research perceives the learning process as situated in social collaborative settings and was constructed as a case methodology in order to investigate in depth a wide range of issues and concepts related to map using, reading and constructing.

The research is focused on 2 group of children the same through out the project. Each group consisted of 3 children 5.5-6 years old, the formation of each of it based on the children desire and the possibility to work together appropriately. The activities supported by the technological environment were completed in 8 sessions, lasting one hour each.

The whole analysis method is based in a mixed approach: 1) Micro-genetic analysis of the whole technology based learning activities' process, permitting to study in details the learning process and explain the results. 2) Pre-test / post test analysis: allowing us to distinguish in a clear way eventual learning effects in individuals without using technological tools, a week before and after the collaborative technology-based learning activities sessions.

Data were collected on: (a) the verbal exchanges during intra groups interactions as well as during inter-group interactions, (b) the pupils motions in the space, (c) the pupils gestures d) the use of representational and communicative tools, (e) the data captured on the computer-screen (the traces of motions in the prepared maps).

COLLABORATIVE SETTINGS: KINDS AND ROLE OF INTERACTIONS

The proposed activities permit us to work and study on distributed synchronous collaborative setting over two groups, the base team and the field team. More precisely, are observed three main kinds of general collaborative interactions, with different status and properties according the context of their surrounding, the tools that they use and the objectives of each activity: *1) Intra-group collaborative settings*, where there is face to face communication and collaboration internal to each of the group. *2) Inter-group collaborative settings*, where the main communication media is the walky-talky and the main target is the coordination of 2D and 3D representations of spaces and the transmission of comprehensible information by both teams during the activities, and *3) Inter-group face to face collaborative settings* where briefing and debriefing sessions at the beginning and at the end of each activity session, are taking place, so as either to decide what will be the game of the day, or to discuss on some events during the session and on the general appraisal.

ANALYSIS OF COGNITIVE ACTIONS

Most of learning theories lead the researcher to focus on the study of expressions and actions of the individual. 'Distributed Cognition' theory requires the researcher to analyze the interactions among people and among people and artifacts, considering as unit of analysis the "whole distributed system" as a single cognitive system (Rogers, 1997). In our study, as central unit of analysis it could be considered the functional system of the two groups of children that should lead to focus on the intra-group interactions between field and base team. This approach is valuable, but could lead to lose the significant internal interactions of each team. Thus, we distinguish and study three different distributed cognitive systems: (a) as central cognitive system, the system formed from the groups located in different representational systems, where the analysis focuses on the interactions, the flow of information and the communicative paths between the two systems; (b) a subsystem formed by the base team, working on the 2D electronic map, and (c) a subsystem formed by the field team working outside in the real space. In every case of considered analysis' units, the dimensions that are studied concern the kind of the learning activity (different activities implying variations in the cognitive properties of the system), the tools that are used and the social organization of the group.

More specific, in the analysis presented here, we initially determine the minimum cognitive actions that are required in each distributed learning activity, which has been divided in steps for analysis' purposes, and then we examine which of them the sub-group of children activate each time, as well as what others cognitive actions or strategies are activated by them.

In a case that an individual is called to read a map and try to orientate himself and move in space, follows quite different "cognitive actions" from those activated in a situation of collaboration

internal of a team or between two teams, which are communicating. For instance, a single child who reads a map has in general: a) to understand and find his place on a map and in real place, b) to put the map into congruence according to the real space, meaning to designate orientation, c) to decide which direction has to take and finally d) to do it. In reverse, as concerns the case, which involves teams of individuals in a situation of collaboration, it seems to be much more complex.

But let's examine what is actually happens in our case of collaboration between two teams of children, the base team and the field team, which are communicating while using a map. The base team is in front of the workstation and runs the activity-software while the field team wanders around in a specific place. The main role of the base team is to give orders of navigation to the field as regarding the activities of Labyrinth, the Pattern 1 and Pattern 2. In this activity the base team has in general to follow instructions given by the field team The whole activity could be divided for the needs of analysis in minimum 'steps', from the one position or landmark to the following one.

In general, after having decided the whole activity and the specific trajectory to follow, the base team in each of map using (reading- navigating) related activities, for each 'step' has to do at least, a sequence of ***'minimum'/typical Cognitive Activities*** as:

CA.B.1. The **Base** team has to *"Think"*, *"Discuss-Negotiate-intra"* and *"Decide"* about how to navigate the roamer team to the next step, *"Thinking on the representational media"* that is the 2D *electronic map on the computer screen*). The language that they use for intra group discussion may be with gestures (they have to go from this block 'here' to 'there').

CA.B.2. *"Formulate"* by the group, and *"Express a verbal complete instruction"* communicating via *walkie-talkie* (by the temporally responsible of the "*oral media communication media"*)

CA.F.1. The **Field** team has to *"Hear the instructions"*, *"Understand"* or *"Negotiate the meaning"* of these instructions (*oral instructions transmitted via walkie-talkie*).

