A Framework for Educational Word Games

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Abstract—Modern game based learning needs open and free software platforms for easy, rapid and cheap construction of efficient educational games using course content. The article presents a novel framework for creation and play of educational games. The framework includes a methodology and workflow of construction of simple educational games (such as word and logic games) using semantically structured educational content and, as well, a software platform enabling this workflow. By means of that framework, four word logic games were created using semantically organized bachelor course content and provided with software agents. The paper discusses some of the results obtained from the conducted practical experiments with game based learning using parameterized instances of the constructed word games.

Keywords—educational games, agents, semantic, framework.

I. INTRODUCTION

LATEST developments of modern technology enhanced learning show a trend of integration of traditional instructional techniques with game based learning activities. Educational games have been proven as an efficient mean for attracting and retaining attention of learners in given course topic [1]. Games have great entertaining, educative and cognitive value, which can contribute greatly to traditional instructional practices of learning [2]. Since last decade, cognitive games are widely used as a complementary educational mean with predictable outcome thanks to precisely defined goals, constraints, consequences and rules for payoff [3].

In order to facilitate massive usage of educational games in modern e-learning, teachers need simple, efficient and extensible software platforms providing mechanisms for rapid and easy construction of cognitive games on the top of course content of taught domain. Semantic structuring and organization of educational content will enable automatic content extraction and promises to make such games more appropriate for e-learning purposes [4]. The present paper describes in brief a framework for construction of simple single-user word and logic games based on semantic organization of educational content. The framework includes consists of both design workflow and software platform and is used for development of word games, some arranged with intelligent agents [5]. The practical experiments conducted by using the ADOPTA platform for adaptive e-learning [6].

II. MOTIVATION

Nowadays, the most popular and useful types of cognitive games used for education in natural sciences are quizzes, puzzles and problem solving games [6]. Such games may be viewed as board games, which suppose moving figures across a surface (board or a map) using counters [7]. Game types such as word, logic, board or problem-oriented games may utilize semantically organized course content for dynamic extraction of terms, concepts, and semantic relationships such as sub-typing, association, aggregation, instantiation and dependency. A model for such semantic structuring of educational content is proposed in [4], where UML (Unified Modeling Language) class diagrams are used for intuitive and visual content modeling providing class hierarchies, instances, class attributes, and relationships plus axioms. On other hand, OWL (Web Ontology Language) is a more powerful XML language for representing ontology by means of data type properties, restrictions (e.g., cardinality), properties types such as transitive, symmetric, inverse and functional, Boolean combinations, enumerations, class unions, intersections and complements. However, there are much more UML modeling tools available than OWL editors. As well, UML class diagrams may be transformed into OWL representations [8].

Another great fuel for educational games development is creation of intelligent agents participating games as tutors, collaborators, opponents, etc. [9]. Agents are very promising in embodying innovative strategies for content (courseware) presentation and various interdisciplinary approaches dealing with complexity. Usually, they execute rules controlling tutor’s behavior, collaboration and shared control. Intelligent agents may act in adaptive way by extracting cognitive, affective, learning/gaming style and social characteristics of individual learner in an implicit way [10]. In general, agents may have various levels of implementation complexity - from a simple search procedure to controlling multidimensional state space of a virtual world model [11]. For complex games representing virtual worlds, agents may cooperate within a community of social agents.

III. WORKFLOW OF CONSTRUCTION AND DELIVERY OF EDUCATIONAL GAMES

As stated above, computer games most suited for educational purposes are games using educational content included into a logical or practical problem to be solved such as simple word and board games, or more complex community games using video and special visual effects. The
present framework for creation and play of educational games includes two chief issues: methodology and workflow of construction of simple educational games (in particular, word and logic games) and, on the other hand, software architecture and platform for game construction and play. The methodology is based on a workflow for game creation and delivery presented in fig. 1. It involves four actors, as follows:

- Content author – provides educational content in a semantically structured way, by means of using appropriate authoring tools; semantic relationships among content terms are going to be written to a common repository and, latter, to be used within any educational game using that content;
- Game developer – creates new simple educational games such as word or logic games using a game construction software framework;
- Course instructor – uses an instructor tool in order to select a game for given group of learners, to instantiate that game with selected semantically structured content from the repository, to parameterize that game instance and, eventually, to adapt it to some features of the learner model [5] and/or to select some intelligent agents for playing the role of advisors, partners or opponents of the learner playing the game instance;
- Learner – plays the game instance according to the parameterization set by the course instructor.

