

S.M.I.L.E.: Smart Multipurpose Interactive Learning Environment

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Abstract. Modern technologies have brought many innovations into the system of education. Students now have an opportunity to educate with the help of many electronic materials. However, the majority of students find studying from such materials less exciting than playing today's popular computer games that – on the other hand – lack signs of education. In this paper, we describe the design and functionality of a system, which combines the educational potential of electronic study materials with the excitement of computer games by giving teachers the ability to effortlessly transform study materials into exciting educational games playable even by handicapped students.

1 Introduction

Education has significantly evolved for the last decade, mostly thanks to the Internet and its World Wide Web service, which enable students to learn interactively and share their ideas and knowledge with each other – even if they are miles apart.

Today, students are presented with a countless number of diverse educational materials, such as multimedia encyclopedias or interactive online tutorials. We promote the usage of computer games, since they offer something that students cannot get from any present kind of electronic or printed study materials – enjoyment and fun, both of which play a crucial role in effective learning [2].

Most children often play computer games in their free time and – on the contrary – many children are not willing to study for school. Although there are some exceptions, the fact that children need to be motivated more into studying yet endures.

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Computer games do a great job in motivating students [1],[4]. However, the most popular ones are far away from being educational. Games intended for education not only lack the thrill of popular computer games, but also do not allow teachers without programming expertise to alter their scenario. What is more, these games are not available – in such extent – to handicapped students.

We have designed a system named S.M.I.L.E. (Smart Multipurpose Interactive Learning Environment), which is a unique solution for the above specified problems. It combines the advantages from both interactive educational materials and popular computer games by giving teachers the ability to easily transform study materials into exciting educational games, which can be played even by handicapped students.

2 System Overview

S.M.I.L.E. enables teachers to create or import various study materials (representing knowledge) into the *Shared Knowledge Base* (see Figure 1), which is shared among various schools. The system then allows teachers to effortlessly create educational games based on the stored knowledge materials by themselves and thus provides education for all – even for handicapped students (e.g. visually impaired or deaf students).

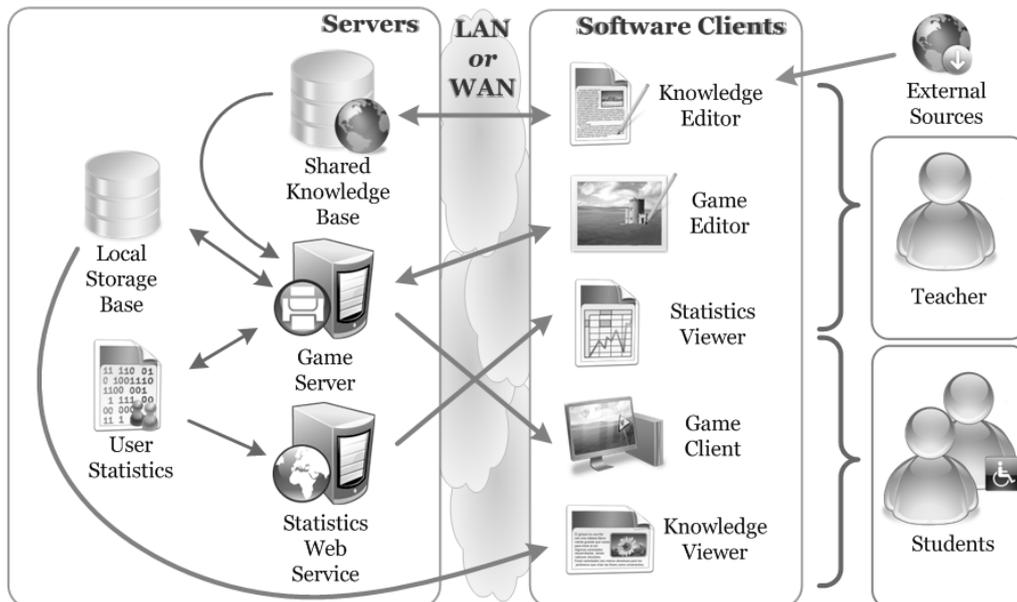


Fig. 1. Overview of the S.M.I.L.E. system.

Knowledge Editor. The creation or import of educational materials is done with the assistance of the *Knowledge Editor*, which is a full-featured WYSIWYG editor designed to ease the process of creating multimedia materials for educational games created by the S.M.I.L.E. system.

One of the most assistive functions of the editor is the feature to automatically search the Internet for multimedia elements (pictures, videos and audio files) related to the topic of the currently edited knowledge. Chosen elements can be easily inserted (respecting copyright issues) into the current material by drag 'n' drop.

