

The Web Geometry Laboratory Project

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Abstract. The *Web Geometry Laboratory (WGL)* project's goal is to build an adaptive and collaborative blended-learning Web-environment for geometry.

In its current version (1.0) the WGL is already a collaborative blended-learning Web-environment integrating a dynamic geometry system (DGS) and having some adaptive features. All the base features needed to implement the adaptive module and to allow the integration of a geometry automated theorem prover (GATP) are also already implemented.

The actual testing of the WGL platform by high-school teachers is underway and a field-test with high-school students is being prepared.

The adaptive module and the GATP integration will be the next steps of this project.

Keywords: adaptive, collaborative, blended-learning, geometry.

1 Introduction

The use of intelligent computational tools in a learning environment can greatly enhance its dynamic, adaptive and collaborative features. It could also extend the learning environment from the classroom to outside of the fixed walls of the school.

To build an adaptive and collaborative blended-learning environment for geometry, we claim that we should integrate dynamic geometry systems (DGSs), geometry automated theorem provers (GATPs) and repositories of geometric problems (RGPs) in a Web system capable of individualised access and asynchronous and synchronous interactions. A system with that level of integration will allow building an environment where each student can have a broad experimental learning platform, but with a strong formal support. In the next paragraphs we will briefly explain what do we mean by each of these features and how the Web Geometry Laboratory (WGL) system cope, or will cope, with that.

A *blended-learning environment* is a mixing of different learning environments, combining traditional face-to-face classroom (synchronous) methods with more modern computer-mediated (asynchronous) activities. A Web-environment is appropriate for both situations (see Figure 1).

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An *adaptive environment* is an environment that is able to adapt its behaviour to individual users based on information acquired about its user(s) and its environment and also, an important feature in a learning environment, to adapt the learning path to the different users needs. In the *WGL* project this will be realised through the registration of the geometric information of the different actions made by the users and through the analysis of those interactions [4].

A *collaborative environment* is an environment that allows the knowledge to emerge and appear through the interaction between its users. In *WGL* this is allowed by the integration of a DGS and by the users/groups/constructions relationships.

Using a DGS, the constructions are made from free objects, objects not defined by construction steps, and constructed objects using a finite set of property preserving manipulations. These property preserving manipulations allow the development of “visual proofs”, these are not formal proofs. The integration in the *WGL* of a GATP will give its users the possibility to reason about a given DGS construction, this is an actual formal proof, eventually in a readable format. They can be also used to test the soundness of the constructions made by a DGS [1,2].

As said above to have an adaptive and collaborative blended-learning environment for geometry we should integrate intelligent geometric tools in a Web system capable of asynchronous and synchronous interactions. This integration is still to be done, there are already many excellent DGSs [7], some of them have some sort of integration with GATPs, others with RGP [1,5]. Some attempts to integrate these tools in a learning management system (LMS) have already been done, but, as far as we know, all these integrations are only partial integrations. A learning environment where all these tools are integrated and can be used in a fruitful fashion does not exist yet [6].

2 The Web Geometry Laboratory Framework

A class session using *WGL* is understood as a Web laboratory where all the students (eventually in small groups) and the professor will have a computer running *WGL* clients. Also needed is a *WGL* server, e.g. in a school Web-server (see Figure 1).

The *WGL* server is the place where all the information is kept: the login information; the group definition; the geometric constructions of each user; the users activity registry; etc. In the *WGL* server is also kept the DGS applet and the GATP will also execute

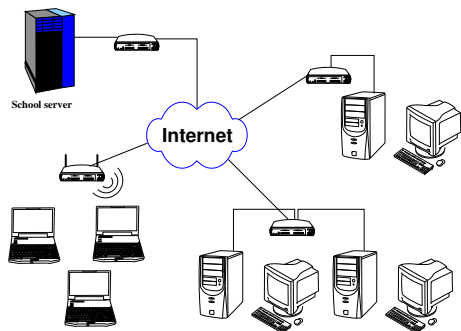


Fig. 1. School Server

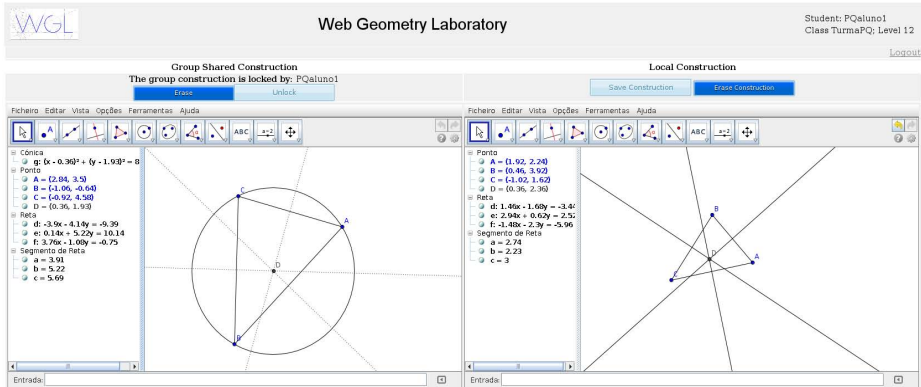


Fig. 2. Students' Interface

there. Each client will have an instance of the DGS applet, using the server to all the needed information exchange.

