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Improving geometry by using dialogic hypermedia tools: A case study

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Summary

In this paper we present the results of using an interactive geometrical environment, regarding the acquisition of certain mathematical skills by deaf students (12-16 years old). Communication and variability skills are analyzed when the class is organized using computer distance support. We present the main trends of the experiences and formative regulation assessment perspective.

Keywords

Hypermedia tools, deaf students, Geometry

Introduction

Deaf and hard of hearing Students are to be able to think mathematically. Thus, they must be given the opportunities to exercise their mathematical powers and be supported in developing these powers by means of distance learning specialized opportunities. Therefore, the idea of using ICT tools in a democratic collaborative perspective. We want to analyze the nature of corresponding hypermedia scenarios and techniques for oralist deaf students included in regular Junior High Secondary Schools. Our general aim (in AUDIMAT Project) is the improvement of instructional materials which can be used in a structured and coherent way to ensure best practice in exploring and developing mathematics with students-centred tendency in distance classrooms. In our particular research framework we will focus how ICT can improve on pupil-pupil and pupil-teacher interactions in constructivist environments and how we use ICT to promote regulation and self-control in the process. We'll focus on explaining somre diagnosis aspects of visualization found in the Project, and some regulation trends for introducing the notion of volume.

We focus in this presentation on geometry trends and the need for using ICT to improve functional reasoning in variability situations by continuous dialogue about mathematical activities proposed. In fact, standards for secondary education emphasise objectives to be carried out in a classroom setting, such as peer-discussion in a community; handling of objects in the space; learning how to speak and moderate a debate; and we are far away from consolidated proposals joining the use of distance learning to the objectives of the actual curricula. Rejecting simplistic approximations concluding if the conversion from a non-technology-oriented course structure to a technology-oriented one led to a quantifiable difference of any sort, our commitment in this specific project is a social and politic one: distance education at a secondary level to attend those people for whom it seems to be the best opportunity, specially the use of the Internet. The core principle of our research is that every technique we advocate will lead to a more effective student-centred environment as possible by using an equity principle. According to our Spanish Curriculum, we can use geometrical content knowledge in an open and dialogic way. Therefore, we promote authentic instruction, cooperative learning, active learning, and cognitive apprenticeship not only for their instructional benefits, but also for their ability to put students at the centre of their own learning – introducing elements for students' effective control.

Mathematics' Tele-Tutorial structure is based on socioconstructivist scenario (Johnasen & Murphy 1995). At the beginning of each tutorial session, student has a welcome page that is modified weekly, and also in special cases in order to convey additional information. Communication tools used were tutorial aids by using multimodal possibilities: videoconference, current writing exchanges, direct asynchronous communication (Gimenez & Fortuny 2000) among other possibilities. Students connect this web, via Internet, from their computers classroom. Periodically, the tutor holds a videoconference with each one of the students.

Study description

Theoretical basis

The main holistic idea behind our Teletutorial practice is that realistic learning is most meaningful when topics are relevant to the students' lives, needs, and interests and when the students themselves are actively engaged in creating, understanding, and connecting to knowledge (McCombs and Whistler 1997). And we improve human beings by using ICT tools in a democratic collaborative perspective. They are not only solving tasks, but dialoguing with the teacher and other colleagues. Students will have a higher motivation to learn when they feel they have a real stake in their own learning. Instead of the teacher being the sole, infallible source of information, then, the teacher shares control of the classroom and students are allowed to explore, experiment, and discover on their own. Nevertheless, it's very difficult to do it in a way that decisions are completely in students' hands and we accept some guided instruction suggestions for vertical mathematisation processes.

We accept knowledge as constructed through interactions with new ideas and experiences, causing cognitive disequilibrium, which in turn alters conceptual schemata in an individual's knowledge base.

