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A Programming Experience of High School Students in a Virtual World Platform*

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Virtual Worlds have become a very popular kind of software application that has been used in different fields, from games to simulation or education. They allow individuals to interact with others through their avatars and with objects in the environment. Virtual Worlds provide new educational experiences where collaboration and cooperation among users can be easily achieved. This paper presents the results of an experience in which students from several high schools were offered a course on programming through a VW educational platform in order to make programming concepts more appealing. At the same time the proposed platform minimizes the effort required by the teachers to use the VW environment. The paper analyses the didactical issues of the created virtual world and the main problems that have been solved in order to develop the operative educational platform. Finally, an evaluation of the subjective experience of students and teachers when using the WV environment was carried out. The results of this evaluation show that both teachers and students had a very satisfactory educational experience.

Keywords: Virtual Worlds; OpenSim, Second Life; Educational Experiences; Programming Courses; Virtual Education, V-Teaching

1. Introduction

A Virtual World (VW) is a computer-based simulated environment where users can inhabit and interact among them by using avatars. These avatars represent the user, usually as a three-dimensional (3D) object, who is free to interact in the simulated environment with other avatars or with the elements (objects) in the world.

Although VWs have been used in different domains such as Economy [1] or E-Commerce [2], the most popular are related to massively-multiplayer online games, such as World of Warcraft or Doom. However, VWs can be used as a new powerful instrument for instruction and education, where characteristics like persistence (active and available 24 hours a day and seven days a week) allow continuous and growing social interactions, which can be a basis for collaborative education.

The attractive 3D graphical environments provided by these VW can be used to improve interaction and a sense of realism, for the users who access them. In these environments it is not only possible to see, hear and touch virtual objects, but also to create, edit and manipulate them as if they were physical objects. These technologies also allow teachers and students the use of innovative learning strategies: practical training, group work, discussions, field practices, simulations, and visualizations of concepts.

Our interest in VWs was initially motivated by the problem of making computer science courses more attractive for high school students. Spanish high school curriculum includes different courses on computer science. However, most of these courses are more related to learning how to use end-user applications (word processing, spreadsheets, image processing, etc) than to really understand how they work. Several studies [3] demonstrate that ICT technologies are hardly used in Spanish high and primary schools (e.g. 71% of Spanish teachers never use a computer to support explanations at their lectures). However, 94.6% of teachers state to have access to computers at their school, and many of them admit that ICTs have a great educational potential. Furthermore, programming languages are not a central point within the computer science courses and the programs that students create are simple and uninteresting, specially compared to the games and applications that students are used to. The consequence is that many students do not take into consideration to apply for a Computers Science degree and a considerable percentage of the students that finally register in this degree have a mistaken idea of what a computer science professional is. This results in a high dropout rates in Spanish technical studies (as high as 40%) as shown in the study by Cabrera et al. [4]. This study points out that one of the main reasons for this fact is the academic failure due to a scarce previous education.

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To overcome this problem we propose to offer high school teachers a 10 hour course on basic programming that will be motivating for students, easy for the teacher, and will let students to get the flavor of what Computer Science is about.

This paper presents an innovative educational platform, named V-LeaF (Virtual LEArning platform, http://this.ii.uam.es/vleaf) which has been designed to stimulate interest and learning ability of students through the use of technologies that are familiar and particularly attractive to them. It also facilitates the implementation of collaborative (students sharing knowledge on a particular topic) and cooperative (students perform a task or solve all together a common problem) teaching techniques. By using the V-LeaF platform, the learning model goes from one in which students have an almost passive role (apart from a minimal interaction) and learn on their own, to one where students play the leading role in the learning environment and work with other students and teachers in the creation of knowledge that can be shared with others.

Our approach uses a particular Virtual World engine, named OpenSim, compatible with Second Life, as the base element to implement the new educational platform. Do not confuse this software with opentk-opensim, the biomechanics 3D simulation software from NIH National Center for Biomedical Computation. The initial goal of this work is to develop a teaching community where students can acquire basic skills related to computer programming.

An introductory programming course oriented to high school students has been designed to analyze: (1) how VWs could help teachers to improve the students' interest, and (2) what elements, traditional (such as web portals, documentation or multimedia support) and virtual (such as teaching gadgets), are needed by educators.

