Teacher Training with Cabri Géomètre

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Abstract:

The use of Information and Communication Technologies (ICT) in scientific education has considerably spread in the last few years. Nevertheless, many teachers haven't yet completely overcome their fears and suspicions about applying ICT in mathematical education. Furthermore, there is a generational gap which raises further difficulties: while most of the in-service teachers don't have confidence in the new technologies nor with their application in educational activities, the young teachers are more acquainted with these tools and appreciate their potential in mathematics teaching. Of course, they need help and suggestions for a powerful use in the classroom.

In this paper I will present the experience of a course for future mathematics teachers given at the University of Perugia. The aims of the course were: introducing mathematics teachers into a learning experience with a Dynamic Geometry Environment (Cabri Géomètre); making them work in small groups on topics chosen by themselves; making them develop teaching units based on 'Cabri' dynamic geometry projects; stimulating discussions about ICT's strengths and weaknesses in the learning/teaching process.

The experience showed that the participants, after getting used to the new technological tool, were able to apply their competence in the construction of interactive educational materials for a classroom situation. Moreover, they could focus on their (technical, mathematical and educational) difficulties and develop some critical reflections. The Course Management System 'Moodle' was utilized for hosting the learning materials, and most of the projects were developed by the participants in the course. For that purpose, the CabriJava technology was used.

Keywords: teacher training, Cabri Géomètre, dynamic geometry systems, education of mathematics, pre-service mathematics teachers, ICT, information and communication technology, mathematics teacher education

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Introduction

In everyday life Information and Communication Technology is ubiquitous. In the past few years people have become familiar with using a computer for a great variety of purposes. Nowadays, ministerial curricula suggest or prescribe the use of ICT in education, particularly in mathematical and scientific education. In this phase of transition, teacher education has acquired an increasing importance for bridging gaps between past and present curricula, teaching methods and technologies. Numerous publications report on initiatives for pre-service teachers that involve theoretical and practical courses about integration of ICT in mathematical education [Chaachoua, 2001; Da Ponte, 2002].

I describe in this paper a similar experience carried out by teaching the course "Didactics of Mathematics with Computer Laboratory" at the University of Perugia. The course was included in the first year of the Postgraduate School of Education for lower secondary school science teachers (course code A059) and for upper secondary school mathematics teachers (course code A047).

The entry requirements for the School are graduation in Mathematics (for the A047 class), or graduation in Mathematics or other Scientific Faculties (for the A059 class) and the completion of an entrance exam.

Beside the course "Didactics of Mathematics with Computer Laboratory", the future teachers also took courses in psychology, pedagogy, didactics of mathematics, didactics of probability and statistics, etc. In the academic year 2002/2003 this course was attended by 67 people; they came especially from Umbria region and other regions of Central Italy and their ages varied between 24 and 40 years.

Participants' background

By the period of the course, participants hadn't yet completed the professional practice required by the Postgraduate School itself, but many of them had already taken part in educational activities in private or public schools mainly as temporary teachers.

In order to learn more about the participants, we made them compile a questionnaire. Of the 67 attendees to the course, 38 answered. It turned out that about a quarter of them had never taught before entering the School, but some of them had been teaching for at least one year.

Teaching Experience	N. of attendees
Teaching for at least 1 year	6
Some temporary teaching	7
Private lessons	10
Never have taught	10
Other didactical activities	5
Total	38

Therefore, it was necessary to consider the attendees' varied teaching experience. It was not easy to try and avoid boredom among in-service teachers, and to make the course useful for them as well, while at the same time not to presume a wide field of teaching experience as owned. Thus, in this paper I avoided using terms as "in-service" or "pre-service" teachers: I preferred to say "attendees", "participants" to the course or also "future teachers" although it's not a completely exact term.

As regards technical preparation, the attendees were asked whether they had ever been involved in classroom activities with educational software when they were students (before university), and how frequently and for what purposes they had been using the computer before beginning the Postgraduate School.

It resulted that only 10, of the 38 questionnaires we had, had had a technological learning experience before university, but all of them had been using the computer for one or more purposes (study, work, entertainment) at least a few times a week last year. Twenty-one of them had been using the computer daily in the working place and 26 had been using it for study at least some times a week. This means that technological instruments belong to the everyday life of young teachers; hence, we didn't have to tackle the problem of how to use the computer itself, and we were able to better focus on educational aspects.

