

Interactivity in Mathematics Education: Collaborative Knowledge Generation in Internet Based Sharing Environments

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Introduction

Computer literacy is fundamental, but integrating computers across the curriculum or learning about multimedia is not enough; NOVEMBER (2001) suggests that: *"in order to prepare students to be flexible, adaptive, and interdependent we will need to re-engineer the organizational design of learning". "We need to look beyond the technology to seek the ways of collaborating together to help children become independent, critical managers of their own work"*.

The interaction between students makes cooperative learning a powerful tool to teach. While working in groups, students have to exchange ideas, make plans and propose solutions to accomplish the group's task. Thinking is intellectual work and will promote intellectual growth. Being the teacher's job to encourage such exchanges and structure the students' work, the exchange of alternative ideas and viewpoints enhances that intellectual growth. In this sense, we can refer to Powell, (1994), which says: *"Group assignments should help learners combine new knowledge with prior knowledge, leading to the construction of new ideas within the group. Students should question, discuss, make mistakes, listen to the ideas of others, provide constructive criticism and summarize discoveries"*. This author suggests several models that can enhance the effective use of cooperative learning groups: the Jigsaw model, the Group Investigation model, the Numbered Heads Together model and the Think-Pair-Share model; the last one, for example, encourages responses from all students – students pair with a partner to share their responses to a question but they are also invited to share their responses with the whole class.

Through the creation of shared goals, shared exploration, and a shared process of meaning-making, collaborative learning processes help students to achieve deeper levels of knowledge generation; the engagement in a collaborative learning process forms the foundations of a learning community. The online learning environment is the modality of learning context that lets a group of students formulate a shared goal for their learning process, allows the students to use personal motivating problems, and takes dialogue as the fundamental way of inquiry. When students are learning collaboratively online, reflections on the contribution of technology to the learning process are almost inevitable. The instructor should act as a mediator in order to guarantee the reflective process (Pallof and Pratt, 2001). But not only traditional cooperative learning is fundamental if the challenges of this new world of technology are considered; it is also necessary to stimulate students to write. Magalhães (2001) indicates that in our *"cultural era"* it is fundamental to be able to properly write in order to express ideas after conceiving them. Burton and Morgan (2000) discuss several aspects of writing in the field of mathematics that are fundamental if we intend to have students writing. Even classes of mathematics could offer an explicit understanding of the role of language in specific mathematical contexts as a way to accelerate the insertion of students in the world of technology teaching them how to use computers to better think and write.

A cooperative approach in the process of teaching / learning of Mathematics that would consider report compositions and exchange of information through techniques like e-mail would just help students to better prepare to the technology world. In this sense, the best use of state-of-the-art computer aids (Mckown, 1992) is fundamental when technical analysis underlies the issues being presented, in others words, computers can help with spelling, style, grammar, organizing, rewriting, debugging, etc. In this context, we can reflect about the importance of interactive context in the process of exploration and construction of collaborative knowledge and witch kinds of tasks for cooperative learning are necessary for determine a modality of interaction. So, Santoro, Borges and Santos (1999) uses Kumar's (1996) terminology to identify tree kinds of tasks: cooperative tasks of learning of concepts, cooperative tasks for solution of problems and cooperative tasks for the

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development of designs. These tasks have determined the model of cooperation considered for the environment and can be enumerated independently of the subject domain that is being taught.

CMC Tools in Education

In educational environments that stress collaboration, the use of computer-mediated communication (CMC) tools can be a source of support to the teaching / learning process as well as a challenge. Wolz, et al. (1997) explain that CMC refers to any form of interpersonal communication (synchronous and asynchronous) that uses some form of computer technology to transmit, store, annotate, or present information that has been created by one or more participants. CMC tools include email, conferencing groupware, chat rooms, desktop videoconference, and Internet-based audio applications.

Both synchronous and asynchronous tools have appropriate educational uses. Synchronous tools facilitate real time demonstrations, discussions and collaborations as well as the more informal communications and interactions to building effective learning communities. However, asynchronous tools can facilitate learning environments that allow users to exchange information at their own pace without the limitations of time and space.

