The use of Collaborative Virtual Environments to provide student's contextualisation in programming

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Experience has shown that one of the biggest difficulties that students find while learning programming languages is the understanding of its abstract concepts, and this difficulty translates into a lack of motivation for learning. We propose the use of a collaborative virtual environment to allow students to program within the context of a business-like professional programming environment, akin to that found in a software house, in order to make abstract concepts and requirements more concrete and therefore increase the learning effectiveness and students' motivation. This paper includes a reflection about the features that would be required of such a virtual environment in order to improve the learning experience for students of computer programming.

Keywords CVE; collaborative virtual environments; learning programming; context.

1. Introduction

The learning of programming is a difficult process. To become good programmers, students must acquire a series of capabilities that go well beyond knowing the syntax of a programming language, they must understand its abstract concepts, and this difficulty translates into a lack of motivation for learning. We propose the use of a collaborative virtual environment in a way that allows students to program within the context of a business-like professional programming environment, akin to that found in a software house, in order to make abstract concepts and requirements more concrete and therefore increase the learning effectiveness and students' motivation.

The ability to coordinate human efforts towards a common goal can be supported by the use of virtual environments, since these allow for greater contextualization of collaborative activities. Some approaches try to simulate real environments, while others employ virtualization as a way to render concrete concepts that are usually seen as abstract, or whose rendering in concrete form is not viable due to physical or economical constraints.

In the next section of this paper the motivations for this work are described. Then we introduce the concepts of Multi-User Virtual Environments and Collaborative Learning Environments, the features that result from the union of both, and some illustrative examples. Finally, we present the results of our work so far, and the work plan we will follow aiming to increase the learning effectiveness and students' motivation.

2. Common difficulties in the learning of programming

It is common to find references in literature about the difficulties many novice students face to learn basic programming concepts and, especially, to apply those concepts to solve problems in several areas, namely in Engineering. Generally students are used to courses that depend mostly on theoretical knowledge and memorization, but basic programming learning needs a more practical approach, based mostly on problem-solving activities.

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The learning of programming is a difficult process [1]. To become a good programmer, a student must acquire a series of capabilities that go well beyond knowing the syntax of a programming language: it has been shown that the most important problem for many students is their low ability to develop an algorithm to solve a given problem efficiently [2]. Our own experience is similar, since many of our Computer Engineering students experience various difficulties to learn how to program. Although most of them can easily master the details of a programming language such as C or Java, many fail when asked to use that language to solve a specific problem.

A literature review shows several types of attempts to improve student's learning. Among them, we have collaborative programming. Research supports that collaboration is an effective pedagogy feature for introductory programming, and that pair programming in particular is appropriate to the learning of programming [3, 4, 5].

The problem that results from the adoption of collaborative learning of programming is to find a schedule outside school where students can work together [3, 6, 7]. This difficulty is worsened by the fact that it is necessary to spend a lot of time to learning how to program, because it is advisable to have a practice-oriented study, since one needs to build programs and not just see how the others do it.

2.1 Collaborative Learning

Collaborative learning is an important topic of investigation in education. However, it is easier to give an example than a definition. It can be defined as a set of strategies in the learning field which depend on the interaction of a small group of students as central learning tasks take place in class [8]. It also shows us that the class is organized in small groups, helping each other in the learning process. According to Roschelle & Behrend [9], this is a mutual commitment shared in a coordinated effort to solve a problem together.

Collaborative environments can offer important support to students in their activities for learning programming. According to [10], collaboration in problem-solving provides not only an appropriate activity but also promotes reflection, a mechanism that enhances the learning process. Students that work in groups need to communicate, argue and give opinions to other group members, encouraging the kind of reflection that leads to learning.

Virtual learning environmemts contain obvious affordances for collaborative learning. Dillenbourg [11] point the features that a virtual learning enviroment should contain to support colaborative learning:

- Structuring collaboration: the teacher does not simply ask the group members to do some task together, but specifies a scenario. A scenario includes several phases and, at each phase, the team has to produce something and the team members have some role to play. Roles such as criticising the partner's proposal, summarising what the partner has read, probing the partner for justifications, are expected to trigger productive interactions.
- Regulating interactions: even if the efforts to structure collaboration increase the probability of occurrence of productive interactions, there is no guarantee that the interactions do actually occur. Therefore, collaborative learning would benefit from some external regulation, generally a tutor. The role of this tutor is not to intervene at the task level, but to make sure that all group members participate, to point out contradictions between group members which have not been noticed and so forth. Regulation is however difficult when interactions occur in the virtual space: a teacher cannot for instance regulate synchronous communication in 10 teams of 3 students. Researchers are now developing tools to help teachers to regulate groups and/or to help groups to regulate themselves.

3. Collaborative Virtual Learning Environments

In order to help our students, we want to use a collaborative approach, as reported in the last section, through the use of a Multi-User Collaborative Virtual Learning Environment. A Virtual Learning Environment (VLE) (or "Learning Management System") [12] is a system that creates an environment

designed to support teachers in the management of educational courses for their students, especially a system using computer hardware and software, and involving distance learning.