Half of those who were teaching used the computer frequently for their lesson preparation, but only 6 persons used computer technologies in the classroom. Thus, we could note that they had in fact overcome their fears and suspicions about using a computer, but they hadn't done so about applying it in mathematical education.

The Course of Didactics of Mathematics with Computer Laboratory

This course had a strongly practical outline and it was aimed at making attendees become familiar with an example of dynamic geometry environment, Cabri Géomètre, to make them actively create interactive teaching units and to encourage them to think about the use of these tools in their (future or present) classroom activities.

The course program was divided in three modules:

The first module (the first 5-hour lesson) was dedicated to demonstrate the main tools of Cabri Géomètre and to guide the construction of two simple figures with Cabri. One of them illustrated how to construct macros as well.

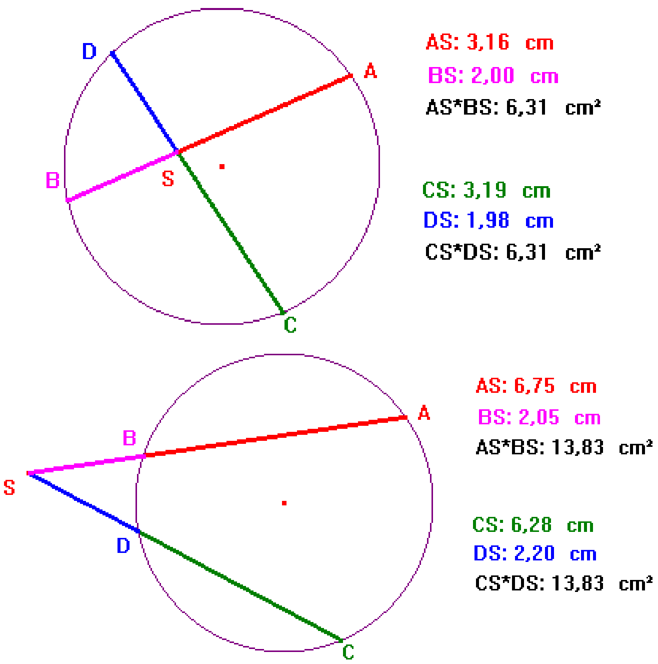


Figure 1: Power of a point

Realization based upon: Getting Started with Cabri Geometry II Guidebook, pages 25-31

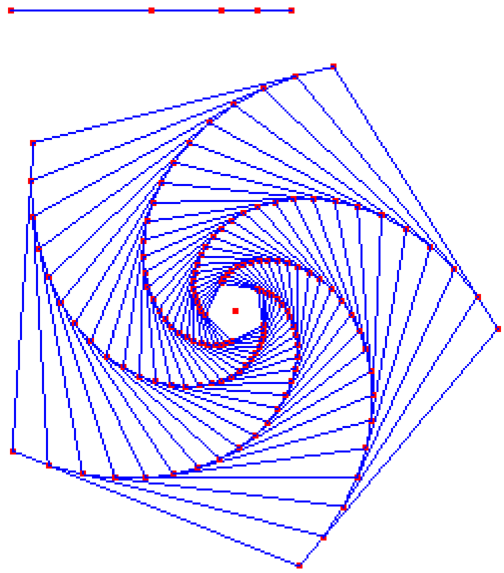


Figure 2: Pentagons and spirals

Realization based upon: Getting Started with Cabri Geometry II Guidebook, pages 32-37

The second module (the second 5-hour lesson) consisted in the assignment of two constructions to all working groups. To facilitate the lower secondary school teachers, one was chosen about Euclidean plane geometry (working about the properties of trapezia and parallelograms), while the other one concerned coordinate geometry and transformation of coordinates (more suitable for upper secondary school curricula).