Game Editor. Teachers can collaboratively edit, share and use the stored materials for teaching their pupils. Most importantly, teachers are presented with the ability to create their own educational games based on these study materials via the *Game Editor*. The constructed games are three-dimensional, fully interactive and based on today's most popular genre of computer games – Role-playing Games [5].

The S.M.I.L.E. system presents teachers with two options on how to create educational games – *visually*, by defining the complete concept of the game, or *automatically*, in which case the system alone creates the game according to parameters set by the teacher. Although the first option already makes the system innovative, it is the latter option which makes S.M.I.L.E. a one-of-a-kind and unique software solution.

Data Storage. All created games including the necessary maps, textures, models and sounds are stored on the *Game Server*, whereas all study materials, quests and game objects along with their relationships are stored in the *Local Storage Base*. The study materials get copied from the *Shared Knowledge Base* by the *Game Editor* when the teacher chooses to create a new game (or quest) based on them.

This mechanism not only reduces requests off the *Shared Knowledge Base* – which can eventually become a bottleneck of the whole system, but also ensures that the necessary study materials are always accessible, even when connectivity to the *Shared Knowledge Base* gets interrupted or is unavailable.

Game Types. Students have the option to educate by playing both games created by their teachers (which are based on quests either directly chosen by teachers, or on quests selected by the S.M.I.L.E. system according to parameters set by the teachers), and also by playing in a virtual world consisting of all quests that are stored in the system and marked *public* by their authors.

The only difference between the teacher-created games and the virtual world is that the games can also contain quests marked as *private*. Practically speaking, S.M.I.L.E. encourages students to first train and educate themselves by solving quests in the virtual world and afterwards to test their newly gained knowledge in games that have been created by teachers – which test the level of comprehension of a certain knowledge (from subjects such as mathematics, chemistry or biology). Since these games can contain *private* quests (which are not available to students in the common virtual world), they represent a friendly way to test students' knowledge.

Knowledge Viewer. To ease the process of learning, students can browse and view all study materials available in the *Local Storage Base* via the *Knowledge Viewer*, which formats the content of displayed materials according to every student's preference. The *Knowledge Viewer* also lets students search for available study materials via keywords or by browsing through study materials that are tied to courses they attend.

The viewer is also accessible in-game, meaning that in case a student is unable to successfully complete a quest, he or she can view the related study materials without interrupting the gameplay.

Statistics. The *Statistics Web Service* gathers various information about each student's in-game performance (e.g. which quests did the student successfully complete and which quests he did not – along with the number of failed attempts and/or the amount of time the completion took). Thanks to the fact that the S.M.I.L.E. system knows exactly what study materials each quest is based on and that each study material is tied to a specific subject, it is possible to compute how good each student is at each subject.

These statistics can be viewed by the *Statistics Viewer* (or by a web browser) and can be helpful not just for teachers, but also for students and their parents. Moreover, the system helps to improve students' knowledge by pointing him or her at quests based on subjects he/she masters the least.

3 Key Concepts

The S.M.I.L.E. system has many functions and features. The most important and interesting ones are described below.

3.1 Storage, Representation and Formatting of Study Materials

The educational materials, which are copied from the *External Knowledge Base* and locally stored in the *Local Storage Base*, contain anything ranging from formatted text and lists to pictures, videos, audio files and other multimedia materials, such as Macromedia Flash elements.

Each material is represented in an XML format that we have designed especially for this purpose. As a consequence to the fact that the format separates the materials' content from their formatting, we are able to let each user specify how he/she would like to format all study materials viewed by the *Knowledge Viewer* (e.g. students with a vision impairment can set the size of all displayed text and have all multimedia elements shown larger, deaf students can set the option to display available subtitles with every video or audio file).

The mechanism of formatting the stored educational materials according to users' preferences is shown in Figure 2.

