WebGeometryLab

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1 Extended Abstract

Introduction The area of geometry allows an easy connection between the abstract and the concrete, between the formal description of a particular geometric construction and its concrete representation.

The dynamic geometry systems (DGSs) allow an easy construction of geometric figures build from free objects and constructed objects, using elementary constructions. The free objects can the be manipulated in such a form that the constructed objects are also changed in such a way that the geometric properties of the construction are preserved. This can be used to emphasise the link between the formal nature of geometry and its models.

The DGSs allow also to perform more complex geometric transformations like translation, reflection, rotations they also allow to build and manipulate a variety of figures, visual demonstrations of theorems, graphs, curves, etc. The advantages of the DGSs in a learning environment are multiple, they are easy to use, they stimulate the creativity and the discovery process. There are multiple DGS available: GeoGebra, Cinderella, GeometerSketchpad, C.a.R., Cabri and GCLC [2, 3, 4, 7, 8] to name the most used.

The use of computational methods in the teaching of geometry should be viewed as a new way of conceiving education, i.e., a new tool for assessment/diagnosis during the lessons. In the high-school curriculum in Portugal the use of such tools is praised. Quoting from the official curriculum specification[1] [1].

> The computer, by its own potential, namely in the areas of dynamic geometry, function representation and simulation, allow activities, not only activities of exploration and research but also activities of recovery development, in such a way that it constitute an important asset to teachers and students, its use should be considered obligatory in this curriculum.

The Pythagoras theorem is an example where the DGSs can be used in a very fruitful way. The dynamic component allow us to work the visuals demonstrations of this theorem (see the videos in `www.cs.wichita.edu/~ye`). This theorem allow us to emphasise the links between the formal specifications in geometry and its visualisations.

WebGeometryLab The "Web Geometry Laboratory" (*WebGeometryLab*)[2] is an Web environment, that integrates a DGS program and a database, aiming to provide a learning environment in geometry with individualised memory.

[1] Translated from the Portuguese text.

[2] `http://hilbert.mat.uc.pt/WebGeometryLab/index.php`

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The *WebGeometryLab* system will allow the teacher to create, store and provide to its students a set of geometric constructions, it will allow the student to access to the professor's constructions as well as those kept in a personal "scrapbook", a place where the student will keep his/her own construction; solutions of problems placed by the teacher and/or his/her own exploratory activities. The teacher will have also access to the constructions made, or being made, by the students as a way to be able to help the student during a class or to evaluate the work done after class, or even as a mean to broadcast the work done by a student to the rest of the class.

That system will be easy to install on a school server, or even on the teacher's personal computer. It will require:

- a computer hosting a network server (local or global) able to provide access to the Web pages of the *WebGeometryLab*, and a database management system to provide access to the database that gives the individualised memory to the system. Any Linux/MacOS computer will be able to provide such an environment, it will also be possible to build such an environment on top of a MS-Windows system;
- access to a network (local or global). The school network or even, with the help of an wireless access point, a local/classroom wireless network provided by the teacher;
- computers containing a Web browser connected to the network for teachers' and students' access to the system. Nowadays any computer is equipped with such a program, if not, installing one is always possible.

All this can be built using open source programs so, apart from the hardware this has no other costs, and even that, at least in the Portuguese case, it will not be a problem given the easy access to laptops provided by the "e-escola" ("e-school") program.

The *WebGeometryLab* system is organised in three distinct modules:

- the *management module* that allows the system manager to set whose users will have "teachers status" within the system;
- the *teacher's module*, which allows access (with validation) for teachers. Through this module it will be possible to teachers to make the management of students; it provides also access to the DGS in order to set the constructions that will be accessible to all the students, and finally it will give access, in read mode only, to the "scrapbooks" of students;
- the *student's module* provides access, through a validation process, to the students. This modules allows access, read-only, to the constructions provided by the teachers, and also full access to the student's personal "scrapbook"

The *WebGeometryLab* aims to provide a learning environment for geometry using all the potential of the DGSs, all the easiness of access provided by an Web platform and with an individualised memory provided by a database where all the history of each student is kept providing in this way an adaptable blended learning environment.

