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Original Contribution

STUDENT MODELLING IN A WEB-BASED PLATFORM FOR LEARNING GAMES COMPOSING

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ABSTRACT

Purpose: The main goal of this research is to introduce an approach of student modeling in a WEB based platform for learning games composing.

Methods: As a theoretical background of the proposed model is used a didactical model of learning game, developed by the authors. The student model is evolved as a composition of sets, formally representing all the elements of the process of acquiring knowledge using a learning game

Results: The general concept and a schematic notation of the proposed student model is presented and a detailed description is also given. The model consists of three areas reflecting activities, individualities and knowledge of the students: Interaction area, Archetype area and Competence area. The model's context is formed by a stimulus environment, for as much as it represents a student who is motivated to learn while playing a game.

Conclusions: The proposed student model is intended to serve not only a standalone learning game but also a WEB-based platform for learning games composing.

Key words: WEB Based Learning, Computer Learning Game, Learning Game, Student Model, School Education, Platform for Learning Games Composing.

INTRODUCTION

Beyond the statements that computer games are valuable and powerful tools in the classroom (1-6) there is still not proposed a unified and detailed enough game oriented student model which can be used in computer game based education thru a WEB platform for Learning Game Composing.

The sporadic approaches of student modelling in computer learning games are not systematic enough and do not follow a clear and well defined pedagogical pattern, on the contrary, a too weak relation between the student model and a certain didactical model is observed. The possibility pedagogical goals to be achieved using a computer learning game which is not based on a didactical model has rather stochastic character than desired and predictable in certain boundaries.

Considering the pedagogical aspects of learning computer games, some limitations of the existing solutions could be noted (7-11). At first, teachers do not take part in pedagogical design of the learning games they use – in the classroom are used already existing games not completely corresponding to teacher's pedagogical approach. Further, the learning games cover a very small part of the course topics – it's difficult to teachers to find games, closely related to the content of their lessons. It could be pointed also the low level of tracking, registering and monitoring of student performance and progress, as well as storage of the records for further analysis.

When considering the research of student modelling in intelligent adaptive learning systems, three types of special knowledge are identified (12). The knowledge of the methods and teaching strategy is one of them representing actually the pedagogical approach lying on a certain didactical background. As a base of the proposed in this work student model is used a preliminarily synthesized didactical model of computer learning game (13).

Currently is still widespread the idea, that every computer game is inherently a teaching tool. This idea could not be ignored but in a didactical point of view when considering the educational process via computer games, the

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basic pedagogical principles should be respected.

The educational process in the School is aimed to provide knowledge and skills and to create routine to use them in the real world. The process as a whole is time oriented, directed by certain principles based themselves on a didactical background (7). Using the benefits of the computer game without conforming the didactical aspects, could produce results slightly different from the main pedagogical School objectives. Therefore a model of the student for computer learning games should be developed and followed. This model should be used during the process of development of computer based learning games. When it comes to the idea about generation of learning games through a WEB based platform the student model should be deployed in order to adapt to the specifics of the platform.

PREREQUISITES

In this work are accepted the following formulations:

□ A didactical model of computer learning game (13), representing as follows:

- Knowledge providing
- Knowledge acquisition
- Knowledge verification – a set of events for knowledge testing $\{E_{test}\}$:
  - Level of acquisition
  - Level of retention
  - Level of application

The mentioned didactical model has a cyclical nature.

□ A computer game, based on this model and used as an educational tool will be further referred as a computer learning game.

□ The computer learning game follows a linear pattern (considering the transition from level to level) (2).

□ The proposed below student model for computer learning game is intended to serve not only a separate learning game, but also a WEB-based platform for learning games composing.

STUDENT MODELS IN THE MIROR

During the last decades a significant development of student models are observed (12, 14) as well as their evolution in the context of the Information technologies (15-18). As basic and general feature of the proposed student models could be summarized the differentiation of the model in three areas: *student's knowledge, student`s behavior and student's profile.*

An insufficient explored territory is the convergence of e-learning and computer learning game approach in the school education. This paper discusses the idea about a WEB based platform for learning game composing which follows a new model of the student in the learning game, based on a certain didactical model.

Because of the specific nature of the game and playing there are not established yet standards supporting the learning process based on computer learning games. This circumstance determines the complexity of the synthesis of a student model that is to be built in a learning game.