Our perspective, students are engaged in the construction of their own knowledge as a social oriented process (Gravemeijer, 2004). In such a Realistic mathematics framework, students should help construct meaning, building on prior knowledge, in ways that reflect authentic use of materials and processes in the real world. This will help students to transfer the knowledge they gain in a school setting across multiple domains and social contexts. In our research we try to adopt a ideological didactic approach (Aviram & Talm, 2005) stems from the conception that the introduction of technology can lead to, or necessitates, the introduction of new didactic or teaching/learning methods through considering equalitarian principles as a means to facilitate key and qualitative change in the teaching-learning process. Mathematical activities are an excuse to develop deaf students' thinking by introducing visualization considered their main supports for building images.

As a theoretical base of our investigations, we agree that personal learning of mathematics is inseparable from the social practices which severely constrain the manner and quality in which learning takes place. We emphasize the need to consider the projection to secondary mathematics education of the current changes in adult education paradigms presupposing an inherent capacity for autonomous learning (Albero, 99). This change goes hand in hand with an increasing use of multimedia learning environments in schools. It is necessary to reflect on their impact on the students' opportunities to interact socially both at school and at home.

We also take into account how the fact that we are working with individual students constrains participation, as their interactions will be different from those arising in a traditional classroom. For example, when studying autonomously (Gigou, 1999), the student is forced to find solutions and explanations to a far greater extent than if he or she were participating in a classroom, where it is much easier for an answer to appear as a result of a joint effort (Spiro et al., 1998).

Computer tasks are introduced in a way , there are meaningful to the students, stimulate curiosity about a mathematical or non-mathematical domain, not just an answer, engage knowledge that students already have, about mathematics or about the world, but challenges them to think harder or differently about what they know, encourage students to devise solutions, invite students to make decisions, lead to mathematical theories about (a) how the real world works or (b) how mathematical relationships work, open discussion to multiple ideas and participants; there is not a single correct response or only one thing to say, are amenable to continuing investigation, and generation of new problems and questions At the same time, we used regular mathematic tools as knowledge-based semiotic mediators (Giménez 2004). In our activities, the teacher can interact with the student when they don't write any sentence, or they show any blockage. Our main design-based principles are:

a. Knowledge construction. The task of actively building a symbolic representation of concepts helps to gain a better understanding and appropriation of such concepts. Particularly in a Web representation which requires the building of logical links between conceptual pieces of information and potentially using different symbolic ways to represent such information.

b. Collaborative construction. The fact that knowledge construction is made in a collaborative way may help participants experience a social encounter with concepts that they may not have experienced in a solo setting. From a sociocultural approach this may be seen as working within learners' Zone of Proximal Development (ZPD) with the help of peers and tutors. Also the collaborative activity may imply that participants are faced with reflective and conflictive situations whose resolution may help produce a better understanding and internalisation of the new learning.

c. Understanding of technology as a text based approach. What counts as objective reality is itself a social construction. In other words"objective reality and social construction are not two aspects of the same artefact but they are different ways of saying the same thing." (Grint and Woolgar 1997: 23).

d. Problem centred approach in using technology. Computer environments should engender and support genuine problem solving and inquiry.

The study wants to see (a) the starting conditions of the students in visualizing processes before the experienmce. And, (b) to see how inclussive teletutorial experience can improve both deaf / hearing students in equal conditions.

The main hypothesis is the need of using–variability mediators as a way of changing and giving opportunities to enter in the world of generability explorations for every student in regular geometrical situations.

Research methodology

An initial quantitative study was driven to understand initial visualization difficulties. Initial observation Population was constituted by 12 students: 4 hard of hearing deaf, 4 hearing , 13-14 years old students, and four15-16 years old students with adapted curriculum (so called UAC in Spain) with language difficulties. A control group of 30 regular students was also used to control the test used in the diagnosis.