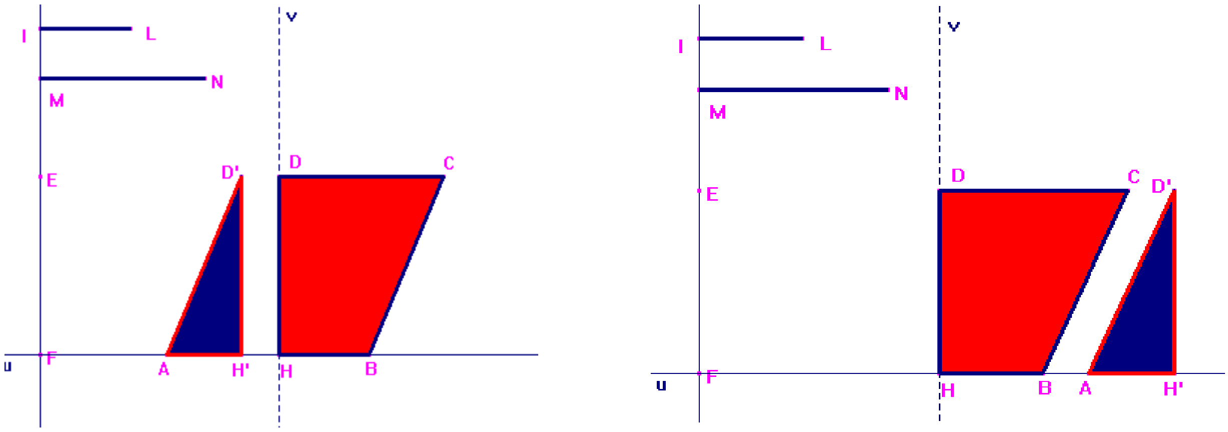


Figure 3: The area of a parallelogram

Realization based upon: Cabri IRRSAE Bulletin, n. 28/2001, pp. 6-8

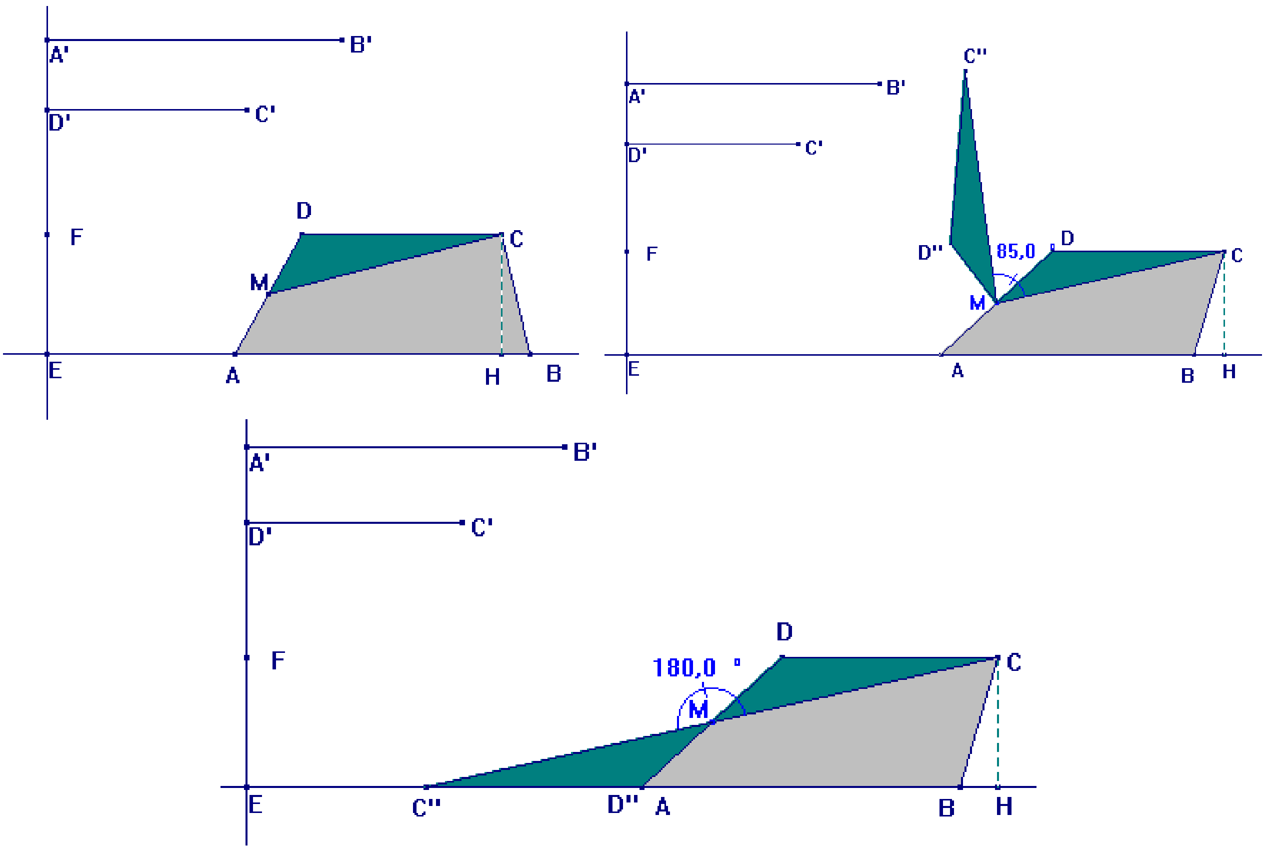
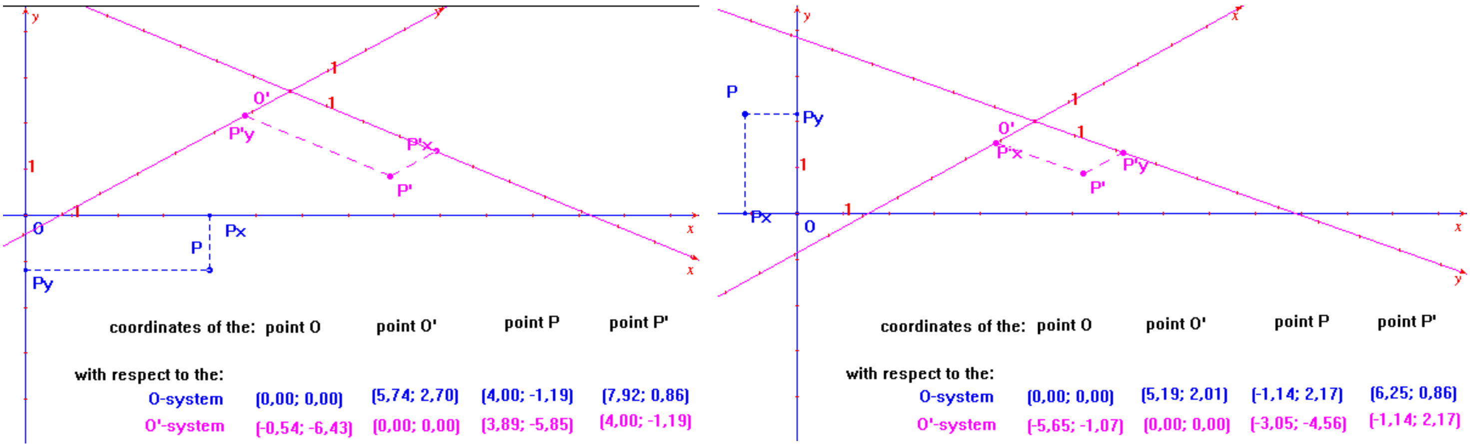


Figure 4: The area of a trapezium

Realization based upon: Cabri IRRSAE Bulletin, n.28/2001, pp. 6-8



<u>Figure 5: Transformations of coordinates</u>
Realization based upon: Cabri IRRSAE Bulletin, n.27/2001, pp. 13-14

The participants were prompted to discuss among themselves about the possible educational application of these projects and about how to use these figures in classroom activities: what activities, what reflections, what aims, what doubts. All groups succeeded in managing Cabri tools, some of them didn't need the instructor's intervention, others needed support for learning about the available features, or for getting over their mathematical difficulties.

At the end of this first semi-autonomous activity, they were shown how to publish their work in Web pages. The Cabri Java applet is very useful because besides making it possible to share each other's work on the Web, it also allows to see Cabri figures and interact with them on computers where Cabri Géomètre isn't installed. In this way, the attendees were able to take their constructions back home with them, visualize and use them at home (not to modify them, obviously) and keep on reflecting about learning activities they could offer.