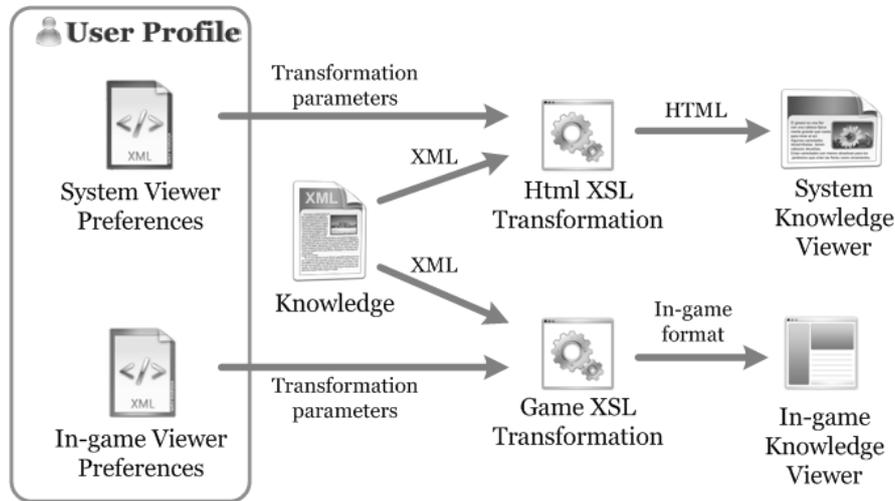


Fig. 2. Mechanism of formatting study materials.

Each user of the S.M.I.L.E. system has a profile containing his/hers preferences according to which the system's *Knowledge Viewer* and the in-game *Knowledge Viewer* format all viewed materials – individually for each user. These preferences contain various formatting parameters (e.g. the font face, size and color used for text rendering, the zoom factor of all viewed multimedia elements and the documents' background color). Users are able to choose from a set of predefined formatting presets or may further customize these presets.

The specified settings serve as parameters for the corresponding XSL transformations [7] – the transformation into HTML (used by the system's *Knowledge Viewer*) and the transformation into the format used by the in-game *Knowledge Viewer*. In other words, the XSL transformations take the viewed knowledge as XML input and the user's settings as their parameters and transform the knowledge into formats used by the viewers. The resulting documents are formatted according to users' preferences.

Thanks to the fact that both study materials and the knowledge viewers' formatting settings are stored in XML format, it is possible to replace them (along with both XSL transformations) with a completely different XML representation in case requirements on the system grow rapidly, and/or for integration with other existing knowledge bases, including e-learning standards [3].

3.2 Automatic Generation of Educational Games

The key to the automated generation of educational games is based on the fact that every study material stored in the system has a defined set of game objects associated to it and each game object can have one or more relationships defined with other objects (see Figure 3).

For example, chemistry study materials about water, sulfur trioxide and sulfuric acid (named *Water*, *Sulfur Trioxide* and *Sulfuric Acid*) may have game objects such as H_2O , SO_3 and H_2SO_4 associated to them respectively.

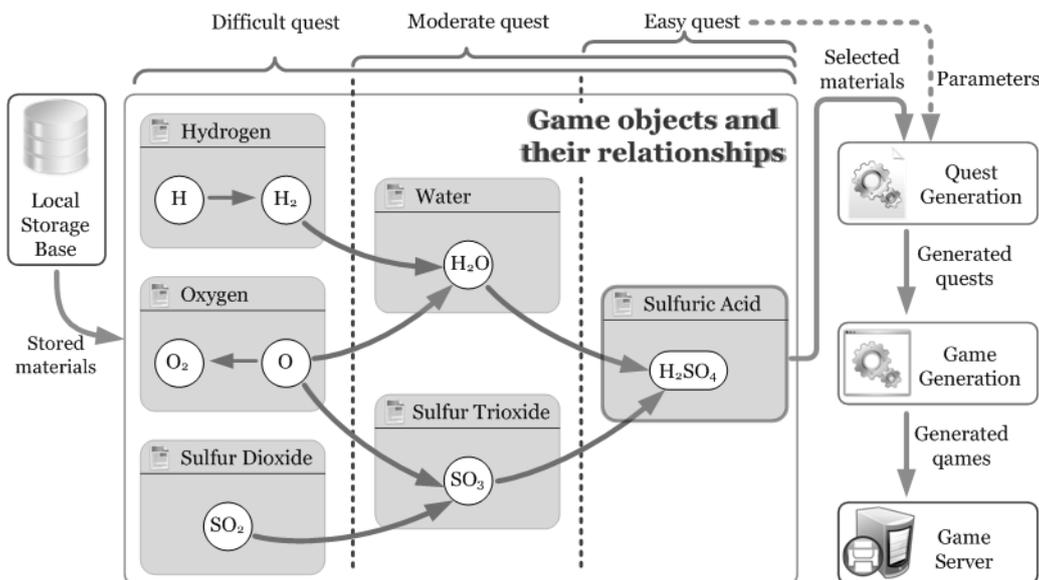


Fig. 3. Automatic generation of educational games.

When a teacher chooses to generate a new quest or game based on a study material (e.g. *Sulfuric Acid*) via the *Game Editor*, the *Quest Generation* phase first finds all game objects related to the chosen study material (e.g. H_2SO_4), examines all their relationships with other game objects (e.g. H_2O and SO_3) and creates an ordered set of interactions among them that forms a task (quest), which students accomplish throughout the game.