In a second part of the research, an ethnographical case-design approach was introduced. A set of two different pairs of students from the previous group participated in two sets of learning activities in two periods. Each pair belongs to different inclussive schools, and they were selected because of their similar difficulties on mathematica (a) Claudia (hearing) and Andrea (deaf), did a triangles study (Muria, 2005) (b) Rita (hearing) and Hellen (hard of hearing) a volume study (Latorre, 2006). Both ahd similar structure for the teletutorial materials. The group was also observed and all the materials were recorded. . Students don't choose the subject, but they can enter into a tessellated way of presentation.

Our virtual AUDIMAT environment was designed and structured around the following hypertextual axes/scenarios: (a) relations with parents and specialists to review their own knowledge and professional activity (b) activities for students, (c) self-regulation activities (d) organizing summaries of contents (e) self introductory regulation and (f) communication tools. The main aim is to promote intersubjectivity, through the creation of shared understanding in joint problem solving spaces. It allows the participation in authentic situations, and not just artificial problem solving situations, to have an active engagement in the experience. The students participate in a collective activity with authentic interdependence. The construction and participation of a shared representation on the site activities may also affect the group interaction. The participants will have access to a shared reference point, constructed collectively and where they can observe and engage in representations of the participant's views and perspectives. That representation can also facilitate or inhibit interaction and the collaborative learning. We found that the sequence "Question-Response-Evaluation" considered to be characteristic (and simplest) of student-teacher interactions (Cazden, 1988) has to be enlarged by at least two more interactions taking the form of nested loops. These loops are initiated by the teacher, looking for the participation and creative exploration on the student's side. These loops repeat up to three times, implying—by the existing lag in communication—that during the whole tutorial process, attention remains centred on one activity. The special properties of written versus oral dialogue call for the formulation of new methodologies allowing an analysis of the complexity of the new sequences. It includes a widely varying linguistic aspect with respect to the elaboration, the extension, and the wide variety of information contained in one and the same intervention.

When information and requests for answers or reflections are introduced on a web page using dialog boxes, the students stops to elaborate an answer. As soon as the tutor chooses to intervene via e-mail, communication is blocked. One possible interpretation for this is that dialog boxes on the screen enhance the willingness to stop reading and proceed to elaborate an answer. In the case of e-mail, questions are considered as a part of a wider narrative including the whole of the message in question, and the student does not feel as if he were addressed. The participation of the student during the whole tutorial process supports this hypothesis, as his written participation via web pages is far greater than via e-mail. From a theoretical perspective, we consider that technologies can connect students with special needs to mathematical concepts presented in a web format. Deaf children have more language difficulties in learning mathematics skills than other children and their results are usually worse (Rosich and Serrano, 1992). Our investigation studied the design of mathematical education for deaf students, and the formative evaluation of the processes.

The scene of the actual experiences is a web page (Muria 2005). It is possible to adapt the content to each student and school. The site presents opportunities for observing that relational understanding sometimes is not completely related with syntactical use of correct sentences, and shows the specific difficulties of 16 year-old deaf children in regular schools. So, the beneficiaries of the experience are the deaf students, their families and their teachers (Gimenez et al 2002). In such a perspective, new technologies and interactions connect students with special needs and mathematical concepts presented in a web structure.

The tutor/teacher establishes a personal planning regime that should be accepted by each student. In a virtual scene, the evaluation activities are different because the communication between student and tutor could be direct or delayed. In this way, the adaptation and integration of the students with special needs could be possible. The help provided by teachers, instructional designers, and parents is very important. But, one of the first objectives is how to motivate the students, because due to their necessities and, in particular, their being deaf, the pupils are much unmotivated for mathematics topics. Activities had also been designed to encourage students to pass through the first three van Hiele levels–from the visual, to the descriptive-analytic, and into the abstract relational (Clements & Battista1992).

