Learning Paths Editor for the Web Geometry Laboratory

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1 Introduction

In this extended abstract we discuss the adaptive and personalised features of an information and communications technology (ICT) learning environment for geometry, focusing in the information needed to analyse students' learning styles and in the construction of personalised learning paths.

The *Web Geometry Laboratory*, *WGL*, is an e-learning, collaborative and personalised, synchronous or asynchronous, Web environment for geometry, with an integrated dynamic geometry system (DGS) [9, 11].

The main research questions are: how to use the information gathered by the environment to find the students' learning styles; how to construct a learning paths editor that, in a easy way, will allow teachers to specify and implement learning paths adjusted to the students' different learning styles. The integration of those tools into the *WGL* environment will follow an action research methodology, where implementation and testing stages are followed by evaluation, i.e. case studies, stages.

Accordingly to Kolb [6] individuals have different ways of learning, which depends on how we perceive reality and how we process it. So an e-learning environment that can adapt to the students different learning styles will provide a more proficuous learning environment.

Several methods were proposed to determine the learning style of an individual, among them the Index of Learning Styles[1] [4] and the Learning Style Inventory [6]. Despite the differences between them, both are intended to be useful in determining the predominant learning style of a student, to understand how he or she assimilates the information received better. In a teaching and learning environment, by analysing the student's learning styles and grouping them appropriately, one can better explore the group's abilities and minimise the frictions that occur due to individual differences. Knowledge of students' learning styles also allows teachers to adjust teaching, in order to better serve the students.

Learning paths are routes in a graph of learning objects and transitions between them, starting from the student knowledge and with routes towards a given topic to be learned. With the same starting and ending points we should have different paths, in accordance with the students different learning styles [7, 12].

2 The Web Geometry Laboratory Learning Environment

The *Web Geometry Laboratory*, *WGL*, is an e-learning, collaborative, personalised and adaptive, Web environment for geometry. It integrates a well known DGS, the GeoGebra JavaScript applet [5], it possesses a database where each user can save geometric constructions produced using the DGS, and the integration of a geometry automated theorem prover (GATP) is planned for a future version [9, 11].

[1] `http://www4.ncsu.edu/unity/lockers/users/f/felder/public/`

Personalised Environment Each user (teacher/student) has a personalised view of the environment, accessing the system after making the login in it. Each user has access to a "scrapbook" in the server where he/she can keep all the geometric constructions produced using the DGS integrated in the *WGL* environment. Each user will have full control over this personal scrapbook, having the possibility of saving, modifying, deleting, and changing the access permissions of each construction produced [11].

Adaptive Module *WGL* records navigation, textual interactions, and also geometric information for each student. The navigation information is a plain list of all the pages visited with enter and exit time-stamps. The textual interactions takes the form of chat messages and messages in the *WGL* forums. The geometric information is recorded when the student is using the DGS applet, using JavaScript listeners of the DGS application programming interface (API). Every step done by the students, every point, line, circle, etc. introduced, any deletion of any previously introduced object and even all the modifications done to them is recorded. Only the time spent in doing each and every step is not recorded (it will be in a future version).

All this information can be used to assert the students' learning styles, i.e. different ways of learning, which depends on how we perceive reality and how we process it [4, 6].

Related Systems Some adaptive educational systems that incorporate learning styles and/or learning paths are available, such as [2, 3, 8, 10]: *Dynamic Background Library*; *Web Intelligent Trainer*; *X-Learn*; *Adaptive Intelligent Personalised Learning environment* (AIPL); *Personalised Adaptive Filtering System* (PAFS); *Web-based Educational system with Learning Style Adaptation* (WELSA); *Intelligent System for Personalised Instruction in a Remote Environment* (INSPIRE); add-on for *Moodle Learning Management System*; PCMAT; CS383; *Multimedia Asynchronous Networked Individualised Course-ware* (MANIC); *Intelligent Distributed Environment for Active Learning* (IDEAL); MASPLANG; *Learning Style Adaptive System* (LSAS); *iWeaver*; *Task-based Adaptive learNer Guidance On the Web* (TANGOW); *Adaptive Hypermedia for All* (AHA!).

The *WGL* is a more specific system. It focus itself on geometry, incorporating a full fledged DGS, well known by its users and supported by its developers. The *WGL* distinguishes itself because, apart the usual information: navigation; chats; forum messages; etc., it collects also the geometric interactions done by the students whenever they use the DGS. The two modes, collaborative work and stand-alone work, the well grounded permissions system and the capability that this opens for a personalised contact with the environment, are also points in favour of *WGL*. The many case-studies already conducted, validating the *WGL* goals, and the internationalisation, i.e. the ability to receive translations into different languages, are also positive points for *WGL* [9, 11].

3 Learning Path Editor

Learning paths can be seen as subsets of the student's learning evolution. They allow to specify a number of personalised routes, each one describing how to direct students towards the understanding of new topic, respecting each and every student learning style [7, 12].

Students should be able to choose different routes: with more or less help; with more exercises, instead of a more theoretical explanation (or vice-versa); etc. The students should be able to choose the route that fits better with his/her learning style [7, 12].

A learning path editor should open the possibility for the teachers to design learning paths, specific for a given topic and tailored to each and every student.

Personalised Learning Paths In *WGL* the learning path structure will be given by a direct graph of nodes and edges. Each node would be a learning object, e.g. a geometric task to be solved by the students: an example;

a quiz; the answer to a previously given problem; etc. Each edge would be a transition between two learning objects [1, 12].

The nodes (learning objects) should have:

- a name;
- a description (normal text/mathematical text);
- auxiliary geometric constructions;
- specification of a geometric task.

The transitions could be (among other types):

- with automatic validation of the solution (synchronous);
- with a request for help from the teacher (asynchronous);
- without validation, but presenting the solution.

Implementing the Learning Path Editor Using a syntax close to *Cypher*,[2] the *Neo4j's*[3] query language, the specification of a learning path can be very simple. Teachers should begin by specifying the graph as two sets, the nodes and the edges. After that initial step, it is time to specify the attributes to each node and each edge.

After this step, it is a question of filling the attributes for each node (learning object) and edge (transition), specify what to do in each learning object and how to make the transition from that, to the next one(s).

This specification would be automatic translated to a graph database and it would create new learning paths, that can be provided to the students, with different routes corresponding to different learning styles.

4 Conclusions & Future Work

The current *WGL* version (1.4), already collects the student's information regarding: navigation; chat messages, during the collaborative sessions; posts in the forum; and all the geometric steps done when using the DGS in the stand-alone sessions. It also allows the teachers to browse through all the information. All this information will give the teachers the possibility to find, and adapt, the students' learning styles. The learning path editor will give the teachers the capability to implement the corresponding learning paths. A next step, a more ambitious one, will be to provide the system with capabilities of (semi-)automatic construction of those learning paths in correspondence with the learning styles, and with the determination/evolution of the students' learning styles to be made also (semi-)automatically.

Using an action research methodology the implementation of the new features will be followed by a validation stage, case-studies to be implemented in Portugal and (eventually) Serbia.

We are confident that *WGL* will continue to reveal itself as a good learning resource, improving the interaction between students and teachers.

[2] `https://neo4j.com/developer/cypher-query-language/`
[3] `https://neo4j.com/`

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