STUDENT MODELLING IN THE WEB-BASED PLATFORM FOR LEARNING GAMES COMPOSING

Modern educational technologies offer a variety of ways to support the learning process. Each of them has its own specific features, advantages and disadvantages. Before introducing the student model it is reasonable to be outlined the fundamental differences between traditional e-learning approach and learning game based approach **(Table 1).** The differences listed below suggest that the existing student models, oriented to e-learning systems could not serve efficiently a learning computer game, especially a platform for generation of learning games.

Figure 1 shows the basic concept and notation of the proposed in this work student model. It is important to remark the stimulus environment in which the areas of the proposed model are deployed. It outlines the context of the model and particularly denotes that the model represents a student who learns while playing a learning game. This is one of the differences between the proposed model and the existing ones.

The proposed student model is organized in three areas, reflecting activities, individualities and knowledge of the students, namely: *Interaction area*, *Archetype area* and *Competence area*.

Interaction area represents all the useful interactions in learning game. Considering the Table 1, the interaction area should provide a probability for knowledge acquisition $P(Knldg) > 0$. When modelling this area it is important to find a balance between the pedagogical goals and the learning game scenarios. This could be achieved by relying on the Flow theory (20). The required game skills/challenges in regard to functional, architectural, informational, visual and user interface design should be corresponding to student's abilities in order to reach purposefulness. **Figure 2** shows the *flow learning state* of the computer learning game.

Table 1. *Traditional e-learning vs. game based learning*

№	Traditional e-learning approach	Learning game based approach
1	In the classroom or e-learning system the probability of knowledge providing has always a non-zero value. $\text{Pelearning}(t) > 0$ Each lesson in the classroom and each session in the e-learning system ensure that the knowledge is provided to the student.	When the student plays a computer learning game the probability of knowledge providing is greater or equal to zero. $\text{Pegame}(t) \geq 0$ The knowledge provision depends on learning game scenarios and student's actions and performance. There is a possibility for the student after performing a set of actions to miss the portion of knowledge, assigned to current game session.
2	The knowledge is transferred directly to the students.	The knowledge is not provided to the students – it is rather gained while the student follows the game scenario.
3	The knowledge perception is a functional correlation between the teaching strategy and learning styles of the students (19).	The knowledge perception depends on the pedagogical efficiency of game scenario and learning styles of the students.
4	Limited type of tests to evaluate student's knowledge. In the classroom or within an e-learning system, there are several basic types of test questions given to the students.	The computer learning games provide to the teacher a range of ways to evaluate the acquired knowledge – not only traditional tests, but also small tasks within the game, as well as records of students' performance on each game stage.
5	Low level of motivation for learning.	The process of computer game playing itself generates a natural curiosity and interest to the game content as well as positive emotions engendered by the rewards gained by the student. When the game is a learning one these perceptions will contribute to increase the motivation for learning.

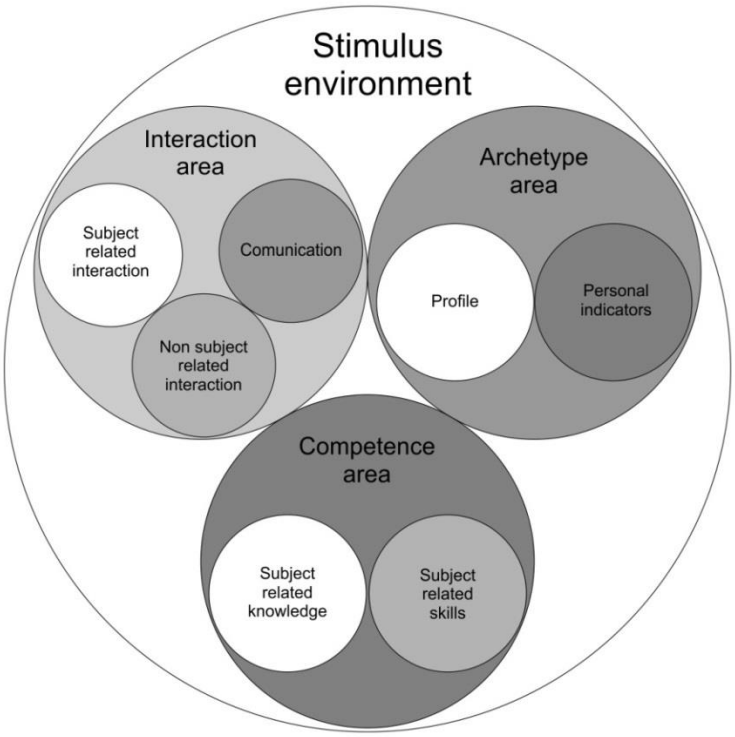

Figure 1. Basic concept and notation of the student model for WEB based platform for learning games composing

Figure 2. Flow learning state of the computer learning game

- ***Subject related interaction*** TINTR – interaction between the student and the learning content via various learning activity forms. There is a functional relation with the aggregate acquisition factor AAF of learning game, the level of retention, the level of extra load during the gameplay, etc. This functionality could be shown as

$$\mathrm{TINTR} = \Phi(\mathrm{AAF}, \mathrm{T}, \mathrm{RET}, \mathrm{APP}, \mathrm{ELOAD}, \mathrm{t}) \quad (1)$$

See also "Personal indicators" section.

