Cooperative Distance Learning in Mathematics*

*Luiz Carlos Guimarães*** *Instituto de Matemática-UFRJ, Rio de Janeiro, Brasil*
*Thiago Guimarães Moraes**** *Instituto de Matemática e NCE-UFRJ, Rio de Janeiro, Brasil*
*Francisco Roberto Pinto Mattos***** *IApUERJ- Colégio Pedro II – COPPE/UFRJ*

Abstract: In this paper we report on two complementary research results. In the first we describe a tool that allows different modes of synchronous distance teaching of mathematics. In the second we report the preliminary results of a pilot study conducted using this tool to teach geometry, both with school students aged 14-15 and with undergraduate students at a teacher's training course.

Key words: Synchronous distance teaching of mathematics Dynamic Geometry environment Brasil

The modelling of the several modes of interaction in a mathematics classroom was the starting point for the ongoing development of a tool that allows different modes of synchronous distance teaching of mathematics, including a collaborative learning environment. The tool in question has been on development for a number of years, and reports on the initial versions can be found for instance in references 2, 5 & 6. The present incarnation is much more sophisticated, including server software that allows the teacher to choose, at any given moment in his classroom, between different configurations ranging from a strict lecturing mode to fully collaborative modes in which groups of students interact privately among themselves before discussing their results with their classmates (figure 1). Collaborative learning strategies in mathematics, for the case of a face to face classroom, are studied for instance in references 1. The online case is discussed in references 3, whereas a compilation of reports on the use of different computer technologies in the school mathematics classroom can be found in references 4.

We have been experimenting in the last year, using an alpha version of this software coupled with our own implementation of dynamic geometry, with groups of schoolchildren and university students, in distance activities complementing face to face lectures. The initial observations from this pilot study are very encouraging, and indicate a strong potential for this instrument as a vehicle for a full scale virtual classroom. Plans for the near future include the use of this tool as a platform in web based on continuing education programs for school teachers of mathematics.

At present the tool is embedded within a Dynamic Geometry environment (DGS), which was also developed from scratch for the project. The environment, called Tabulae, is in intensive use as a stand alone DGS in schools and teacher training courses in Brasil, and is gradually establishing itself as a local alternative to more traditional products. The advantages of coupling the communication side of the platform with a DGS are that the format is becoming very familiar to students and teachers in schools, and there is already an extensive literature on its advantages and usage at several levels on school as well as a fair amount of cautionary tales about inadequate

* Acknowledgements: This work was partially funded by the Brazilian Ministry of Education (MEC).
** Luiz Carlos Guimarães, Instituto de Matemática-UFRJ, Rio de Janeiro, Brasil.
*** Thiago Guimarães Moraes, Instituto de Matemática e NCE-UFRJ, Rio de Janeiro, Brasil.
**** Francisco Roberto Pinto Mattos ,IApUERJ- Colégio Pedro II – COPPE/UFRJ.

usage, which should help to isolate the effects of the communication framework we want to test. Also very important to our purposes is that this kind of platform provides a familiar language, capable of conveying a variety of mathematical concepts and of modelling an endless supply of rich problems. The interested reader can find more at the special issue on DGS of *Educational Studies in Mathematics*, volume 44 (2001).

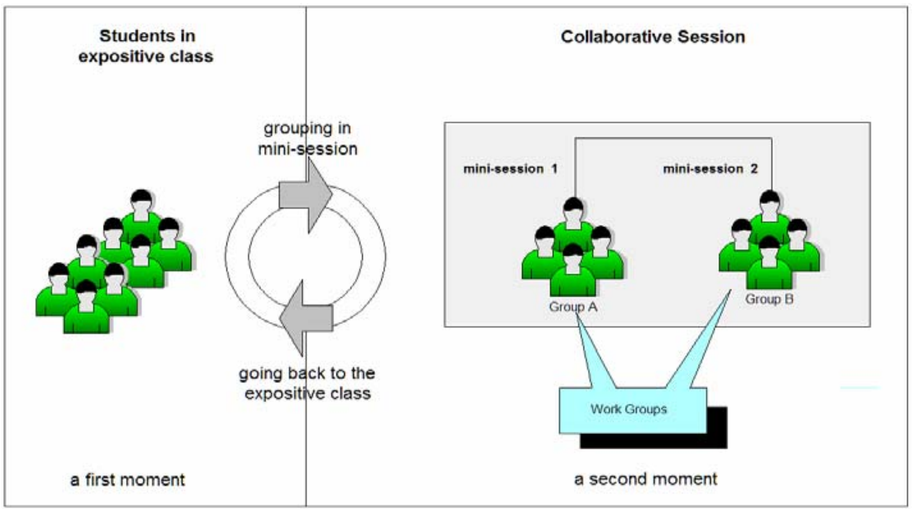

Figure 1 Expositive and Collaborative

The choice we made allows us to address some of the issues raised by Nason and Woodruff in [1]. According to them, "*...establishing a maintaining knowledge-building communities of practice ...in the domain of mathematics have been found to be a rather intractable problem...*", and this could be, at least in part, ascribed to the "*...limitations inherent in most CSCL environments' math representational tools and their failure to promote constructive discourse and other knowledge building activities*". They go on to conclude that "*...the following innovations need to be designed and integrated into CSCL environments:*