Findings in the study A visualization test was introduced to understand initial students' background. A sample of 8 deaf students and 8 hearing pairs constituted a group. A 30 students regular group without any physical problem was considered, and a third group was constituted by special needs students (so called UAC in Spain) included in regular extra-classes, having support and adapted curriculum. Deaf students presented more difficulties in problem statements' interpretations. Similar results appeared in researching arithmetic word problem activities in Spanish inclusive schools (Rosich & Serrano, 1995). Personal interviews gave us the opportunity to recognize the real difficulties: negative constructions, hypothetical sentences, confusion between applying or just observing, and word contextual interpretations when the student is confronted with a text and must build the corresponding figure. From quantitative results, a set of observations (see details in Rosich & Muria 2006) was elaborated (figure 1).

	4 Deaf , hard of hearing	4 Hearing pairs	4 UAC students
Understanding tasks statements	More difficulties in statements understandings	They understand in general all statements and understand quickly the aims for the tasks	Some difficulties with complex sentences
Results	Getting lost or unsatisfactory results	They answer all tasks, but they did mistakes in complex tasks.	More errors than hearing people were revisited Similar results as deaf students
Explicit reasoning	No answers (or short) in many cases.	No reflective sentences appeared. Just observational comments many cases.	Very poor sentences as deaf students' answers
Visualization difficulties	Need for discussion to understand dynamic situations as generalized result.	No previous practices in action in complex tasks situations	Need for time discussion
Facing non traditional tasks	Hard difficulties in processing novelties	En muchos casos obvian la respuesta.	Many difficulties in focusing resolution processes
Specific geometrical difficulties	Difficulties in generalizing properties	Some difficulties appeared , but less than other populations	Similar results than deaf students
Time devoted for doing tasks	Doubled time used for understanding the meaning of the task	Regular time considered	Time used among both

Figure 1. Comparison between difficulties of deaf students, hearing and UAC

Within the overall context of solving carefully designed sequences of problems in a classroom culture of inquiry, students should be able to make and test conjectures not only about their problem solutions but about their own personally evolving mathematical conceptualizations. In fact, in an ideal environment, students would generate not only possible solutions to instructionally-presented problems, but peripheral ideas about phenomena being investigated. Looking to the first part of the study, about triangles, we found similar results (deaf vs hearing) in giving meaning for exemplifying triangles classification, but it was more difficult for Andrea to identify impossible cases. Does it means the difficulties in understanding mathematical meaning for "impossible"? After classroom discourse analysis, we suggest hard of hearing students, presented more difficulties on these interpretation issues, ad we conjecture it'sbecause of the lack of understanding verbal specific explanations.

AN – Here's an isosceles triangle. I guess it could maybe be an equilateral triangle. But I'm not sure if this is exactly... maybe.

Instead of this, a good student B in the class can move from thinking holistically to thinking about interrelationships between a shape's parts, that is, about its mathematical properties.

B - (regular student without language difficulties) –I saw when I was playing how you could move it and things like that, that whenever I made it bigger or smaller, it was always an equilateral triangle, but sometimes it would be leaning up, but the sides are always equal. In our study, dialogue is used as regulator in content construction by using interviews as a tool for learning. Let's explain an example of the second study. The teacher and tutor promote conflicts and hints. In many tasks, hard of hearing students showed similar difficulties than hearing pairs. But some differences in "momentum" were identified in their mathematical discoveries. We assume there are sometimes geometrical difficulties, but many unexpected language problems appeared hardly related to geometrical contents.

> T- You told me the maximum is the high part of a box.
>
> H- - Yes
>
> T- Are you sure?
>
> H – I thought it must be inside, let's say in the plane.
>
> T- Yes, of course. . Oh, I understand… Your idea is that the maximum is this wall (high size).
>
> H- No, No I thought inside the room. I think in the basis.
>
> T- Look at this box (Teacher shows a closed box as a model for the room).
>
> H- Yes, I considered the basis.
>
> T- I told you must consider every possibility inside the box. (Open the box). This is our room. But, which is the position for the maximum length?
>
> H- Outside. Whenever you want.