Other initiatives aimed at applying VW to learning, or educational, processes exist. For example, Second Life has been used by Psychology instructors as a meeting space with students to create labs, buildings and objects that can be used to learn psychology contents and skills [5]. Cunha [6] uses Second Life as an environment for collaborative learning and generation of new educational contents, and De Lucia *et al.* [7] used Second Life to create an environment and a location for collaborative learning in which objects have been modeled and programmed to support the synchronous role-based collaborative activities required by the jigsaw learning technique in a 3D virtual meeting setting. No related to Second Life, 3D worlds have been used to enhance the interface of mobile-learning applications [8] or to enhance instructional methods (instructor-led *versus* simulation-based instructions) [9].

In the specific context of teaching technical subjects, Second Life has been used with medical and health librarians and educators in order to explore its pedagogical potentials [10]. Another approach [11] analyzes how multiple remote participants can engage in 3D geometry within a virtual environment.

Other e-learning platforms such as Moodle, Claroline or WebCT, although advantageous, present several limitations. One of them is the learner's isolation: to be alone when interacting with a computer can be unnatural and makes the dropout rate in this type of distance learning greater than in the human-based training. The lack of direct contact between teacher and student can make dialogues rigid and difficult to follow. As for the materials offered by these platforms, the quality control is sometimes inadequate. It has also been demonstrated that students using such tools can design strategies to overcome courses by making the least effort. However, we should be cautious when comparing with e-learning platforms since the goals and functionalities provided by these tools differ significantly from the ones provided by the V-LeaF platform.

Open environments, such as Second Life, where there is no control over the people who can interact with students, nor over the locations they can visit, are not suitable for high school students. Our approach offers a closed environment, in which strict people controls can be applied. Additionally, Second Life has several technical limitations, detailed in section 3, that restrict the system features.

There are several other initiatives that are using virtual worlds for technical education. Park et al. [9] compare instructor-led versus simulation-based environments for engineering students, and measure two variables: achievement and interest. They conclude that both environments produce similar results concerning these variables. Slator et al. [12] present a virtual world with no teachers (named ProgrammingLand MOOseum). In this world, computer science students explore rooms populated with interactive objects. These objects are aimed at facilitating the learning experience. Nelson and Ketelhut [13] use an individualized guidance system (IGS) for students, in a virtual world (named River City) with no real teachers. The IGS prompts students with questions and hints and collects data about simple student activities such as clicking on pictures, or reading charts. Additionally, Nelson has included virtual worlds in his institution's curriculum. V-LeaF combines most of the features used in these environments and offers the advantages of an instructor-led environment, such as more control over students. In addition, the utilities offered can be used to increase the attention level of students and the effectiveness of teachers.

2. Educational experience with V-LeaF

The next subsections provide an overview of the disciplines in which our approach focuses, the developed course, the ways in which this approach improves the educational process, the didactical issues addressed and a brief description of the evaluation carried out to satisfy these issues. A detailed description of these topics can be found in the rest of the paper.

2.1 Application disciplines

The Spanish education system provides students with a two track High School: standard high school is more theoretical and aimed for students who want to pursue a university degree, and technical high school is oriented to students seeking a professional career. Our empirical experience shows that high school educators have noticed a decrease in the interest of students in programming for the last years. Therefore, there is an increasing interest in High School to stimulate the interest of students in programming. This is especially important in technical track High Schools in which specific Computer Science topics related to programming are addressed as curricular subjects such as Web Programming, or Application Development. In this paper we will describe our experience with these technical high schools, with students and teachers of programming related subjects.

2.2 Description of the course

The V-LeaF virtual world provides its inhabitants with a programming language named Linden Scripting Language (LSL), with syntax similar to C or Java. By means of this language, objects in this world acquire a behavior and become sensitive to events such as being touched or modified. A 10 hours course entitled ‘Programming Workshop in Virtual Worlds’ was offered to students and teachers from technical high schools. The set of programming topics included in the course are detailed in section 4.

2.3 Didactical issues addressed

The main objective has been to make programming concepts more appealing for students and, at the same time, to minimize the required teachers’ effort to use this environment. To this end, the capabilities of the VW have been exploited, by creating a set of programming examples with an attractive effect in terms of visual or social impact. For example, the concept of programming loop was exemplified by a floating object that prompts the user for the number of times that its size will change. Once this information is obtained from the user, the object changes its size the specified number of times.

Concerning the teachers attending the course, they observed the reaction of the students to the pedagogical examples proposed, obtaining a guideline for the development of future courses. They viewed the teaching gadgets specifically created in this VW and suggested new ones that will be developed by our team or even by themselves. The questionnaires show that V-LeaF is considered by teachers an easy-to-use system.