<u>The third module</u> (three 2-hour lessons) was the beginning of the completely autonomous group work. There were no predefined topics assigned to work on: attendees themselves defined their own topics working in 23 groups and agreed on a project title of their own after having performed a thorough research in the World Wide Web, in textbooks and other resources. It was suggested to consult Cabri IRRSAE bulletins, an Italian periodical of Cabri users. In the 37 issues that have been published since 1993 it's possible to find many proposals for the use of Cabri in any mathematical topic, educational ideas and advice, beside the technical description of how to construct Cabri figures. This was an attempt to shift the attendees' attention away from technical questions and problems with Cabri itself, in order to focus on mathematical doubts and educational aspects, to enable them to work in a co-operative way and to discuss on their own projects.

Many of the working groups didn't only limit themselves to reproduce the described constructions, but they also created new ones, or modified the proposed ones according to the aims of their own teaching unit. At first the attendees asked for help about choosing the topic, but later they worked rather autonomously requiring some help mostly in technical questions stemming from the software. However, it could be noticed that the future science teachers in lower secondary school needed more support to bridge their gaps in mathematical questions.

The future teachers were provided with a list of questions, which they should ask themselves when imagining a Cabri based teaching unit:

» What students does this project refer to? (Age, school level, school type)
» In what way(s) can this project be adapted to a classroom situation?
» What mathematical topic can this project be connected with?
» What knowledge, competence, skills and abilities must pupils have in order to cope with the teaching unit?
» The learning of what mathematical concepts is this teaching unit aimed at facilitating?
» What tasks can be performed during the construction of the project? What tasks can be performed with the completed project?
» What further progress can be achieved?

» What were the critical points for you? How did you overcome them?
» What do you think are the critical points for the pupils?
» What interactions do the Cabri figures allow? What are the points of interactivity?
» What is the starting arrangement of the objects?
» What arrangements do you want to make the pupils reach? Why and how?

Obviously, some of these questions are quite general, and so suitable for any teaching unit; however, they can all be easily adapted to an educational situation with other dynamic geometrical systems as well.

No written coursework was assigned to the future teachers beside the Cabri figures, so as to encourage them to reflect on educational aspects. Although, most groups accomplished some written materials: schemes for the teaching unit, didactical notes for the teachers' own use, exercises to be assigned to pupils, working sheets, examples, mathematical notes, paper models, etc. It's to be noticed that many groups organized their work to produce a complete teaching unit: they planned the classroom activities before and after the lab tasks and they designed the complete theoretical scheme for the subject they had to discuss.

Assessment was based on the work performed during the lessons, and on the discussion of the projects. It would have been very interesting to make a whole-class discussion and involve the other groups as well, but unfortunately it wasn't possible.

Some of these works will be presented in this paper, focusing on the Cabri-made constructions and leaving out the other materials presented by the participants.

Some final projects

By the end of the course, the working groups had carried out some Cabri-based projects based on the following topics:

Topic	Number of groups
Conics / Geometrical loci	6
Plane geometry	6
Spatial geometry	2
Coordinates geometry	2
Fractals	3
Golden division	2
Trisection of an angle	1
Trigonometry	1
Total	23

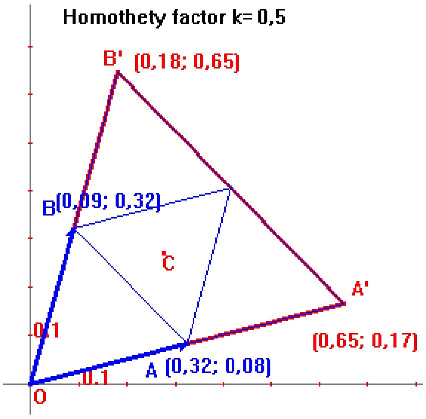
Some teaching units require the students to be involved in the construction process of Cabri figures itself, while other projects are simply targeted at students as final users. In some cases, the same Cabri project could be used in both ways, depending on the age of the target students, the type of school or other factors.

Some of the Cabri projects and other learning materials are available on the course website hosted by the Statistics Department of the University of Perugia: http://www.stat.unipg.it/EDUCATION/moodle (in Italian). Cabri figures have been published using the CabriJava applet and they have been furnished with a concise description and a table of the points of interactivity. The entire course website has been organized with the Course Management System 'Moodle'.

Fractals with Cabri

All projects about fractal geometry necessarily imply designing and creating macros. They stimulate pupils' algorithmical thinking and they can be a basis for beginning programming activities as well. All these projects involve pupils actively in the phase of the construction of the fractal, allowing them to invent new ones by themselves. The only possible interaction with the completed files are translating, rotating and applying a homothety to the fractal using the dragging tool of Cabri.