CA.F.2. The field team has *to "Assess"* if possible "*the appropriateness of the instructions"* related to the constraints of the real 3D space (*representation media = the natural 3D space and their position in this*) and *"Executes the instruction"*. Children (a) *"React when the instructions appear not appropriate"*, related to the constraints of the real 3D space or expressing difficulties they have to deal with so as to execute the instructions of the base team, or (b) *"Execute"* the instructions.

CA.B.3. The base team *"Interprets"* what they hear from the *oral feedback* (reaction) of the field team transmitted *via walkie-talkie*. During the experimentation, the field team reacts positively when the instructions seem 'appropriate' or negatively when the instructions from base team appear

'inappropriate', (for instance when they tell them to turn left and go forward and on their left side there is a wall). Therefore is observed "*inter-group negotiation*"

CA.B.4. The base team *"Read-translate"* (*thinking into the representational media to decode the information*) *the feedback"* representing roamers' movement on the screen as it is transmitted on it by GPS and *"Assesses"* if it is the expected one. In the case that it isn't, the base team has to *"Rethink the situation*", to consider their own oral instructions, and try to understand if the action was wrong with respect to the instructions they gave or the wrong was due to the field' s team interpretation. They have to *"Try to coordinate"* in an appropriate way *"the representation on the screen with a mental representation of the real space"*, and *"Re-adjust"*.

CA.B.5. The base team *"Gives again instructions"* taking into account the position and the orientation of the roamers (empathy).

When there is not any conceptual difficulties in intra-group or in inter-group communication, this set of cognitive activities appears as a coordinated sequence of groups' cognitive activities, respecting the given order and without internal repetitions of some of them. But, most of the cases, the sequence of these actions is similar of the forms presented in Table1, where it is obvious that beyond the five minimum defined cognitive actions in the given order, more recurrent cognitive actions appeared.

LAB 3 STEP 3 S 315-S345	PAT 1 STEP 5 S353-S379
CA.F. 2 CA.B.3 CA.B.3 CA.F. 1 CA.B.3 CA.F.2 CA.B.1 CA.B.1 CA.B.1 CA.F. 2 CA.B.3 CA.F. 2 CA.B.1 CA.F. 2 CA.B.1 CA.B.2 CA.B.1 CA.B.1 CA.F. 2 CA.F..2 CA.B.2 CA.B1 CA.F. 1 CA.F. 1	CA.B.1 CA.B.1 CA.B.1 CA.B.1 CA.B.1 CA,B.5 CA,B.1 CA.F. 1 CA,B.3 CA,B.4 CA,B.5 CA.F. 2 CA,B.1 CA,B.1 CA,B.3 CA,B.3 CA,B.4 CA,B.5 CA.F. 1

Table 1. Two examples of Cognitive Actions' Sequences

But let's examine closer what phenomena arise during intra-group and inter-group interactions according the cognitive activities.

Regarding the intra-group base team interactions

Phenomena that arise during Negotiation 'C.A.B.1'

Effort to connect representations: The children of base team have to coordinate the representation of the electronic map with an appropriate mental representation of the corresponding 3D real space, where the field team is situated. During their mental effort they have difficulty to connect these two

different levels of representation in order to give explicit instructions because they seemed bound to the representational medium (screen). [For instance when they are saying to go forwards or downwards showing on the screen [*LAB 3 STEP 3 S223]*

Effort to de-center considering the tools: Because they are in a continually situation of transition from 2D (screen) to 3D representation (real space) they have to put themselves mentally to the place of the roamers (body syntonicity) in order to give right instructions. In other words, they have to take the point of view of the agent or more specific of the roamers and de-center adopting their orientation which is difficult for them at least for the beginning. [For instance when they have to decide which turn, right or left they have to take, *(LAB3 , STEP 4, S432-S446)*]

Decentering using spatial language: The language development and the spatial concepts they use are also related to empathy and de-center. In the first activities or in their intra-group negotiations they use vague, undefined expressions as "this way", "until here" or "like this" using gestures on the screen but in order to be explicit and as they pass to the next steps of the same activity or to next activities they obligate to use spatial concepts. [*(LAB 3,STEP1, S73), (LAB 3, STEP 3, S321)]*

Using pre-metric concepts through alternative communicative strategies: Concepts related to scales, distance estimation and angle measurement are not need to be used during the proposed activities, given that these concepts are very hard to be acquired by so young children (they don't correspond to their cognitive and perspective level). However, when the need of using such concepts was raised, children avoid them using an alternative communicational strategy. [*PAT 2 STEP 2 S199: "Move on a little bit! Until to say stop. Have you heard us?…. STOP!!!!"]*

Phenomena that arise during the formulation CA.B.2.