1. Authentic mathematical problems that involve students in the production of mathematical models that can be discussed, critiqued and improved, and

2. Comprehension modeling tools that: (a) enable students to adequately represent mathematical problems and to translate within and across representation models during problem solving, and (b) facilitate online student-student and teacher-student hypermedia-mediated discourse.

We would argue that, provided point (2) is achieved, point (1) is a matter of content choice and development by the teacher, unless your environment is too content-specific. Point (2.a) is well covered within a complete DGS like Tabulae, so we will take some time to describe how we addressed point (2.b).

First of all, let us point out that the choice of strategies available to the teacher on-line should not be more limited than what is available in a face to face classroom. In particular, at any given moment of a class there should be a range of possibilities for the model of teacher-student and student-student interaction. We proceed to describe how this is achieved with Tabulae. Please notice that the terms we use should be taken as an analogy, and are not meant to describe a rigidly specified classroom situation.

At the server side, a "teacher" can be endowed with a variety of permissions, including those of a "course administrator", who can create and register one or more "disciplines" (and allocate other "teachers" to them). The teacher in a discipline can create and register classes (or sessions), and oversees students registering to them. Within a given session, the teacher can create sets of mini-sessions, to which subgroups of the students in that class would enroll. A “student” would initially register as such in a given course and discipline also at the server side. The day to day interaction is taken care by the client side (figure 2).

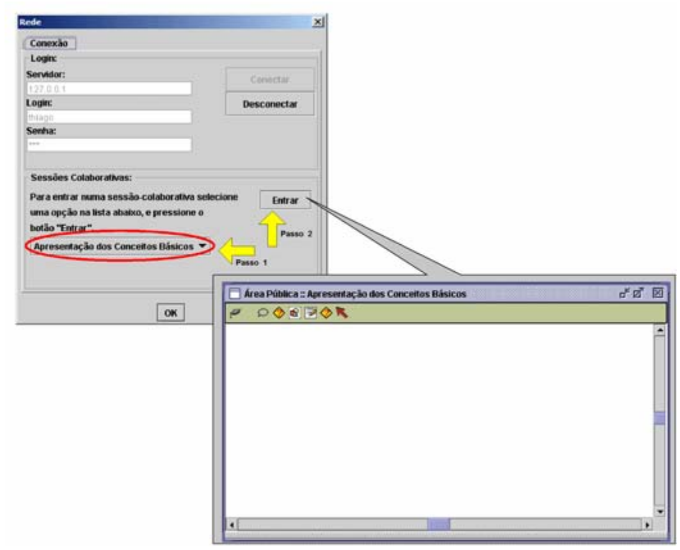

Figure 2 Accesses for Mini-session

The client side, on the other hand, is a fully configured DGS, which also takes care of the communication with the server. When offline, it functions as such, providing for instance an adequate environment for homework (and content preparation). Once connected it takes care of the login protocols to the sessions and mini sessions available at that time for a given student. From this moment on the student is shown is a public window (with a role similar to the traditional blackboard or electronic whiteboard). Permissions to write to this public space are controlled by the teacher but, once obtained, the full range of DGS primitives and commands are available for use by a student in this window. The student or teacher may also have one or more “private” windows open (like notebooks in a classroom) to which objects in the public window can be transferred at will, and conjectures and models of solutions can be tested, as well as private notes taken. Once active, this window also provides, at all times, the full range of DGS primitives and commands. There is also another window where a chat environment is available at all times, for interchange off short remarks and, eventually, negotiation of requests of access to the public space (figure 3).