The picture on the left illustrates the construction of the main macro for the Sierpinski triangle: inscribing in a given equilateral triangle a smaller one with 0.5 as homothety factor and rotated with $\pi/6$. The picture on the right shows the fractal construction during the third step of iteration. It can be noticed how the fractal area tends to the area of the initial triangle.



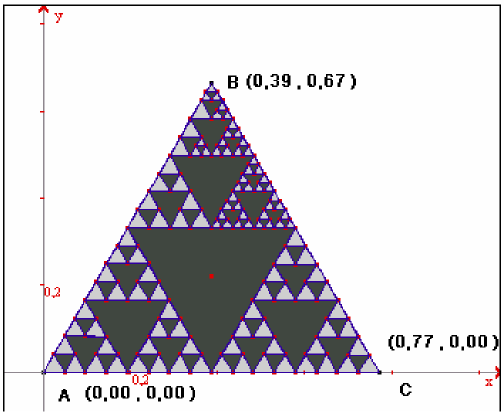


Figure 6: Construction of the Sierpinski triangle

It is possible to work with fractals at lower secondary school level too, as it can be seen in the following example. A group of attendees supposed a learning situation with rather simple tree fractals:

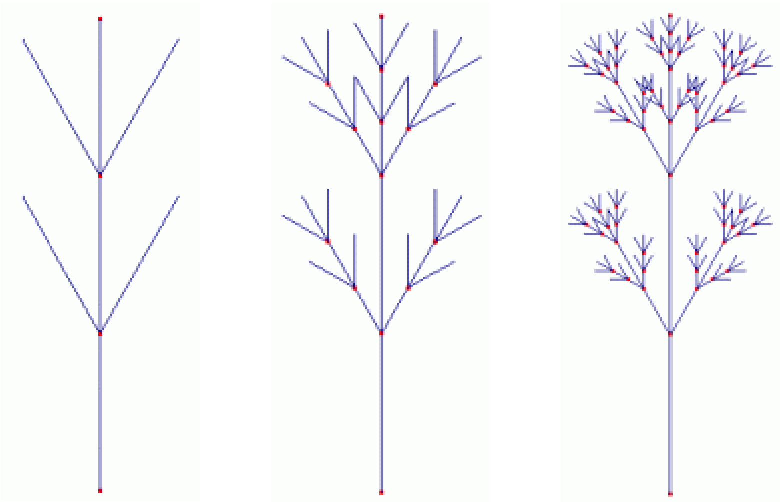


Figure 7: An example of tree fractal

Pupils can easily create other tree-shaped fractals modifying some properties of the iteration step: angle of rotation, factor of homothety or number of branches to apply in a step.

This is a fir tree fractal:

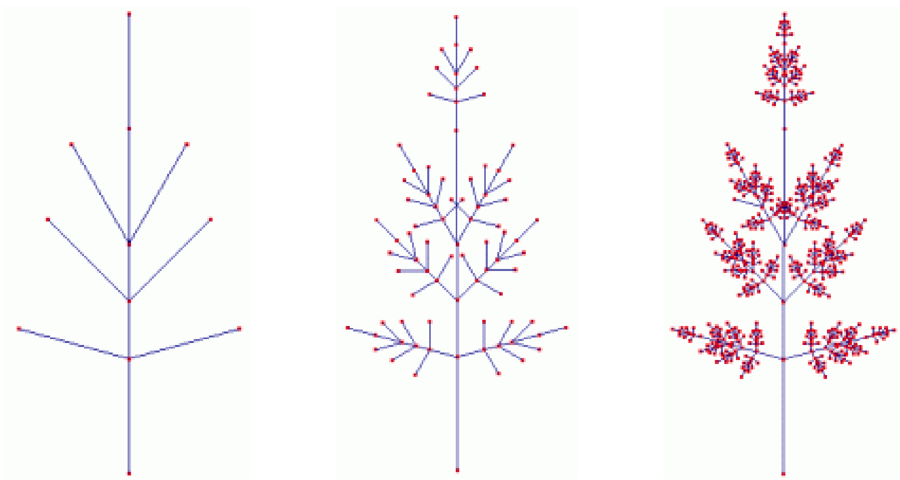


Figure 8: The "Christmas tree" fractal

Conics with Cabri

Many groups (6) chose this topic to work on, but each of them dealt with this subject from different points of view. These projects can be used in a strongly interactive way, and most of them are quite difficult to construct with the students. It's always the teacher who each time decides how much time s/he can spend on this type of activities.