After the intra-group negotiation one member of the team holding the walkie-talkie have to transmit the message to the field team.

Renegotiation and explanation of the instructions: The decided instructions accepted by the team, may not be understood by the member who transmits it to the roamers and that consequently leads to *misunderstanding and confusion* where either they negotiate again until to decide the right order or another member transmits the instruction and trying to explain to the other members of the team

Asking clarifications or implementing alternative communicative strategy: During the verbal formulation of the message there is a chance of not using properly the walkie-talkie (not press hard the button) in order not to transmit complete instruction and that also leads to *misunderstanding and confusion* that is resolved either asking additional clarifications or implementing some alternative communicative strategy.

Regarding the inter group interaction

Phenomena that arise during C.A.B.3. or CA.F.2.- Possible "inter-group *negotiation*"

After the verbal formulation of instructions by the base team during CA.F.1 and CA.F.2, the **field team** appeared to apply **alternative communicative strategies** such as:

Propose actions *[to turn or go straight ahead?]* **or alternative directions** when base team cannot decide, according to the environment, which often are the indicated ones *[LAB 3 STEP 4 S 435-S446]*

Give explanations about the situation **or Direct information from/ for the environment** in case of deadlocks from the part of base team**:** *[we can't move on- or can't go straight ahead, there is a wall", LAB 3 STEP 2]*

Asking clarifications: Ask clarifications according to the instructions which aren't given from the beginning from the base team, offering simultaneously determinative information about specific position in real space *[' to the first or to the second corridor?'*– they mean to turn- *LAB 3 STEP 2]*

It appears that the alternative communicative strategies are often activated by the field or even the base team, in order to avoid miscommunication or conflict concern, specially when they don't understand well complex concepts such as "opposite", "cross", "in the middle".

CONCLUSIONS - DISCUSSION

It seems that the designed distributed learning activities via the technological environment incite children to activate much more powerful cognitive activities than those activated by a single individual.

During intra-group interactions some of the cognitive activities that emerged are related to: (a) effort to connect representation, (b) effort to decenter considering the tools, (c) decentering using spatial language and (d) pre-metric concepts use applying alternative communicative strategies. It was also observed significant cognitive activities such as: (e) renegotiation and explanation of the instructions, as well as: (f) demand for clarifications or implementation of alternative communicative strategies.

As regards the inter-group interaction and collaboration both teams appeared to apply alternative communicative strategies in order to avoid misunderstanding, to collaborate and move on with the activities, completing them. So the field team or the base team (a) proposes possible actions or alternative directions, (b) gives explanations or direct information from or for the external environment, (c) asks clarifications according to the given instructions, or d) use in a significant way the mediational tools in cases of deadlocks.

The two groups through the "Signifie- Signifiant Collaboration Play" Script seem to play a role in connecting the two representations: the physical representation in 3D real place ('signifié') and the 2-dimensional abstract representation of the real space map on the screen ('signifiant'). Children were always invited to communicate translating from one to other which is quite difficult even for adults. They were obliged to think and discuss in two levels, using in manner two quite different "languages": one is used when somebody is in actual space and another is used when somebody interacts with a map. The children are finally provoked to use spatial concepts and more accurate and complete verbal instructions in order to be mutual comprehensible. The technology-based environment from the other hand helps children to avoid spatial concepts that don't correspond to their cognitive level. A point that should be underlined is that in some cases, the children were 'obliged' to find way to overcome their cognitive difficulties and they finally managed to do it applying alternative communicative strategies.

We have to mention here that children of this age are very young to collaborate and even though the proposed activities were very cognitive demanding for them, the children didn't give up, but managed to complete the tasks. Both teams had common accepted the each activity goal: to reach the end of labyrinth, to see what will be drawn at the end of the patterns. This motif seems to lead the level of shared understanding to each stage of activity. The children in each team signaling intention to participate in discourses and prompting each other to move on and to overcome the problematic situations of miscommunication.

It is also to be mentioned that the analysis of pre/post tests results have shown that the participated children, working individually and without technological support (a week after the end of collaborative activities), have developed appropriate intuitions in use and construction of maps and specially intuitions and meanings of spatial awareness, orientation, and representation of objects and landmarks in space (Ioannidou & Dimitracopoulou, 2001).

The proposed activities and the corresponding collaborative settings could lead to the discussion on whether an individual who is below a certain developmental level benefits from the collaboration. It is not clear yet, whether social interaction leads to the decentration necessary for the individual to benefit from collaboration, or whether that decentration has to happen before genuine collaboration can take place (Dillenbourg et all. 1996). In the present research, the social interaction was established (via intense and cognitive demanding activities) so as to incite children exactly to decenter as well as to develop 'empathy' (pre-operational children luck the ability to decentre from their own perspective according Piaget's theory).

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