Learning environments supported by CMC tools should be perceived as comfortable and easy to use. Designers and instructors need to coordinate specific tools and supported media (text, image, audio, video, etc.) to the appropriate learning task or goal. This requires expertise in both technology and pedagogy.

Learning Theories

The one of the most important factors that they regulate collaboration is the theory of learning in which the cooperative interaction will be based. Levy (1999) in 'Cyberculture ' makes a reflection regarding that the degree of interactivity of a media or of a device of communication, could be measured in well different axis, of which we emphasize:

- ✓ The possibilities of appropriation and personalization of the received message, whichever the nature of this message;
- ✓ The *reciprocity* of the communication (to know, a communicational device "one-one " or " all-all ");
- ✓ The *potentiality*, that emphasizes here the calculation of the message in real time in function of a model and data of input;
- ✓ The *implication* of the picture of the participants in the messages

The learning theories search to recognize the involved dynamics in the acts to teach and to learn, parting of the recognition of the cognitive evolution of the man, and try to explain the interrelation between the preexisting knowledge and the new knowledge. The learning would not be only intelligence and construction of knowledge, but basically, personal identification and relation through the interaction with other people.

➤ **Constructivism**

Collaborative learning is embedded in constructivism. In the collaborative learning environment, small groups provide the social context and members create a community of learners whose goal is to construct knowledge thought common effort. In this new situation both teachers and student roles have to be redefined.

Traditionally the student has been a passive receiver of knowledge. In collaborative learning environment the student gets a central and active role. The prime responsibility for learning is transferred from the teacher to the student. The student is supposed to actively seek information and act upon it. Thus, student become involved in a learning process which encourages them to personally reflect on course material and relate it to their existing knowledge structures, as well as requiring students to articulate and justify their reflections via overt communication with their peers.

Collaborative learning procedures may be effective for promoting students progress to more advanced stages of cognitive development. The learning is fewer instructors centered thereby reducing student perceptions of the teacher as the absolute authority. The teacher's role is changing from the facilitator of knowledge to the mediator providing the environment of learning. This raises a number of issues that have to be dealt in order to provide a functioning learning environment.

Computers-Supported Learning Environments

➤ **HyCLASS**

HyCLASS is a projected educational collaborative system to allow that some students, in distant localities, share a three-dimensional virtual space. This environment can be used for the accomplishment of virtual experiments and procedure of creative tasks: the students can create objects dynamically, active its properties and behaviors. The students are represented by avatars, and if they communicate in real time (through chat, or video/voice conference) (Hosoya et al., 1997).

➤ **Cooperative Remote Learning Guided the Objectives Design**

This environment was developed with the objective to support the cooperative learning in distributed environments, where interaction between pairs in the search of the solution of a problem occurs, in the accomplishment of a project. The metaphor adopted in the environment is the 'room of studies', where the learner is involved with a project that will go to unchain the learning of new concepts or the deepening of others. The rooms of studies possess the following features: book bookshelf, archives with information and screen to attend conferences.

➤ **E-TEAM**

E-TEAM consists of a computational environment, which allows for clear and detailed electronic communication with the convenience of the use of multimedia resources. With the E-TEAM, one can carry out the following procedures: to retrieve graphs on the screen (drawings, pictures, images, graphs in general), to import images JPG, GIF, Bitmaps, texts from other programs (Word, PPT, Excel, etc), to make comments on these objects, and also to record one's voice. All these procedures are carried out at the same time, as if the user were face-to-face with somebody else explaining a certain subject. All this information is compacted and sent to the receiver, by using the e-mail program of your preference. The person who receives the file can open it and edit it and make comments about its objects in an interactive way.

The general objectives of E-TEAM can be described as follows: to create an appropriate educational context for the subjects to use the different kinds of E-TEAM files and to develop abilities to work with different formats of files and to know how to apply them to new situations. The specific objectives of E-TEAM can be described as follows: to make it possible for the subjects of the research: to interact critically with a computational tool; to apply the potentiality of this tool to pedagogical practice and to build knowledge from the interaction with the potentialities and limits that this environment offers, by using the mathematical concepts that can come up during the process of collaborative learning.