Based on parameters specified by the teacher – such as difficulty, the generated quests may require more or less effort and knowledge in order to be successfully completed. For example, if the difficulty was set to easy, the resulting quest will require the students to only find H_2SO_4 throughout the game. In case the difficulty was set to moderate, students will have to find both H_2O and SO_3 and afterwards mix them together correctly in order to complete the generated quest. A quest of high difficulty would not only require the students to find all objects in any way related to H_2SO_4 , but also to combine them correctly altogether.

In the *Game Generation* phase, the inputted quests are analyzed and a landscape is generated according to properties of game objects (such as their place of occurrence, e.g. a desert or forest) that the analyzed quests consist of. Afterwards, all inputted quests are placed throughout the whole generated landscape. After the educational games have been generated, they are stored on the *Game Server* and are ready to be played by students.

To summarize, the process of automatic educational game generation consists of two separate phases that utilize algorithms used in artificial intelligence [6] – the *Quest Generation* and *Game Generation* phase. The following actions make up the phase that generates quests:

1. Analysis of all game objects related to the specified knowledge, including their relationships.
2. Formation of an ordered set of in-game interactions from the analyzed relationships.
3. Creation of *generic* Non-player Characters (NPCs) [5] who assign and explain the generated quest to the players and reward players that have successfully accomplished the quest.
4. Generation of textual dialogs for the created *generic* NPCs.

The *Game Generation* phase consists of the following steps:

1. Content analysis of all specified quests.
2. Landscape generation based on the properties of the analyzed game objects.
3. Grouping of *generic* NPCs (from quests) into specific *in-game* NPCs, since one *in-game* NPC can be responsible for and handle the assignment, explanation and accomplishment of multiple quests.
4. Placement of all quests and *in-game* NPCs onto the generated landscape.
5. Generation and positioning of waypoints for the movement of sight-handicapped players throughout the landscape.

3.3 Support for Handicapped Students

S.M.I.L.E. can be fully controlled and interacted with via voice recognition and also with peripherals for the handicapped, such as Braille keyboards. Handicapped students may use the keypad of their mobile phone or PDA (with Bluetooth connectivity) as an input device. All of these interfaces enable disabled students to fully control and interact with the system.

Practically speaking, students with a sight handicap control the system with voice commands and have the contents of all educational materials read to them using a computer-synthesized voice. Moreover, such students have all text in the study materials shown as large as they prefer. Similarly, deaf students are presented with subtitles below every video or audio file.

All educational games created by S.M.I.L.E. can be played by means of voice-activated commands using a version of the *Game Client* software specialized for blind and vision-impaired students (this does not prevent *all* students to control the system with their voice). It reads all available in-game actions to users via computer voice synthesis and lets them speak which actions to take back at the system. To other players, a blind or vision-impaired student playing the same game looks just like any other player, with the exception that he moves according to waypoints automatically

placed by the *Game Editor* when the game is created. Likewise, deaf students are informed of every in-game event visually, not audibly.

All in all, specialized interfaces enable handicapped students to participate in the educational process by playing educational games with their classmates and thus socialize with the community.

4 Used Technologies

The following technologies were utilized in order to implement the S.M.I.L.E. system: Microsoft .NET Framework 3.0, .NET Web Services, Extensible Application Markup Language (XAML), Windows Presentation Foundation (WPF), SQL Server 2005, SQL Native Client, MSXML 6.0, Speech SDK 5.1, XNA Framework and Torque Game Engine 1.5.

5 Conclusions

The goal of our project is to improve and reshape education of children primarily aged between 10 to 16 years. We have designed and implemented a system that encapsulates and combines the advantages of two distinct worlds – interactive study materials and popular computer games – in order to provide a better, more flexible, more interactive and more enjoyable educational environment. The system also supports handicapped students and enables them to educate together with their non-disabled classmates. Such concept has not yet been realized in any of the existing applications and thus makes the S.M.I.L.E. system a unique and innovative project.

The most important benefits that our project brings to society are:

- Dynamic generation of three-dimensional educational games based on teachers' preferences without requiring any knowledge of programming.
- Interactive forming of teams from students handicapped or not, in which they compete by combining their strengths and weaknesses – resulting in a better education for all.
- Adaptation to every student's individual level of knowledge and game progress.
- Support of collaborative work among teachers via the *Shared Knowledge Base*.

Through a technical point of view, the most remarkable advantages of the S.M.I.L.E. system are:

- Separation of the games' representation and content from their realization.
- Numerous supported interfaces and thus a wide variety of supported user devices.
- Usage and utilization of the newest technologies.

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