Both students and teachers have specific documentation in the V-LeaF web site. For example, students can get tutorials and guides with detailed information about LSL, and teachers have access to documents describing the usage of teaching-gadgets or guides to develop courses in this environment.

2.4 Motivation and collaboration issues

Students report that our tool contributed to enhance three key aspects of their learning process: (1) motivation, given by the fact that the result of program execution has an immediate 3D visualization, (2) collaboration between peers since the 3D world is an attractive environment in which students can chat in a public channel (that anyone can hear in a 20 meters radio) to make public questions as in a traditional learning environment, or in a one-on-one private chat channel to exchange source code files or talk about code details, (3) cooperation by means of a sharing source code mechanism that allows course participants to create objects with a behavior that can be analyzed, copied or modified, if its creator allows it.

Teachers have specific teaching gadgets such as (1) a code-blackboard, designed to provide a shared view of source code that any student can get immediately to test, modify, or improve by following the teacher guidance, or (2) automatic teaching tours, designed for students who want to review lessons, and that can be used whenever teacher is not available.

A set of specific objects have been designed and stored as educational libraries in the platform. These objects are illustrative examples that teachers can show to students as a source of inspiration or as a base to be extended by students or teachers.

2.5 Evaluation of didactical issues

The evaluation was carried out by means of a questionnaire presented to students and teachers at the end of the programming course. The experimental setup and the obtained results are detailed in section 5.

3. Description of the V-LeaF platform

The V-LeaF platform, as shown in Fig. 1, is composed of the following elements:

- A web portal that provides:
  - Fast access to the documentation about the courses and LSL.
  - User management. There are three different roles: administrator, educators and students. Easily, teachers can create groups and students can change its data. A set of Web tools allow educators to manage and control the students enrolled in a course.
- Several data bases that store:
  - Technical and user guides
  - Educational documentation such as courses guides, multimedia, etc.
  - Groups info: groups, teachers and students profiles
  - Data mining information such as logs, conversations or student and educator interactions in the VW.
- Other software programs:
  - Data mining and statistical software
- A VW grid (V-LeaF) that provides:
  - Virtual spaces where lectures and laboratory activities can take place
  - Virtual spaces to store the educational objects created by teachers and students.

The V-LeaF platform is built on a grid over OpenSim. Based on our previous experience in Second Life (SL), this new grid has been designed to allow high school institutions a restricted access to the educational spaces. Our first campus (http://www.ii.uam.es/esp/sl/index.html), still available at SL, was deployed in 2008 and is located at the European University, an SL island where there are about 20 universities.

However, the use of SL as the basis for a Virtual Educational Platform has several technical problems that can be summarized as follows:

- The maximum number of *prims* (basic elements used to build any object in the Virtual World) that can be created in every island or space is limited.
- Information related to course dynamics, such as student-teacher interactions, chats or even student programming skills cannot be easily retrieved from SL. As a consequence, the later analysis of courses that can be carried out by administrators and teachers is limited.
- SL does not allow easily to restrict the interaction among avatars.
- In general, SL is a public virtual space that cannot be fully configured to provide a controlled educational environment.

OpenSim provides a fully compatible with SL simulation 3D environment that solves the previously mentioned problems. As Fig. 2 shows, we can define as much space as we need for educators (it is free, so there is no cost associated to the educational task),