Utilization of E-TEAM at LAPEMMEC / UNICAMP²

A project entitled "Computational Environments in the Exploration and Construction of Mathematical Concepts in the Context of Teachers Reflective Education" is being developed at LAPEMMEC/CEMPem/FE/UNICAMP³ coordinated by Rosana Giaretta Sguerra Miskulin. Some results of the research, inserted in the project will be presented in this paper.

This research is about the several ways of using technology in the development of mathematical concepts in the classroom, in a critical and reflective way. The objectives are: 1- To offer theoretical-methodological assumptions for reflective and informed education of future teachers in the field of Mathematics Education, regarding the understanding and use of computational environments, thus helping these future teachers to develop a critical view of how technology can be incorporated and used in the context of the classroom to help in the development of mathematical concepts. 2- To offer data and pedagogical-cognitive elements to the design of interactive environments based on computational environments, Simulation, Tutorials, Problem Solving, Programming Language, AVI Constructor (Animation), Internet, among others, appropriate for the development of mathematical concepts. 3- To offer theoretical-methodological data for devising an

² LAPEMMEC – Laboratory of Research in Mathematics Education Mediated by Computer.

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alternative methodology based on the well informed use of technology by the teachers, thus giving a new dimension to the process of teachers education and to the process of exploration and construction of mathematical concepts.

The methodology of this research consists of a modality of action research in which the intervention takes place based on the interaction of the researcher and the subjects involved in the research. Such an interaction allows for several ways of communication, which results in a very dynamic approach. It is pointed out that the methodology that is being used with the subjects involved in the research is based on Problem Solving, in the various computational environments: Simulation, Tutorials, Programming Language, AVI Constructor (Animation), Internet, among others.

Problem solving is being seen as a design activity (Miskulin, 1999), in which the formulation and definition of the problem itself are challenging tasks for the subject, that is, s/he constructs hypotheses, suppositions; as s/he devises his/her strategies, s/he relates them to his/her objectives and to the context in which s/he is working. These are problem-situations which contain the subject's own characteristics, without ready solutions and answers, but rather with cognitive processes which take into account guesses and risk taking, that is, abductive thinking as well as deductive and inductive thinking.

The subjects in this research are undergraduate students in Mathematics at UNICAMP, undergraduate students from the College of Education, graduate students of Mathematics Education, elementary and high school teachers, and university professors.

In this paper, it will be presented an example of the projects developed by the subjects involved in the research, elaborated on the computational environment E-TEAM, aiming at the development of interactive contexts of collaborative learning.

Research Methodology with E-TEAM

Some methodological procedures were used during the development of the research with the computational environment E-Team, such as: the use of Tutorials, the use of Chat Rooms, aiming at the discussion of important aspects related to the subjects' projects; critical and reflective reading of selected texts related to the theme; research in websites; historical rescue of some aspects of the projects of the subjects; development of collaborative projects on topics related to the subjects' mathematical education, besides the construction of interactive messages in the E-TEAM and the exchange of these messages with other groups, always reflecting upon the mathematical concepts that came up in the individual projects.

Subjects' Activities with the E-TEAM

The students were engaged in some activities – mathematical problems and challenges, giving examples of the pedagogical-cognitive possibilities of the computational environment E-TEAM, in the development and exploration of mathematical concepts. The following activity illustrates the pedagogical ability of the E-TEAM to provide an appropriate context to collaborative learning and shared knowledge.

Figure 1 – Activity 1



Figure 2 – Answer to Activity 1



➤ Inspiration

INSPIRATION consists of a computational environment, which allows exploring conceptual maps. This computer environment was developed by Don Helfgott e Mona Westhaver and allows the creation and representation of ideas and concepts through maps or semantic networks.