From the point of view of the server the system aims to be easy to install, maintain and use, from the point of view of the clients, teachers and students, the only feature that is needed is the access to a java capable[3] Web browser, which is, nowadays, irrelevant given the ubiquity of such type of program.

If installed in the school server the *WebGeometryLab* it is not confined to the classroom, it can be opened to the global network, thus enabling its remote use by teachers and students, extending its use

[3]The *WebGeometryLab* uses the GeoGebra Applet

to a blending learning environment, allowing the teacher to set new challenges to be solved outside the classroom, allowing each individual student to work in his/her own pace.

In technical terms the *WebGeometryLab* system was designed and has been implemented as a multi-platform system, i.e. independent of any computer/operating system platform, based on tools: network server (e.g. Apache), PHP, MySQL in the server side, and a browser, and the languages, JavaScript, AJAX and Java in the client side. All this tools/languages are multi-platform. Also in its implementation it is taken into account the need to adapt to different languages, the *WebGeometryLab* is an i18n/l10n (Internationalisation and localisation) system having the English has its base language an relying in translation to adapt the interface to other languages (e.g. the Portuguese).

Defining a network environment that integrates a DGS program and a database, the *WebGeometryLab* provides more then the simple sum of its components: integrating the DGS fully in a Web-environment it opens the use of the DGS to a collaborative blended learning environment; linking all that with a database allow an individualisation of the learning environment with the creation of individualised learning path.

Extending *WebGeometryLab* to a LMS As described above the *WebGeometryLab* will provide an adaptative, collaborative, Web learning environment to Geometry. In spite of the DGSs outstanding features, they do not create a learning environment by themselves, the *WebGeometryLab* goes a step further on that incorporating the DGS and a database in a Web environment implementing some features of a learning environment, nevertheless some important features of a learning environment are still lacking. The learning management systems (LMS) are the proper setting enabling the management of courses, teaching assistance, management and distribution of content to students, in an Web environment with synchronous and asynchronous features.

In the next section we will try to expand on how and why to incorporate *WebGeometryLab* in a LMS.

Learning Managements Systems With the construction of *WebGeometryLab* we wanted to build an Web environment, integrating a DGS and a database, where both teacher and students, have the tools necessary to study Euclidean geometry its theories and models and to be able to understand the bridges connecting these two perspectives, exploring the axiomatic nature of geometry. A learning environment that enables students to test and enhance their knowledge.

The LMSs are courses management systems capable of handling a large number of courses and users. They aim to support the learning process of each student, without physical barrier and asynchronously. They are collaborative learning environments promoting the learning through collaborative efforts.

To merge *WebGeometryLab* in a LMS is the ultimate goal of the work that is being developed. Adding a dynamic geometry tool to this type of system will make the system more rewarding because it will allow students to explore themes of geometry in order to overcome some (not necessarily all) difficulties or shortcomings that may have. Merging the dynamic geometry tool and the database, for an individualised memory, into a LMS will provide teachers and students with an adaptive learning environment for geometry.

Future Work The *WebGeometryLab* is a "work on progress" project, as a first task we need to complete a first prototype of a standalone system capable of being distribute to schools and/or teachers, install and be used by them, such a system should already include a set of geometric constructions a course syllabus to help teachers to organise there work. After that the integration of this system in a learning management system with some samples courses already in placed would be the second task. The integration of

automated theorem proving (ATP) and/or interactive theorem proving (ITP) it is also a wanted feature and it is planned as a task to be pursued in parallel with the described tasks [5, 6].

The goal of this project it is to build a dynamic adaptative learning environment, an environment where the student has at his/her disposal the necessary tools for the study of theories and models of geometry, to understand the differences and connections between these two perspectives, improve their knowledge. A system in which the student can also being challenged by new problems, giving the student the opportunity to develop and improve their study in the area of geometry anywhere, anytime and at their own pace.

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