After installing a *WGL* server the administrator of the system should define all the teachers that will be using the system. The teachers will be privileged users in the sense that they will be capable of define other users, their students. In the beginning of each school year the teachers will define all his/her students as regular users of the *WGL*. The teacher may also define groups of users (students), these groups can be define at any given time, e.g. for a specific class, and it will be within this groups that the collaboration between its members will be possible. The definition of the groups and the membership relation between groups and its members will be the responsibility of the teachers that could create groups, delete groups and/or modify the membership relation at any given time.

Each user will have a “space” in the server where he/she can keep all the geometric construction that he/she produces. Each user will have full control over this personal scrapbook, having the possibility of saving, modifying and deleting each and every construction he/she produces using the DGS applet.

To allow the collaborative work a permissions system was implemented. This system is similar to the “traditional Unix permissions” system. The users will own the geometric construction defining the reading, writing and visibility permissions (rwv) per geometric construction. The users to groups and the constructions to groups relationships can be established in such a way that the collaborative working, group-wise, is possible.

By default, the teacher will own all the groups he/she had created granting him/her, in this way, access to all the constructions made by the students. The default setting will be `rwvr-v---`, meaning that the creator (owner) will have all the permissions, other users belonging to his/her groups will have “read” access and all the others users will have none. At any given moment he/she can download (read) the construction into the DGS, modify it and, eventually, upload the modified version into the database.

The collaborative module of *WGL* distinguishes students having the lock over the group construction from those without the lock. The students with the lock will have a full-fledged DGS applet, and they will be working with the group construction (see Figure 2). The students without the lock will have also the two DGS applets, but the construction in the “group shared construction” one is a synchronised version of the one being developed by the student with the lock, and a full-fledged version that can be used to develop his/her own efforts. A text-chat will be available to exchange information between group members. The teacher could always participate in this efforts having for that purpose an interface where he/she can follow the students and groups activities.

The *WGL* collaborative features are thought mostly for a blended-learning setting, that is, a classroom/laboratory where the computer-mediated activities are combined with a face-to-face classroom interaction. Nevertheless given the fact that the *WGL* is a Web application the collaborative work can extend itself to the outside of the classroom and be used to develop collaborative work at home, e.g. solving a given homework. In this setting the only drawback it will be a slow connection to the *WGL* server. We estimate that a normal bandwidth ($\geq 20\text{Mb}$) will be enough.

The *WGL* as a Web client/server application; the database (to keep: constructions; users information; constructions; permissions; user’s logs); the DGS applet; the GATP and the synchronous and asynchronous interaction are all implemented using free cross-platform software, namely PHP, Javascript, Java, AJAX, JQuery and MySQL, and also Web-standards like XHTML, CSS style-sheets and XML. The *WGL* is a internationalised tool (i18n/l10n) with already translations for Portuguese and Serbian, apart from default support for English. All this will allow to build a collaborative learning environment where the capabilities of tools such as the DGS and the GATP can be used in a more rich setting that in an isolated environment where (eventually) every students could have a computer with a DGS but where the communication between them would be non-existent. The exchange of text, oral and geometric information between members of a group will enrich the learning environment.

Learning environments supported by computer are seen as an important means for distance education. The DGS are also important in classroom environments, as a much enhanced substitute for the ruler and compass physical instruments, allowing the development of experiments, stimulating learning by experience. There are several DGS available, such as: *GeoGebra*, *Cinderella*, *Geometric Supposer*, *GeometerSketchpad*, *CaR*, *Cabri*, *GCLC* but none of them defines a Web learning environment with adaptive and collaborative features [6]. The program *Tabulæ* is a DGS with Web access and with collaborative features. This system is close to *WGL*, the permissions system and the fact that the DGS is not “hardwired” to the system but it is an external tool incorporated into the system, are features that distinguish positively *WGL* from *Tabulæ*. The adaptive features, the connection to the GATP and the internationalisation/localisation are also features missing in *Tabulæ* [6].

3 Conclusions and Future Work

When we consider a computer system for an educational setting in geometry, we feel that a collaborative, adaptive blended-learning environment with DGS and GATP integration is the most interesting solution. That leads to a Web system capable of being used in the classroom but also outside the classroom, with collaborative and adaptive features and with a DGS and GATPs integrated.

The *WGL* system is a work-on-progress system. It is a client/server modular system incorporating a DGS, some adaptive features, i.e., the individualised scrapbook where all the users can keep their own constructions and with a collaborative module. Given the fact that it is a client/server system the incorporation of a GATP (on the server) it will not be difficult. One of the authors has already experience on that type of integration [2,3,5].

A first case study, involving two high-schools (in the North and Center of Portugal) three classes, two teachers and 44 students and focusing in the use of *WGL* in a classroom, is already being prepared and it will be implemented in the spring term of 2013.

The next task will be the adaptive module, the logging of all the steps made by students and teacher and the construction of student's profiles on top of that. The last task will be the integration of the GATP in the *WGL*. We hope that at the end the *WGL* can become an excellent learning environment for geometry.

A prototype of the *WGL* system is available at <http://hilbert.mat.uc.pt/WebGeometryLab/>. You can enter as “anonymous/anonymous”, a student-level user, or as “cicm2013/cicm”, a teacher-level user.

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