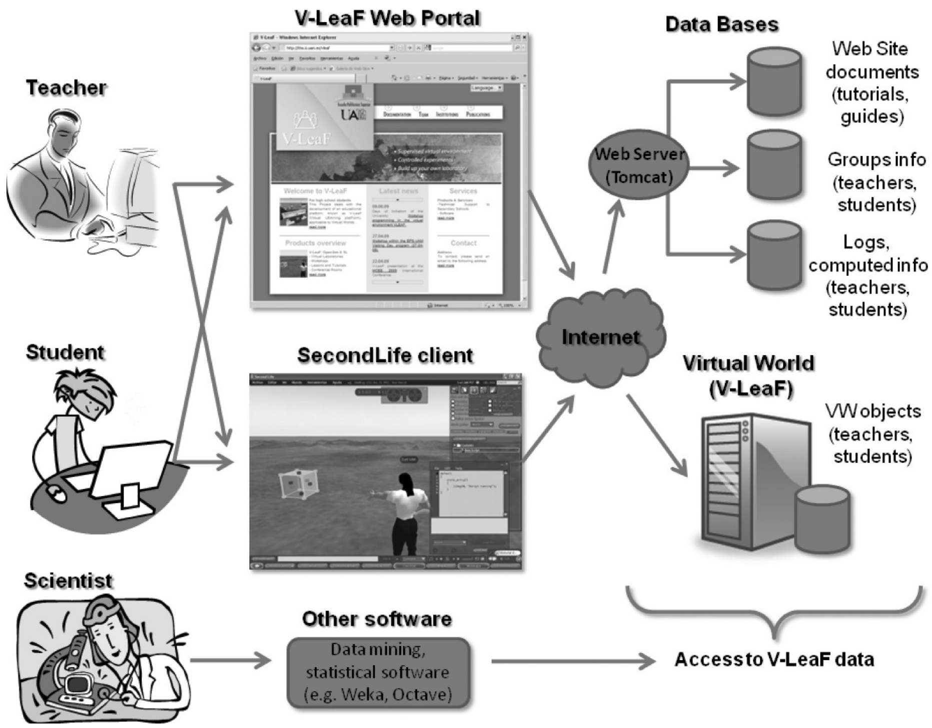

Fig. 1. The V-LeaF platform.

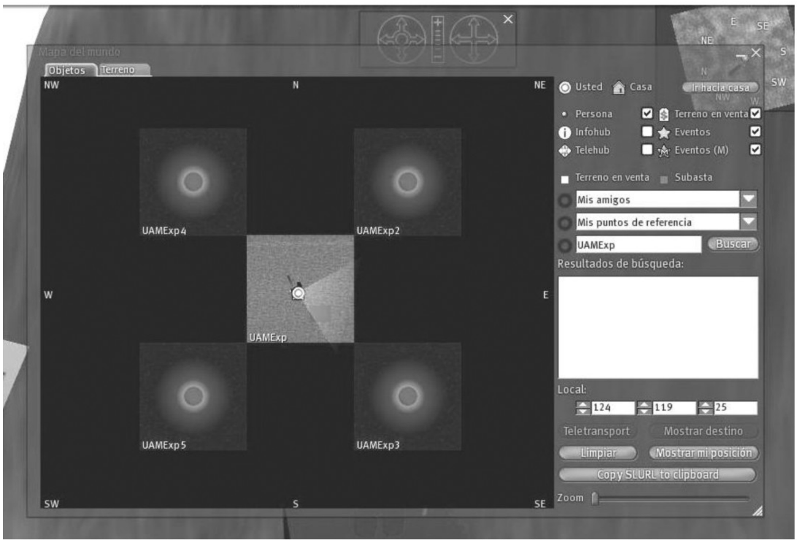

Fig. 2. Island map built within the V-LeaF grid. This map shows five different islands available for educational tasks.

the information can be stored in locally owned servers, so that it can be later analyzed by educators, and the control over all this world is in the educator hands.

4. A basic programming course in V-LeaF

The programming course described in this paper has been designed to evaluate the potential interest of students in learning these basics by using the VW technologies . This course provides the basics about working in the OpenSim VW and about algorithm programming. The programming course is divided into several sessions as shown in Table 1.

The first two sessions explain how to install, create avatars and interact within the 3D VW (both Second Life and OpenSim have the same interface and working procedures). The following two sessions describe the basis of the LSL (Linden Scripting Language) programming language. The basic data types allowed in LSL are described. Session five teaches the essential control elements in any computer program: the conditional and loop structures. Figure 3 shows how a student is building an object that will execute an LSL method once a particular event ('touch') is executed by any other avatar. The figure shows the virtual object (or *prim*) and the associated script.

4.1 High-School educational processes in V-LeaF

When the potential users of an educational environment similar to the one described in the previous section are teenagers, special care must be taken in order to avoid harassment or any other kind of possible attacks to this kind of users.

For this reason, although V-LeaF can use our current campus at SL, access to the V-LeaF educational platform will only be allowed through our OpenSim grid. In this grid we can control at any

Table 1. A programming course in the V-LeaF virtual world

Session	Duration	Title	Goal
1	2 h	Introduction to VW	Installation, avatar creation, and brief introduction to VW
2	2 h	Building basics	Introduction to *prim* creation and combination to form complex objects Rotation, position, and other more advanced attributes of *prims*
3	2h	Introduction to LSL	Syntax and basics of Linden Scripting Language. Compiling and debugging a script in the VW How to create scripts to perform basic operations Script structure
4	2h	Data and variables in LSL	Basic data types and variables in LSL Script examples
5	2h	Control structures	How to control the execution flow in scripts through variable values, conditional statements and the three different loop structures available in LSL.