Working with INSPIRATION the students can better understand the relationships and concepts, which express the knowledge that have been represented in the conceptual maps. Jonassen (1996) says that constructing computer-based semantic-nets engages the students in the reorganization of the knowledge; explicit description of concepts and their relationships; relating new concepts to existing concepts and ideas, which improves understanding and spatial learning through spatial representation of concepts in an area of study. A conceptual map is a diagram resource to represent a set of conceptual meanings inside of a structure of proposition. According to Novak, J. D. and Gowin, D. B. (1999), conceptual maps may have a hierarchic structure, general and inclusive concepts may stay on top and the specific concepts may stay successively below them. But, according the recent tendencies about conceptual maps (Jaramillo, D., 2000), they don't have this characteristic because the representation of the knowledge through conceptual maps may respect the choices of the organization of the student, although these choices can assume a new meaning from a shared negotiation.

The conceptual maps can be used in the educational context as a methodological resource for the teacher for evaluation and as a meta-cognitive resource for the student to reflect about the thinking process and restructure yours actions in the teaching / learning process. According to Novak, J. D. and Gowin, D. B. (1999), the most meaning contribution of the conceptual maps in the educational context is in the fact that they allow the evaluation techniques, in specific those that apply in the investigation and research.

Utilization of the INSPIRATION at LAPEMMEC / UNICAMP

The computer environment INSPIRATION has been explored by the participants of LAPEMMEC / UNICAMP, as a methodological resource mediated by computer that allows the collaborative learning and shared knowledge.

First of all, the participants do LAPEMMEC explore the didactic-pedagogical possibilities of this environment and then they elaborate conceptual maps with the selected texts about the integration between Mathematics and technology. In another moment, these conceptual maps had been sent through the Internet to others groups of students with the objective of the creation of an interactive context of collaborative learning and shared knowledge. The following figure illustrates the pedagogical ability of the INSPIRATION to provide an appropriate context to collaborative learning and shared knowledge.

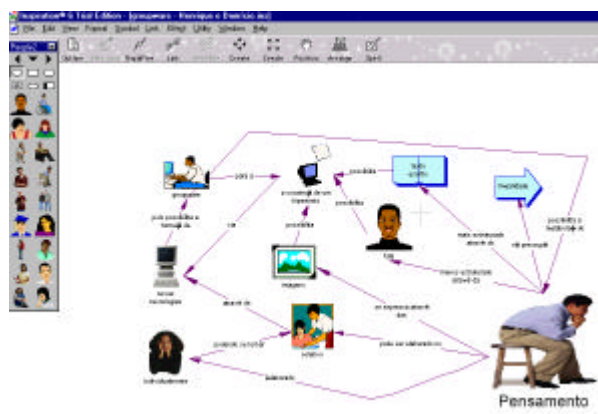


Figure 3 – Discussion of knowledge

Final Considerations

Some consideration can be described about the utilization of Internet based sharing environments. We can infer that the interactive contexts of web-based learning environment offer a collaborative environment for construction of the shared knowledge, which integrate the different perspectives or view in the reflexion and (re)elaboration of the concepts. We know that the

understanding of the concept is related to the expression of it in diverse contexts or interactive medias, which provide the interactivity between the participants, providing a online discussion of the different views about the same concept.

In this sense, we can say that the example given with the computer environment E-TEAM aims at making clear the cognitive and pedagogical possibilities of the E-TEAM as a multimedia interactive environment, which provides a favorable context for collaborative learning and shared knowledge, through electronic communication.

Thus, the objectives of the research LAPEMMEC / UNICAMP, with the computational environment E-TEAM are reached as the development of an interactive educational context makes it possible for the subjects to use the different kinds of E-TEAM files in the development of mathematical problems and challenges.

These considerations can be extended to the another computer environment INSPIRATION. The example given with the computer environment INSPIRATION aims at making clear the cognitive and pedagogical possibilities of the INSPIRATION as a interactive learning environment, which provides a favorable context for collaborative learning and shared knowledge, through web communication.

With these perspectives, another aspect emphasized is related to the fact that the subjects have shown that the critical interaction with a computational tool can give them theoretical-methodological data for the application of the pedagogical and computational potentialities of that environment to their pedagogical practice and to the construction of knowledge, which favor and contribute to a new view in education consonant with the technological development.

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