Observing such dialogues, we found difficulties in interpreting words as "maximum". In our perspective it's not only as a language problem but a variability problem, very important in sense making (Mason & Johnston-Wilder, 2004). During the research we found the need for more variability helps for supposed linguistic misunderstandings. For instance, adding a video suggesting the use of the box will be introduced in next version, according the need for manipulating to accept variability. But also to use a string to show different possible length in a box among two different points, will help to overcome variability problem in using the word "maximum".

In the global research we compare the progress of the students in different learning hypothetical trajectories: volume as a function, unit concept and volume computations. As an example, figure 2 shows the evolution in a set of 13 activities about volume variability as a function.

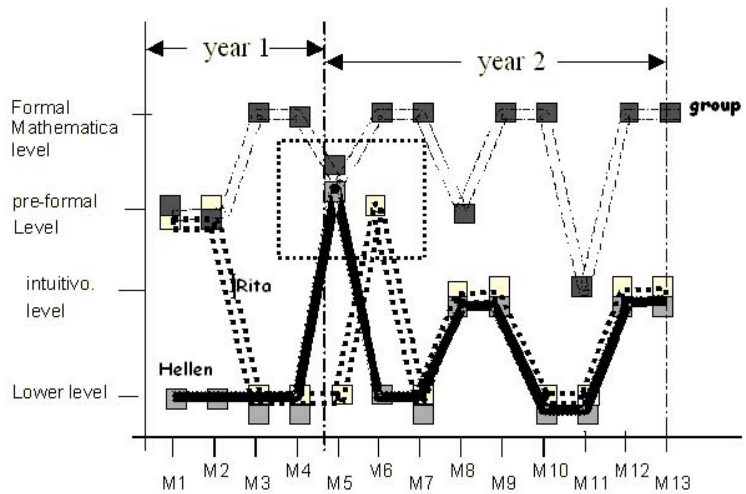

Figure 2. Trajectory Evolution for variability volume.

Assigning a level of understanding on each activity, according the level of reasoning used, we found that deaf student and her paired hearing have similar behaviour and level in many cases, but always lower level than the group general level (Latorre 2006).

Conclusions and perspectives

There is a complex set of issues involving research with computers that focuses around standard mathematical knowledge, knowledge about the artefact, and computational transformation of mathematical knowledge it involves. The important insight was to notice how the technology shaped the ways in which the critical features of a mathematical problem could be marked, modified, and built into a mathematical structure and how some (but not necessarily all) elements of the invariant relationships between the given objects were identified and related (Hoyles 2004). The tools of an environment may encapsulate mathematical relationships in some sense: but these relationships lie dormant until they are mobilised, and it is in their mobilisation that meanings are created. Computers may make to collaborative learning (and therefore, perhaps to learning in general), it is important to consider the problem from an epistemological-design perspective as well as social-psychological. Our learning environment serves not only as a reflection about a cognitive tool, but also as a genuine mediator of social interaction through which shared expression can be constructed. The environments offers to the learner a domain of phenomenology within which they cannot simply read the mathematics, instead they have to develop modelling relationships in which mathematics is a tool to make sense of what is experienced. After the analysis and results, some pedagogical implications appeared: a) deaf students need more time than hearing group; b) previous histories were shortly related to visualization tasks; c) many difficulties appeared because of lack in using technological issues previously; d) these students require specific mathematical language help from logopaedians in order to improve mathematical argumentations; e) technological issues don't solve mathematical problems, and f) complex tasks must be introduced to press them to solve their language problems.

We finally assume that the ideological trap is delicate. On the one hand, one needs to acknowledge the epistemological validity of the mathematical knowledge one is attempting to teach. On the other hand, one must recognize that immersing an individual or a group within a particular expressive computational medium one is inevitably constraining the appreciation of mathematical relationships to the environment itself. (Hoyles, 2004).

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