The figure below show an "elliptical compass": an interactive tool for tracing an ellipse as the geometrical locus determined by the point *P* while the point *M* moves along the circle *c1*. The point *M* is the centre of the circle *c2* with radius *r* and passing through *O*. *C* and *D* are the points of intersection of the circle *c2* with the axes. *P* is an arbitrary point on the straight line passing through the points *C* and *D* and its position determines the lengths of the axes of the ellipse.

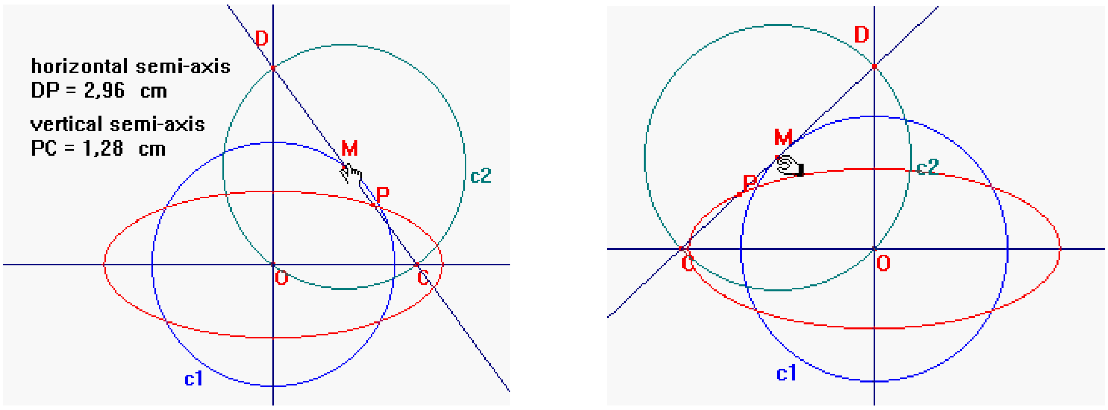


Figure 9: Elliptical compass

Studying trigonometry with Cabri

The dragging tool of Cabri resulted particularly powerful in a trigonometry project (see figure beside).

By moving the point *P* on the unit circle, the values of trigonometrical functions of the angle can be easily observed and tabulated. Again, the dynamic nature of Cabri offers the benefit of an easy manipulation of geometrical objects in an almost continuous way, according to the constraints arisen from the construction itself. Instead, in a traditional paper/pencil environment only a sequence of few static drawings could illustrate the same phenomena, and pupils would have to transform these 'snapshots' into an animation sequence in their imagination [see: Bardone, 2000].

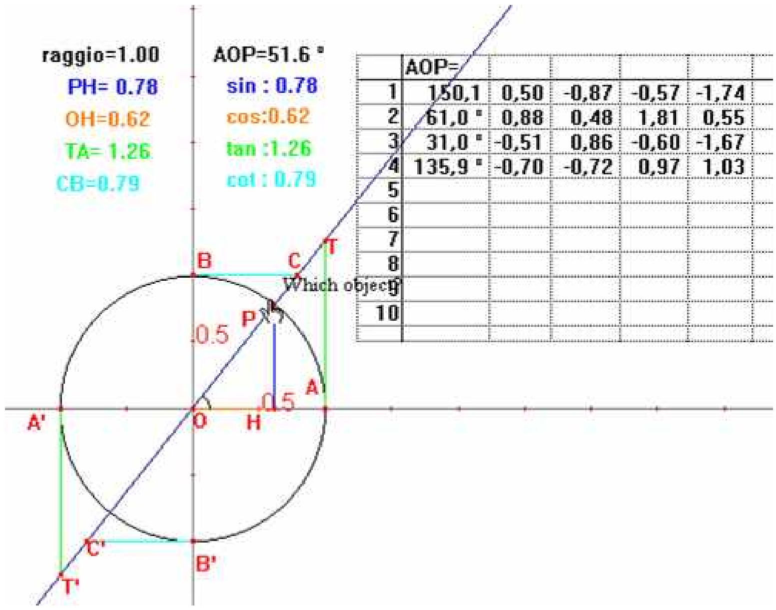


Figure 10: Trigonometry with Cabri

Conclusions

Nowadays many courses on the didactical use of technological tools are given to pre-service teachers. The literature report that pre-service teachers make a scarce use of technological resources prior to this kind of courses and they also manifest a certain resistance against the didactical use of ICT. However, these initiatives produce positive changes in both perspectives. [Chaachoua, 2001; Da Ponte, 2002]