Fig. 3. Building an object and associating a particular script in V-LeaF.

moment the avatars connected and the actions that they could be doing. The platform needs to provide the following roles to different users:

- *Administrator.* S/he can control any avatar within the platform (it can only be applied over the grid deployed under OpenSim VW).
- *Educators.* They will have the control over their student team. They will have the control (through the logs stored related to their students) and can prevent a connection for a particular student or a group of students. They will manage the educational materials (in traditional formats and in the educational virtual objects format) available through the web portal and the Virtual World.
- *Students.* They can access different educational documents through the web portal, and solve exercises proposed by educators through the Virtual World.

Currently the control over high school students is made by a peer-to-peer process where the system administrator provides a set of predefined avatars (including names and passwords) to the responsible educators.

5. Experimental measures

The experiment carried out is aimed at measuring the subjective experience of students and teachers when using the V-LeaF environment. This experiment was performed with students and teachers of two specific technical high schools. Four courses were held each with approximately 15 students with ages between 16 and 18. The total number of participants was 62. The aforementioned programming course was offered within the V-LeaF environment to students with some programming skills.

During the course, one of the authors of this paper played the role of teacher, and students as well as real teachers attended the course. Only the students were allowed to interact with the teacher, whereas the high school teachers acted as merely onlookers.

Once the course was finished, students and teachers filled up a questionnaire divided into five different sections (see the Evaluation section at http://this.ii.uam.es/vleaf/en/documentation.jsp for further details):

- *User data.* For students this section collects data related to their age and years of programming experience. For teachers, questions in this section have to do with the number of years as teachers and as programming teachers.
- *Experience with virtual worlds.* For both students and teachers, a Likert scale was used to evaluate their experience with 8 popular video games that simulate virtual worlds (e.g. War of Warcraft, Doom, Sims). The range runs from 1 (basis) to 5 (advanced).
- *Programming skills.* Only for students, this section includes 5 Likert questions related to programming topics such as *variables*, *control flow*, or *timers*. The range runs from 1 (low) to 5 (high).
- *The V-LeaF environment.* This section includes 9 questions in a 1-5 Likert scale aimed at comparing the V-LeaF environment with a traditional educational environment. The teacher's questionnaire includes three additional questions more

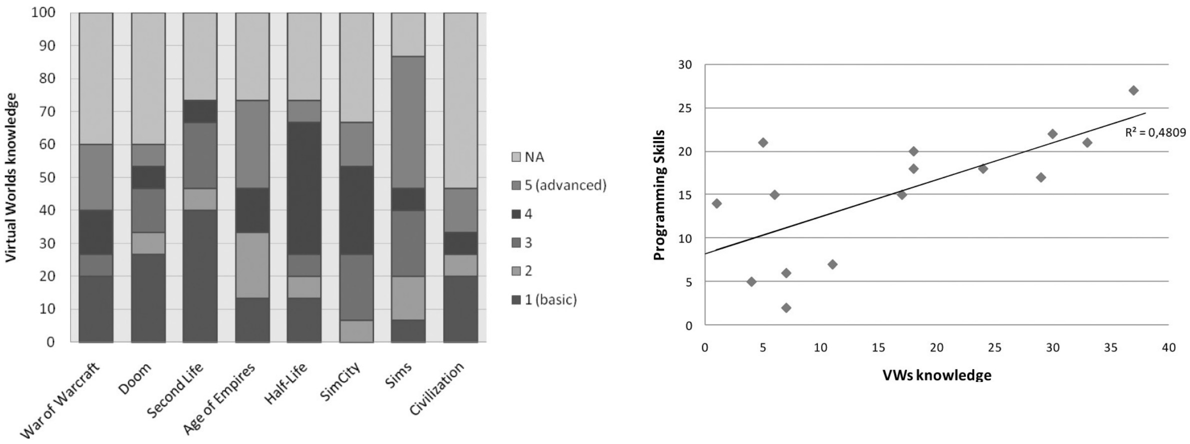

Fig. 4. Experience with some popular virtual worlds (left). Correlation between knowledge degree of VWs and programming skills for a typical group of high school students (right).

directly related to teaching tasks. With these questions the students are allowed to compare the traditional lectures, by means of which they learnt C and Java, to the V-LeaF virtual environment.

- *Open questions.* This section is the same for students and teachers and includes 3 questions related to how useful they find the V-LeaF platform, and the limitations they perceive.

