Intelligent Agents and Game-Based Learning Modules in a Learning Management System

Kristijan Kuk, Dejan Rančić, Olivera Pronić-Rančić and Dragan Ranđelović

Abstract Many researchers have taken a great deal of effort to promote high quality game-based learning applications, such as educational games, animations, simulations, animated or interactive simulation mechanisms in learning management system (LMS), and so on. The Bloom's taxonomy strategy was successfully implemented as effective gaming model in two different game-based learning applications (puzzle and platformer games) that motivate and actively engage college students in order to make learning process more enjoyable. During using the game-based modules in LMS Moodle, special attention was paid both to the integration of game-play aspects and the relationship between learning styles and game genres. In this paper we shall describe the proposed approach and introduce an adaptation and personalization of player as student model based on game genres. We have analyzed learning styles and teaching strategies that match the game features which resulted in embedding the analysis personalization and teaching strategies into the game. This article presents the effectiveness of agent-based approach in teaching strategies of Moodle gaming education resources.

Keywords Learning management system · Intelligent agent · Game-based learning · Learning styles · Game genres

K. Kuk · D. Ranđelović
Academy of Criminalistic and Police Studies, Belgrade, Serbia
e-mail: kristijan.kuk@kpa.edu.rs

D. Ranđelović
e-mail: dragan.randjelovic@kpa.edu.rs

D. Rančić (✉) · O. Pronić-Rančić
Faculty of Electronic Engineering, Niš, Serbia
e-mail: dejan.rancic@elfak.ni.ac.rs

O. Pronić-Rančić
e-mail: olivera.pronic@elfak.ni.ac.rs

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1 Introduction

The advantages of *LMS* (Learning Management Systems) such as Moodle, to support the presential lectures in higher education. The convergent use of the *ITS* (Intelligent Tutoring Systems) in *LMS* approaches can potentiate the learning process, making the LMS an intelligent learning environment [1]. The features provided by the *LMS* can be enhanced by using *AI* (Artificial Intelligence) techniques, and using cooperative intelligent agents (working in the background) or animated pedagogical agents (interacting with the user) [2].

Pedagogical agents are autonomous software entities that provide learning process support through interaction with the students, lecturers and other participants in the learning process, as well as cooperation with other similar agents. Personalized approaches based on intelligent agent technology imply that each student has its own personal (pedagogical) agent, tutor respectively that directs student towards learning. The role of such agent is to gather, maintain and analyze information on assigned students and on the basis of such information perform adaptation of the contents provided to the student. The whole process is based on the model of students that is in the case of game represented as the player model, both in the other approaches to personalization, and in case of agent. Pedagogical agent can be realized as a window of *Help option* in special class of game-based learning modules as stated in the paper [3].

The aforementioned results show that educational games can be an effective tool to complement the educational instruments available to teachers, in particular for spurring user motivation and for achieving learning goals at the lower levels in the Bloom's taxonomy [4]. In Bloom's taxonomy, there's a presumption that one must master the low-tier elements before reaching true learning, in the form of being able to evaluate and create. However, in most of the digital game environments, players are often expected to create, improvise and learn from their mistakes first, and later on to learn about the details. This contradiction shows where the interesting parts are, in the details. In order to learn and understand the game, inclusive of all the dimensions outlined in Bloom's taxonomy players have to perform competently [5]. But rather than the linear order that makes Bloom's taxonomy neat and useful for curriculum planning and evaluation purposes, the game-based approach looks to take a different route in how players gather and use knowledge. Games are often classified into genres, which purport to define games in terms of having a common style or set of characteristics, e.g. as defined in terms of perspective, gameplay, interaction, objective, etc.

An adaptive *AI* can drastically increase the replayability of our game, and make the game experience much more intense and personalized for the players. A technique we call player modeling is borrowed from the similar notion of student modeling in intelligent tutoring system research. Following section briefly address game genres based on Bloom's educational objectives and applied for education in *LMS*.

2 Related Work

Moodle supports plugin based structure where a new idea can be implemented as plugin. A game is a great plugin in Moodle. Game plugins help in making assessment test creative and bring game-based learning in Moodle which seeks student's interest. It makes use of questions, quizzes and glossaries to create a variety of interactive games. These games take questions from either quiz or glossary to form a board where student can play the game. The first component is the activity module named Game [6] by Vasilis Daloukas created in 2008. There are 8 games in this module available as a plugin for Moodle. The games are: *Hangman*, *Crosssword*, *Cryptex*, *Millionaire*, *Sudoku*, *Snakes and Ladders*, *Hidden Picture*, *Book with questions*.

Kumar was to create a generic game, as a plugin for Moodle [7] that can be used by any available course. During the project he thought of some games that can be very handy in a particular course like physics and mathematics. He is proposing four new games: *Tic-Tac-Toe*, *The weakest link*, *Guess-in-time* and *Anagram*.