- ***Non subject related interaction*** OINTR – interactions which results and consequences do not contain or provide information related to the subject. They could be described as common user interactions with the application.
- ***Communication*** defines the whole set of internal communications between the students and the dialog with the teacher during the active process of playing or offline. The communication between students includes instant messages and sharing internal resources. The dialogue with the teacher is not only implemented via instant messaging, but is also extended with the possibility to provide guidance, instructions and directions via program applications – remote activating of SSA (small simple applications). These SSA are displayed to the student as appearing hidden windows, hidden shortcuts or as an extension of the learning content.

This is one of the advantages of the introduced student model in which an autonomous communication line between student and teacher is built in real time. In the same time, in multitask environment the teacher is able to apply a specific approach to each playing student.

Archetype area models student's personal data, as well as personal characteristics, achievements and progress, mentioned further as personal indicators. These indicators are intended to serve a WEB-based system which generates separate sets of learning games for various subjects, taught in the classroom.

- ***Profile*****:** a tuple of 6

$$\mathrm{UPCh} = (\mathrm{UID},\ \mathrm{UENV},\ \mathrm{SRI},\ \mathrm{GI},\ \mathrm{ULS},\ \mathrm{USTR}) \quad (2)$$

where**:**

- UID – user identification is a tuple of 6, containing user personal data (username, password, name, gender, student ID, class);
- UENV – a tuple of 3 describing the environment of the student (address, parents, after-school activities);
- SRI – a set, describing the subject oriented interests of the student;
- GI – a set, describing the general interests of the student;
- ULS – a set, describing the learning style of the student (visual, auditory, read/write, kinesthetic);
- USTR – a set, describing the behavioral stereotype of the student (choleric, sanguine, phlegmatic, melancholic);

- ***Personal indicators:*** a tuple of 14

$$\mathrm{PI} = (\mathrm{M}, \mathrm{AAF}, \mathrm{T}, \mathrm{RET}, \mathrm{APP}, \mathrm{SE}, \mathrm{BS}, \mathrm{COL}, \mathrm{RES}, \mathrm{GGA}, \mathrm{SGA}, \mathrm{R}, \mathrm{FSEN}, \mathrm{LGP}) \quad (3)$$

where:

- M – level of motivation in percentage, defined by the teacher.
- AAF – aggregate acquisition factor with two functional arguments – volume of knowledge and time of knowledge acquisition.

$$\mathrm{AAF} = \Phi(\mathrm{lr}[i], tac[j]) \quad (4)$$

where lr [i] ∈ (LR), 0 < I < n is an element of the set of subject related learning resources (LR) and $t_{ac}[j]$,
$0 < j < m$ is the time of acquisition of the learning resources, associated to the current game module in the first stage of learning game, where the student gains knowledge while playing. m is the number of all game modules. A game module is a part of a game level and could be considered as a small learning unit. The number of learning resources, associated to a game module depends on teacher's preferences

- T – indicator of success for every test module m (1..n) in the second stage of the game. It is a TRUE/FALSE function

$$T = \Phi\left(\frac{Et}{Ef}\right) \quad (5)$$

where Et is a set of "TRUE" result test events and Ef is a set of "FALSE" result test events
The value of T, indicating the completion of this stage of the game is preliminarily defined by the teacher.

- RET – level of retention, achieved in the third stage of learning game. Retention is measured through a set of test events, which differ in a certain degree from the second stage tests. In this case a time interval is set for solving of each test unit and the questions are more detailed and complicated. RET is expressed as the following relation:

$$RET = \nu\Phi\left(\frac{Yt\text{-}Yf}{Ymax}\right) \quad (6)$$

where Ymax is a set of all the predefined test events for this level, as Ymax ∈ (TE) is the maximum possible number of test events, defined by the teacher, Yt is a set of released events, passed by the student with "TRUE" result, Yf is set of the released events, passed by the student with "FALSE" result and v is the frequency of test events generation in the third stage of the game. The third stage of learning game could be completed only when the indicator RLevel is reached. The value of this indicator could be defined by the teacher or the system could check whether the condition RET ≥ Rlevel is satisfied.