We had a similar experience at the course of Didactics of Mathematics with Computer Laboratory. Saving that the participants to the course seemed to have a good relationship with computer technology, the same attitudes of suspicion could be noticed as far as the didactic use of ICT is concerned.

On the other hand, applying technologies in classroom is a recent issue, which poses many challenges to teachers and raise many difficulties such as:

- knowing a variety of educational software;
- knowing how to choose educational software or how to judge whether it fits one's aims;
- knowing how to use it in classroom activities (for what purposes, how, how much time is needed, in what order, etc.);
- being able to manage a different kind of classroom situation.

[See also Chaachoua, 2001]

It can be noticed that many of these problems stem from a poor experience of educational application of computer technology either as students or as teachers.

The course described here was an effort to act on these critical points and to try to remove or soften attendees' negative attitudes towards the integration of ICT in direct classroom activities. Besides, it was a good opportunity to show young teachers an example of a possible learning experience with a dynamic geometrical system.

References

Abboud-Blanchard, M. Utilisation du logiciel CABRI-GEOMETRE dans la formation mathématique des PE1 : recherche exploratoire, in: http://www.dijon.iufm.fr/format/recherch/abstrac1.htm, 2002

Bardone, L., Trevisani, M., Bagnari, R. Proprietà necessarie e sufficienti per una figura con Cabri-Géomètre - Unità di Lavoro, progetto SeT, in: http://www5.indire.it:8080/learning_risorse/Castelletto/set/pub_readUnit.asp?ID_Progetto=2&ID_Unt_Lavoro=5, 2000

Cabri IRRSAE Bulletins, http://kidslink.bo.cnr.it/cabri/

Chaachoua, H. Usages éducatifs des technologies de l'information et de la communication: quelles nouvelles compétences des enseignants? - RAPPORT DE RECHERCHE, in: http://www.inrp.fr/Tecne/Savoirplus/Rech40003/pdf/chaachvers_courte.pdf, 2001

Da Ponte, J. P., Oliveira, H., Varandas, J. M. Development of pre-service mathematics teachers' professional knowledge and identity in working with Information and Communication Technology, in: Journal of Mathematics Teacher Education, 5: 93-115, 2000

Getting Started with Cabri Geometry II Guidebook, Texas Instruments, http://education.ti.com/us/product/software/cabri/guide/cabriguideus.html

Laborde, C., Why technology is indispensable today in the teaching and learning of mathematics?, Contribution to the T3 World-Wide conference in Tokyo – 6-8 August 2000, in http://emptweb.mps.ohio-state.edu/dwme/t3_post_icme_papers.asp

Mariotti, M.A. 'Un software per una teoria', in Atti del 20° Convegno Nazionale UMI - CIIM, Orvieto, Notiziario dell'UMI Supp. n. 10, Ottobre 1999.

Schumann, H. For the Design of a Computer integrating Geometry curriculum (http://www.mathe-schumann.de), Paper presented in the Working Group for Action 11: The Use of Technology in Mathematics Education on the 9th International Congress on Mathematical Education (ICME 9) in TOKYO / Makuhari (July 31 - August 6, 2000)

Tomasi, L. Geometria dello spazio con Cabri-Géomètre e CabriJava: alcune possibilità didattiche in classe e nel Web, in: Notiziario UMI, Ottobre 2001, Supplemento al n. 10, Atti del XXI. Convegno Nazionale UMI-CIIM sull'insegnamento della matematica, Salsomaggiore 13-15 aprile 2000

Tucker, G. R., Willis, E. M. Using Constructionism to Teach Constructivism: Modelling Hands-On Technology Integration in a Preservice Teacher Technology Course, in: Journal Of Computing In Teacher Education Vol. 17 / No. 2, 2001