The virtual learning environment concept has been used by some authors in a very broad way, from Web sites that simply include static Web pages to systems making use of 3D or even virtual reality technology. During the past decade, several of these technologies have been designed and adapted as environments for distance learning. Among those technologies, interesting contenders in this field are three-dimensional (3D) virtual worlds. 3D virtual worlds can be roughly described as a networked, desktop-based virtual reality. While there are a variety of applications providing 3D virtual worlds, typically most provide three important features: the illusion of a 3D space, avatars that serve as visual representations of users and an interactive chat environment for users to communicate with one another. Some of the most popular 3D virtual worlds are Everquest [13], World of Warcraft [14], Habbo Hotel [15], and There [16].

One of the main advantages of using VE is that the learners are able to view an object or setting from multiple perspectives. Dede's [17] research revealed that virtual environments offer many benefits such as opportunities for experimentation without real-world repercussions, opportunities to "learn by doing," and the ability to personalize an environment. Similarly, Bricken and Byrne [18] noted that VR provides learners with opportunities to learn by interacting with virtual objects, which, depending upon content, may lead to better conceptual understanding of the content. It is this transparency of knowledge representation that allows learners to approach some concepts as first-person non-symbolic experiences, whereas too often information is coded and represented as "third-person symbolic experiences".

Although 3D virtual worlds are relatively new, they are already being used as pedagogical media (e.g., [19]). Constructivist and constructionist learning approaches in particular may see potential in these environments because they provide educators an accessible means of creating a rich and compelling 3D context for situating learning, communicative tools to support discourse and collaboration, and Web integration to provide just-in-time resources and information-seeking tools.

3.1 Examples of Collaborative Virtual Learning Environments

Several educational projects have been developed in collaborative virtual environments. As an illustration we present here the following examples:

- Virtual Harlem [20] is a virtual reality reconstruction of Harlem, New York, during the 1920s. It was designed to immerse students of the Harlem Renaissance directly in the historical context of the literature of that period. The goal of this prototype is to develop rich, interactive, and narrative learning experiences to augment classroom activities for students in humanities.
- NICE (Narrative-based, Immersive, Constructivist/Collaborative Environment) [21], developed by the University of Illinois, is a system where children construct and cultivate simple virtual ecosystems, collaborate with other children remotely located and create stories from their interactions on both real and virtual worlds.
- Historicity [21] is a collaborative virtual environment that shows old Singapore's history.
- Caspian Learning [22] promotes itself as a company which creates learning-based games. They use sensory 3D gaming environments combined with educational content and have developed a range of educational learning-based games. Titles to date include: „A Village in India", „WWII", „The Tudors", „Industrial Britain", „Local and National Politics", „Friction", „Numeracy: Problem-solving and Electricity".

4. Using Collaborative Virtual Environments for Learning Programming

Several aspects should be considered in the development of Collaborative Virtual Learning Environments (CVLE), and we should strive to establish the ones critical to its success. These are but a few that can be considered: (1) a CVEL should offer a variety of ways to learn with varying degrees of difficulty, since a central aspect of CVLEs is the ability to offer concrete experiences providing

relevance and engagement, hopefully leading to student's greater investment in the learning activity; (2) the notion of a learning activity, in virtual environment, should refer to something richer than traditional individual courseware, closer to the notion of project, since in CVLE the students are actors, co-constructing the virtual space.

A major difference between what other learning enviroments and CVLE potencially offer is precisely this last notion, of making students not only active ones but also actors, *i.e.* members and contributors of the social and information space [23].

A crucial issue in the use of CVLE is to ensure that the knowledge that is obtained through the educational use of a CVLE is transferrable to other contexts and research must establish links and ways to support this transfer. CVLE can offer concrete experiences that can be elaborated on by the teacher and may result in knowledge that is not merely abstractly tied to the teaching process but is accessible in different contexts and provide a strong experience-base for concepts.

The main goal of this work is the creation of activities in CVLEs so that students can be put in a learning virtual environment resembling real-world business operations in software development. With this process, students can experiment the multiple requirements of a professional software developer.

There are some essential aspects that must be defined. One of them is showing the way it could be integrated within pedagogical contexts. For instance, how can the teacher evaluate the students' performance? As a tutor, perhaps, following their development? What technological support must be developed for that approach? What methods can the teacher use to launch the students' activities? The teacher may divide the class in small groups and decide which tasks each student must do. But he may also assign the students individual tasks which however have to be integrated as a whole. Should this distribution of tasks be done without the teacher's intervention? Would that be required so that the students can collaborate with each other? For instance, another way could be to define a hierarchy for coordination and sub-coordination among students themselves, as in a professional environment.

All these issues required analysis, in order to develop a methodological model and the technological supports, providing significance to the activities for learning programming, using CVLE.

This kind of activities only makes sense if the students are able to work outside of classroom as well. They should be able to work at home, keeping their activities and group-work. Another aspect to keep in mind is that the students have to be well adapted within the group and at the same time have to be responsible and critical to comment on the colleagues's work. Having an active role in this process, the student participates more and feels that he/she is well integrated in the group, having an active role in his/her own learning process.

5. Final remarks

To do post-graduate training at a software company and collaborate in the development or research fields can be considered a moment of personal fulfillment in the students' learning process and in the teachers' teaching activities. However, all this is available only to the students who possess sufficiently-advanced skills to conclude the work in the pre established period of time.

With this research effort, we expect to help the students to develop their performances and abilities in order to help them feeling more confident, sure of themselves and at the same time be more successful and prepared to have an active participation in the business world of software development.

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