- APP – level of knowledge application given in percentage and based on the results achieved by the student while solving tasks by playing with SSA, selected by the teacher from the Resource library. SSA could be selected either during the game composing, or in real time while the student plays in the second and third stage of the learning game. There is functional relation:

$$APP = F\left(\sum_{i=1}^{n} SSAi\right) \quad \textbf{(7)}$$

where SSAi represents the result of execution of i^{-th} SSA.

- SE (self-estimation), a set of ratings given by the learner at the final stage of the learning game and evaluating his/her performance.
- BS (basic IT skills) – an indicator for basic skills to operate with information technologies. This indicator is just informative. It is generated after a short inquiry and helps the teacher to judge whether the student will meet difficulties with the game.
- COL (collaboration) – level of collaboration expressed in percentage and defined by learner's calls to other learners in the active process of playing the learning game.
- RES (resourcefulness) – a value, given in percentage and provided by the teacher.
- GGA (general game activity) – registered common game activity in all stages of the learning game – automatically collected by the system.
- SGA (specific game activity) – registered specific game activity at the current game stage. It allows teacher to suggest differentiated approach to the student during the active process of playing.
- ELOAD – extra load – forms the level of student's attitude R toward educational process as follows:

$$R = F(\text{ELOAD}) \qquad \text{ELOAD} = \frac{AT}{CT}q \quad (8)$$

where AT are the assigned tasks, CT are the completed tasks and q is a coefficient of execution (2..6).

- FSEN – a flag for special educational needs – Boolean variable set by the teacher and indicating that current student needs special pedagogical approach in the learning game.
- LGP – learning gameplay index. It forms a relation between the basic game stimuli as game scores SCRS, rank RNK, game assets GA, levels of completion LCOMP and knowledge acquisition estimation KnlEST.

$$LGP = \Phi\left(\frac{KnlEST}{SCRS, RNK, GA, LCOMP}\right) \quad (9)$$

To be more effective the learning game process, the LGP index should have value > 1.

Competence area – models the knowledge and competence that should be achieved by the students after playing the learning games related to various subjects from the school curriculum. The WEB-based platform for learning games composing allows generation of several learning games, associated to a subject, depending on teacher's preferences. The knowledge sub-model defines interconnections between separate sets of learning content, as well as the ways and forms of their representation to the student. In the learning game the data types for presenting the

learning content are predefined by DT = {V,T,A,D}, a set where V is for visual data types, A denotes audio data types, T is for textual data types and D denotes specific predefined data types.

The learning content could be presented in volume and type ∈ DT by teacher's decision at every stage of the learning game.

- ***Subject related knowledge*** is represented by subject related learning resources which data type ∈ DT. This model allows the teacher to define sets of various types of learning resources and organize them into lessons and courses. While constructing the game, the teacher decides how to organize game levels and game modules according to lessons' structure and how to distribute the resources between game modules. The student interacts with the learning content by revealing small portions of it in the form of learning resources, associated to a game module (a game level consists on several game modules, as their number is defined by the teacher during the game construction). The modelling of subject related knowledge has a subjective nature, since depends on the preferences, experience and pedagogical approach, used by the teacher.
- ***Subject related skills*** SRS(i) ∈ {S} is represented by a set of skills which have to be acquired by a group/class during learning game process for each $1 < i < 9$, respecting the list of basic skills/competences which the student has to acquire, according to the national law of school and pre-school education. The set is defined by the teacher during the game construction. A data structure of acquired skills is created, where the achieved level of subject related skills, evaluated by the teacher in percentage, is stored.

Unlike the subjective nature of subject related knowledge modelling, the model of subject related skills could be used to establish an adaptive approach of the learning game. Considering the achieved skills the system could provide different pedagogical scenarios corresponding to changed skills.

CONCLUSIONS

The presented student model is synthesized on the base of a preliminarily defined didactical model and outlines the basic fields, corresponding to the process of acquiring knowledge using a computer learning game. The student modelling comprises building of a dynamic data structure, representing the archetype of the student, all the sets of interactions with the computer learning game, as well as the acquired competence.

The proposed model could be applied in the development not only of a separate learning game, but also of a set of learning games in various subject domains. The main advantage of the model is the convergence of the computer game and the didactical approach in a stimulus environment for learning.

The proposed model is currently used and examined in the process of development of a prototype of a WEB-based platform for learning games composing intended to be used in school education.

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