There are many types of game designers. Game-based learning (*GBL*) allows game designer to clearly evaluate student performance because they are able to leverage specific achievements that are connected to Learning Objectives (*LO*) embedded within the game. GBL is a type of game play that has defined learning outcomes. Generally, game based learning is designed to balance subject matter with gameplay. Gamification is using game design principles to change non game-like classrooms into fun and engaging gamelike environments, for the purpose of motivating and changing learner behaviors. Stefan Göbel et al. [8] describes the concept and use of Narrative Game-based Learning Objects (*NGLOB*) for the personalization and adaptation of Story-based Digital Educational Games (*DEG*). They characterize the potential of personalized and adaptive *DEG* with *NGLOBs* combining learner modeling, player modeling and storytelling of the Bat Cave application.

Educational Game Learning Objects could basically be reused in different games that use different surroundings and settings. The work of Minović et al. [9] in game-based learning area is moving from traditional web-based *LMS* towards game-based *LMS*, with the intention of integrating the upsides of using games in university education.

Both students and teachers can be provided with the results of the students' activity by the agent-supported Moodle *LMS*, collecting data on the Moodle database. Authors Scutelnicu et al. have presented a novel methodology for incorporating software agents into an *LMS*—Moodle. Their research [10] is focused on the integration of software agents with Moodle to improve its capabilities by creating a monitoring agent based tool for its forum. This approach is demonstrated by a prototype of *JADE* agents for automated forum monitoring.

3 Theoretical Background

Online educational games are usually e-learning systems that use *Flash* or *HTML* technology to create educational game-based applications for enhancing learning outcomes. Aside from the obvious fact that flash games allow hours of free and varied game play, they do a lot to advance various genres of games and actually help students to learn new things and challenge themselves by advancing to higher levels. *Flash* or *HTML* gaming also introduces games to people who don't typically play games, and it could act as a kind of a gateway into console/PC platform. Although there are plenty of exceptions, the majority of flash games on Newgrounds social media website clearly fall into one of several genres and subgenres [11]. Flash authors can pick one from dozens of genres and subgenres when start designing their game. Several larger genres are used in the Newgrounds "games" web page to help users find the style of the game they want to play. To the interest of our teaching curriculum, and on the basis on the game style we have selected following list of game genres and their basic features:

- **Action games**: This genre, initially defined by games such as *Pong* and *Space In-vaders*, is characterized by fast-paced events and movements which usually have to be performed reflexively. Since action games are dynamic, complex and multi-stage games, every level of Bloom's hierarchy is reached repeatedly throughout a number of levels of play. The ultimate goal and the rules of the game must be familiar to the player.
- **Platform games**: A platform game (or platformer) is a video game characterized by requiring the protagonist to run and jump to and from surfaces (platforms, floors, stairs etc.) while avoiding different obstacles represented on a single or scrolling game screen. Traditionally, these were 2D games that achieved a great popularity on earlier gaming platforms. *Klonoa*: *Empire of Dreams*, the first handheld title in its series, was also a puzzle-platformer.
- **Puzzle**: These games fall into such computer game genres as puzzle, arcade, and card/dice. Puzzle games are video games that emphasize puzzle or problem solving. Since they can involve the exercise of logic, memory, pattern matching, reaction time, etc., different problem solving skills can be tested. With their easy objectives puzzle and arcade games are commonly played by those who do not normally play video games. Namely, players are required to solve puzzles based on repetitive manipulation of words, numbers or shapes to complete tasks. Players need to understand the concepts in order to predict what will happen, based on the moves they make. These are typically 2D games with few backgrounds. The main format of the game usually remains the same although sometimes the games have several levels on different screens. Puzzle-platformer hybrids such as *Achievement Unblocked*, which use action elements also belong to this genre.

Bloom's educational objectives are realized to a variety of extents in different broad genres of video games. Authors John Sherry and Angela Pacheco take each

Table 1 Game genres based on Bloom's educational objectives

	Action/Platformer	Puzzle
Knowledge	x	x
Analysis	x	x
Comprehension	x	x
Application	x	x
Synthesis	x	
Evaluation	x	

objective in turn, describing the genre and indicating which levels of Bloom's hierarchy are best related to each genre [12]. Based on their Bloom's hierarchy of learning outcomes, our approach of game genres based on Bloom's educational objectives for previously given genre games is shown in Table 1.

4 Student Model Based on Game Genres

The main component of adaptive e-learning systems is a student model. Student modelling is the process of taking into account student cognition in the design of an *ITS*. The basic idea of our model is to integrate methods and concepts of player and student models: the game maintains a profile of each player that captures the skills, weaknesses, preferences, and other characteristics of that player. Existing types of student models are classified with regard to their diagnostic capabilities and the domain-dependency of their updating mechanisms. Domain-specific information and domain-independent information are two major groups of information collected in the student models [13]:

- The domain-specific information model is referred to as the student knowledge model. It describes the students' knowledge level, their understanding of domain knowledge or curriculum elements, the errors that the students made, the students' knowledge development process, records of learning behaviors, records of evaluation or assessment, and so forth.
- The domain-independent information is information about the student' skills, so it is based on their behavior. Learning goals (evaluating the learners' achievements), cognitive capabilities (inductive reasoning skill and associative learning skill), motivational states the learners are driven by, background and experience, and preferences might be incorporated in it.