The educational effect of such word/logic/board games is thanks to the fact these games make use of course content organized in a semantic way.

A. Semantically Structured Content Authoring

According the workflow of construction of educational games given below, learning courseware should be used at run time of game instances and delivered to learners. In order to facilitate dynamic extraction of educational content, the last should be structured in a semantically-oriented way. Such structuring should provide semantic information like concept types, data type properties, metadata and inter-concept relationships.

As stated in chapter II, there are chosen two ways for authoring semantically structured content. The first one relies on OWL as a XML-based language for describing ontology. OWL is rather powerful mean for describing more detailed range and domain specifications such as properties types, Boolean combinations, enumerations, and also class unions, intersections and complements. OWL specifications may be developed by free software tools like Protégé [12]. The second approach is to author semantic relationships by using UML class diagrams, which provide intuitive and visual content modeling of class hierarchies, instances, class attributes, and relationships plus axioms. This approach is described in [4], with explanation of usage of concepts, instances, metadata and some of the model relationships. A practical advantage of this approach is possible usage of any UML-compliant free editor.

B. Construction and of New Games

The workflow supposes availability of an extensible game framework for an easy design of word and logic educational games. The game framework should provide basic business and graphic components (such as for text and graphic rendering and, as well, control over actions and events within the game) for a straight-forward game design and, if needed, should be extensible by some new components created for special new games and being not available in the current version of the framework. Thus, the developer creates new games using existing gaming components and related actions and events, saves them in the common repository and, in some cases, may develop new components for specific cases such as for showing flying text, for example.

An important feature of modern educational games is availability of intelligent agents to be included within the game play. The game framework should provide a library of such predefined agents and, as well, an appropriate agent framework for easy construction of new intelligent agents.

C. Using Games in Instructional Design of a Course

Educational games created by developers are ready to be used in any instructional design, according the vision and necessities of the instructor. The workflow includes the instructor role as a role of key importance of the way games will be incorporated into an instructional design. Fig. 2 presents an UML communication diagram for creation and initialization of a game instance (respectively, a game object). For accomplishing this, the instructor has two main tasks:
D. Playing a Game Instance

Finally, the learner access the game instance usually included in the flow of the curriculum of a course. For simplicity, any game instance is to be played in single player mode only. He/she may run once or more times the parameterized game instance at given place within the course. After finishing the game, the learner may get the correct answer and, probably, a feedback on the outcome of the game and the time elapsed for solving the task, whether successful or not.

IV. ARCHITECTURE OF THE SOFTWARE PLATFORM

While the previous chapter dialed with the workflow of the proposed framework for creation and play of educational word and logic games, here there will be presented the architecture of the software platform supported that framework. It is designed in a modular way fully compliant to the workflow described above.

Fig. 3 shows a view of the principal architecture of the platform for construction and play of educational games.

Course content model may be structured semantically either as OWL document or as UML class diagram – in XMI (XML Metadata Interchange) format. In order to transform these semantic representations to entity-relation (ER) models, there are provided modules for OWL-to-ER and XMI-to-ER transformations. Thus, the high-level semantic content descriptions are transformed to ER representations stored into the common data repository. Next, these ER representations are used by the business components of the game construction frameworks controlling issues as follows:

- terms (like word to be guessed);
- relationships (such as inheritance, association or dependency relations among terms);
- events handling, in order to be rendered and manipulated within the game play process.

The visual Flex components control mainly text and graphic objects (such as the alphabet, labels with words or phrases, relation representations, images, timer, etc.) and the events initiated during the game play. Game developers are free to add newly created game components, if needed – for example, for board games, by combining existing components, etc. Both new games and game components are stored into the common repository.