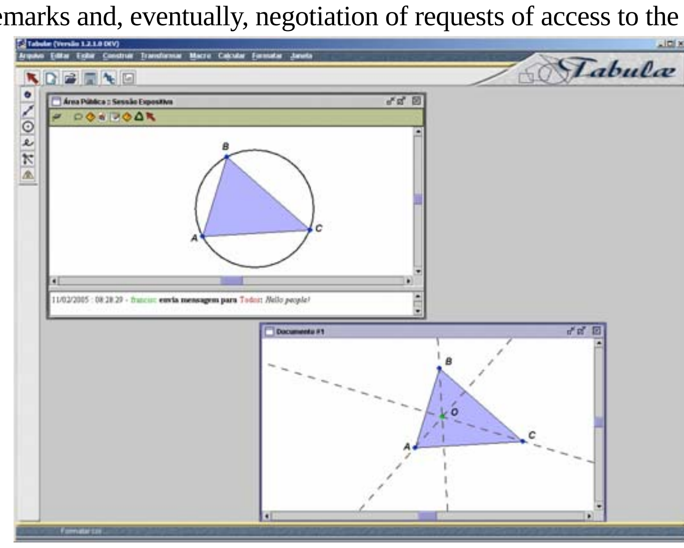

Figure 3 Public and Private Area

For whole class teaching, the teacher can at any given moment choose to reserve exclusive access to the public window, share it with one or more students, or surrender it temporarily. The class may also be divided into groups participating each in a mini-session. Within those the structure is similar, each group having its own public area, restricted to its participants, and if so desired its own tutor, with attributions resembling the teacher's. On the other hand, in a small group it could be desirable to maintain the public area open at all times for any member to write on, and this option is available at the teacher's discretion at all times.

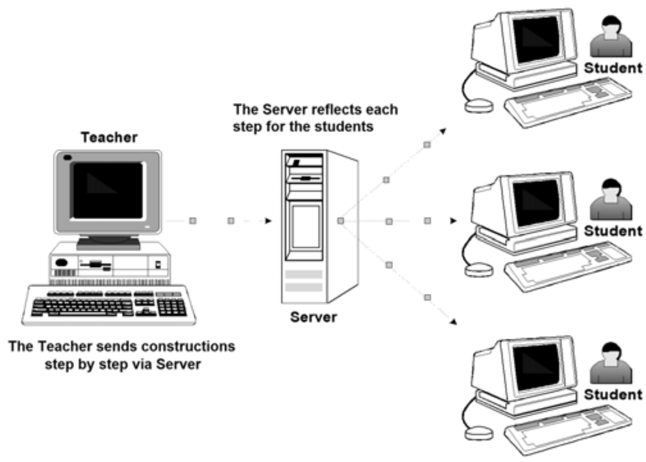

Figure 4   Service Frame

During a class the server has also the role of maintaining a database with the registers of interaction. In this way a student who is late to join the class, or has temporarily lost connection, is available to him or her, the record of what went on before on that class. Those records may also be consulted at a latter time, as study material for the course.

The groups formed in a particular class might also choose to interact online outside classroom hours, so the tool will allow them get together for instance to work on home assignments (figure 4).

The architecture chosen for communication allows for very short response times, even with slow and noisy telephone lines, as only very small packets are actually transmitted. In the tests conducted by us the students would sometimes choose to construct, using the geometric primitives, a board game, like checkers or a tangram, with movable pieces that would henceforth be used in a lively online game.

References:

1. Davidson, N. (1990). *Cooperative Learning in Mathematics*. Addison-Wesley, Menlo Park

2. Guimarães, Luiz, C., Barbastefano, R. & Belfort, E. (2002). *Tabulæ and Mangaba: Dynamical Geometry with a Distance Twist*; in Technology in Mathematics Teaching, Borovcnik,M. & Kautschitsch, H. (eds.). Schriftenreihe Didaktik der Mathematik, vol. 26. öbv & hpt, Vienna

3. Nason & Woodruff. (2004). *Online Collaborative Learning in Mathematics*. In Roberts, T. S. (editor) Online Collaborative Learning: Theory and Practice, InfoSci, London

4. Johnston-Wilder, S. & Pimm, D. (2005). *Teaching Secondary Mathematics with ICT*. Open University Press, Maidenhead

5. Vivacqua, A., Mattos F., Tornaghi, A., Souza, J. M. de. & Cukierman, H. (2003). *Perspectives on Creativity in Web Learning*, Wanlei Zhou, Paul Nicholson, Brian Corbitt, Joseph Fong (eds.): Advances in Web-Based Learning - ICWL 2003, Second International Conference, Melbourne, Australia, August 18-20, 2003, Proceedings. Lecture Notes in Computer Science 2783 Springer 2003, ISBN 3-540-40772-3

6. Barbastefano, R.G. (2002). *Ferramentas Síncronas de Ensino de Matemática a Distância*. Tese de Doutorado, COPPE/UFRJ

(Edited by Li Shen, Fangzheng Zhang and Saihu Xu)