Answers to the questions in the second section of the questionnaire show that students know virtual worlds. The most popular is Sims, which is known at different levels (from basic to advance) by around 85% of the participants, as shown in Fig. 4.a (left plot). However, most teachers have never used these environments. Only 15% declare some knowledge about these virtual worlds.

In order to know if the knowledge degree of virtual worlds in students is related to the (self-evaluated) programming skills, these two variables were compared. The Fig. 4.b (right plot) shows that the correlation is low (R^2 = 0.48). Therefore, this hypothesis can be rejected.

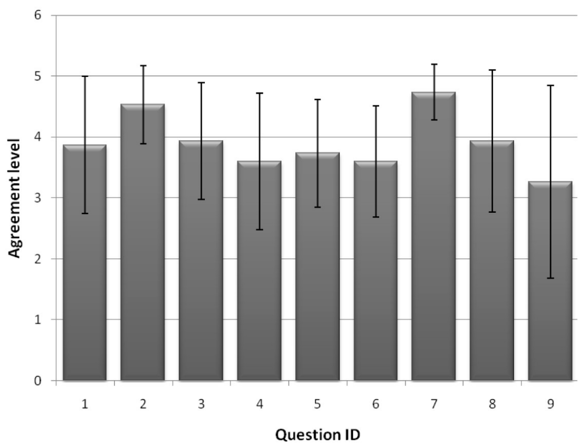

Fig. 5. Questions about the V-LeaF environment.

Related to the questions about the V-LeaF environment, Fig. 5 shows that the highest score was for question 7 ('I had a good time in V-LeaF', with 4.7 in a 0-5 scale), with maximum consensus (lower standard deviation, with 0.46). The second highest score was for question 2 ('Communication is fluent', with 4.5), with the second maximum consensus (std. dev. = 0.64). The lowest score was for question 9 ('I express myself more freely', 3.2), with the minimum consensus (1.58). These results are similar for both students and teachers.

Finally, several '*open questions*' were introduced to evaluate how the learning process of some particular concepts in the LSL programming language (such as syntax, data type definition, control structures, event-based programming, etc) satisfied, or not, the student's expectations using this environment. The overall impression of students was that learning this scripting language was more interesting due to the possibility of direct interaction with the objects (and physically see the effects), and the ease to cooperate with other avatars. Other comment made by students was related to the problem of information overload available in Internet. Although they were able to find a huge amount of information related to Virtual Worlds (SL, OpenSim, etc) and the LSL programming language, contents were sometimes too technical and not very adequate to their needs.

6. Conclusions

Information and Communication Technologies (ICT) are hardly used in Spanish high and primary schools, despite that most teachers state to have access to computers at their school and many of them admit that ICTs have a great educational potential. The use of the new educational approaches, such as V-LeaF, tries to alleviate some of those problems by providing:

- A Virtual World-based domain where students discover that learning can be an interesting experience.
- A specific documentation designed for both high school students and educators, which tries to help and guide in the interaction processes with the platform.
- Courses on the LSL scripting language and physical VW objects. Since the LSL language has syntax similar to that of the C programming language, students learn real programming basics that will help them when they deal with other programming languages such as C, Java or PHP.

Our educational platform offers a new environment, where teachers and students can find a common meeting place for cooperation and collaboration. From our initial empirical evaluation, we have observed that there exists a real interest in educators to interact in this kind of environment. They have observed higher levels of attention, and learning interest, in their students. Students report that learning the LSL scripting language is very appealing (especially because of their interaction with physical objects), and that the environment facilitates the cooperation with other avatars (students or teachers). Since the participant students had some previous knowledge about programming languages, the reported experiments do not measure the exact difficulty of learning the LSL language. New experiments with completely novel students will be performed as part of future work.

The proposed platform differs from web-based or SecondLife-style initiatives in that real educators have the control over their students. As a consequence, some students state that they could not express themselves as freely as they would have wanted. However, we think this can be an advantage, or even a requirement, when the target students are teenagers and you want them to concentrate on what is being taught.

Although the initial evaluation has been carried out with high school students and subjects related to programming, it is the intention of the authors to use the proposed environment with undergraduate students and people with specific needs and to extend the methodology to teach other disciplines. As future work, the subjective opinion of a set of students will be compared not only to direct students evaluations (e.g. exams), but to experiments in which the student attention can be computed from monitored parameters such as user eye-gaze, avatar position, chat activity or gestures. Although we have an indirect measure of the collaborative and cooperative features of V-LeaF by means of highly agreed questions in the students questionnaire (e.g. 'Communication is fluent' and 'I express myself more freely'), in future work we will design experiments to measure these aspects.

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