For any game created by the framework platform, software agents may be developed and used at game play time. For this purpose, the platform provides a framework for building and integration within games of intelligent agents. Like the approach presented in [13], this framework is based on JADE (a FIPA compliant Java agent development framework) - for
construction of simple agents, used together with JESS (a Java expert system tool) – for definition of rules defining behavior of intelligent agents.

![Create new game instance](image)

**V. FIELD TRIAL**

The workflow and the framework platform for creation and delivery of educational games described above define a simple process allowing creation not only of word and logic games but games of other types as board games, as well. The first prototype of the platform was implemented in Java and Adobe Flex and allows single game users to be created by using ready custom Flex components. Furthermore, the framework allows creation of other logical games using Flex editor, in which existing built-in components are combined and parameterized appropriately. Each game is created in the object class factory calling a Web service with parameter identifier of the game. The Web service returns data for the game instance and used course content.

Using this framework platform, four word logic games were created [4] - hangman (hangman), associations, and anagrams game workout memory (memory game). Fig. 5 presents a play time screenshot of the Associations word game using content from the XML course. In fact, it is the same instance (called test_ASSOC) whose creation is shown in fig. 4. The player should connect by drag-and-drop terms shown at the left side to other appropriate terms given right side (through a relationship component provided by the framework), within given time. A time counted is shown at the bottom left corner by means of using the timer component. For a limited time, the player has to connect the terms in a correct way according their semantic relationship as described by the author in an OWL or UML model for that learning course.

Many instances of games created and parameterized by the software platform have been used for adaptive course delivery by using the ADOPTA (Adaptive technOlogy-enhanced Platform for eduTainment) [5]. During the field trial, about 60 bachelor students have to follow an adapted course in the XML technologies. The course was enriched by game learning objects where some of the game instances have been run without any software agent (like the game instance shown in fig. 5) while others included some software agents as explained in [11]. During the experiments, it appeared crucial to evaluate how important and desirable is playing educational games during learning and, on the other hand, which game types are mostly suitable for e-learning. By conducting several questionnaires, it was found that the word and logic games are most suitable for training [4]. Fig. 6 presents the learners’ opinions about suitability of game types for e-learning purposes according two issues: playing mode and usage of agents. The figures show that most of the students do prefer both single and multi-user word games with intelligent agents as being most suitable for technology enhanced learning. On other hand, students find single user games with simple software agents to have a rather positive impact on educational process. Therefore, results obtained from that enquiry sound optimistic and encouraging regarding further enhancements of the framework platform and constructions of intelligent agents for educational games.
Game rules:
The terms in the left column are related to the terms in the right. Connect the terms from the left to the term in the right to which it is related. The game is over when all the terms are connected. You win if you have guessed all the relations correctly.

Fig. 5 Screenshot of play process of the Associations word game using content from the XML course

Fig. 6 Learners’ opinions about game types’ suitability for e-learning

VI. CONCLUSION

Game based learning continues being more and more promising and has real chances to become a common practice in schools and universities. This trend will be facilitated by availability of simple and effective frameworks and platforms for rapid development of educational games, with easy adaptation for use within diverse course curriculums. Such software tools for creating educational games should provide an opportunity for integration of new educational content, provided it is properly structured and semantically organized.

The aim of the presented work was to provide effective both workflow and software platform as a framework for development of simple single-user educational games that can easily be parameterized, instantiated and executed. Construction and delivery of such logic and word games provides many benefits, as follows:

- Games make use of semantically structured course content and may be instantiated many times over semantic descriptions of various course terms and concepts;
- The game construction modules and intelligent agent framework are fully extensible with new components;
- From an architectural point of view parts of the system can be easily replaced or enhanced according to technological and customer requirements at the time;
- The system workflow separates game development (supposed to be done by game developers) from parameterization of game instances (by course instructors) for particular context of usage (including domain, scope, learner’s goals, styles and other characteristics, etc.).

The added value of such joint efforts of content authors, game developers, course instructors and gaming learners depends strongly on clean separation of repeatable activities for each role and, on the other side, on the synergy gained within a successful collaboration process among all the process stakeholders.

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