Some genres, such as puzzle, combine aspects of platformer games with other genres. Platformers put emphasis on running and jumping through certain environment. They can either focus on solving environmental puzzles. Puzzle platformers are characterized by their use of a platform game structure to drive a game whose challenge is derived primarily from puzzles. After performing an analysis of existing platformer and puzzle games used in the teaching process topic of course

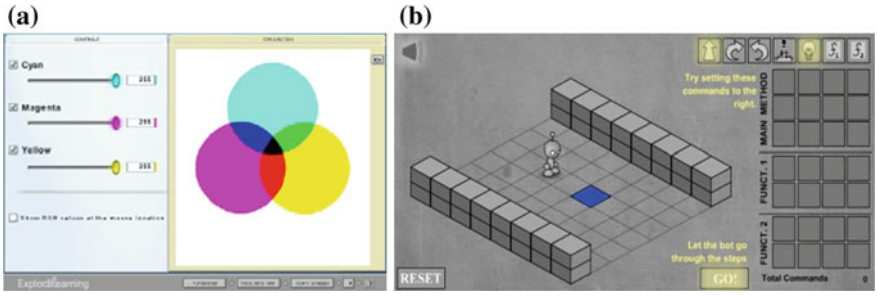

Fig. 1 A screenshot of puzzle-platformer games. **a** Subtractive Colors Gizmo simulation. **b** Light bot game (Color figure online)

Fundamentals of IT. We came to the conclusion that it was necessary to introduce some of those con-temporary teaching resources for units: *Color Fundamentals* and *Programmer-style logic*. We considered that the main objective of computer techniques was awaking interest through two next puzzle platformer games (Fig. 1):

- **Puzzle**: *Subtractive Colors*—online interactive simulation tool (called *Gizmo*) to explore what color light they observe when they subtract each color one at a time from the white light they created.
- **Action/Platformer**: *Light bot*—online game in which you have to control a robot and help it light up all the blue tiles by giving it correct set of commands.

The goal of this experiment is to discuss the effect of different learning style characteristics on game genres in a game-based learning application. There are totally 92 students participating in this study, with the average age of 20–21 years. There are five main phases for implementing this experiment: The goal of this experiment is to discuss the effect of different learning style characteristics on game genres in a game-based learning application. There are totally 92 students participating in this study, with the average age of 20–21 years. There are five main phases for implementing this experiment:

1. First, all 92 students of the 1st year of Academy of Criminology and Police Studies attending *Fundamentals of IT* Course on Department of Informatics and Computer Sciences have to finish pre-test and Index of Learning Styles Questionnaire (*ILSQ*);
2. Second, according to the analyses of the obtained results, the students are divided into two groups, equal by pre-test results. The aim is to generate two groups based on the previous knowledge. One group is called Basic Group (B) with 50 % or less right answers and the other is Advanced Group (A) with more than 50 % of right answers during the pre-test.
3. Third, on the grounds of the experience the authors have created Teaching strategies of gaming for the student towards his learning style and knowledge

Table 2 Results *FS ILSQ*

Learning style	*Vi*	*Ve*	*Sen*	*Int*	*Seq*	*Glo*	*Act*	*Ref*
Percentage (%)	87	13	83	17	74	26	65	35
Number of students	20	3	19	4	17	6	15	8

level so we have formed four groups of students: *Act*-A, *Act*-B, *Sen*-A, *Sen*-B, *Vi*-A, *Vi*-B, *Seq*-A and *Seq*-B;

4. Forth, on the basis of given strategy formed groups used various types of game genres (*Subtractive Colors* and *Light bot*) for playing/learning without time limit. After playing acquired knowledge was tested by post-test;
5. Fifth—analyses of the obtained results, discussion and suggestions.

In the first phase the Felder and Silverman index of learning styles questionnaire (*FS ILSQ*) [14] was given to 23 students and the results are shown in Table 2. We marked with *Vi* for Visual, *Ve* for Verbal, *Sen* for Sensitive, *Int* for Intuitive, *Seq* for Sequential, *Glo* for Global, *Act* for Active, *Ref* for Reflexive.

As shown in the Table 2, four major groups were selected amongst surveyed students: Visual, Sensitive, Sequential and Active. It resulted that most of the surveyed students (71 out of 92 students) preferred learning style with features of these groups. That was the reason why only 71 students were participating in the further experiment. In order to assess current knowledge level for the given field, students were assessed via test from the red teaching units maker in the experiment as pre-test. Current knowledge level of a teaching unit that a student has is marked via two values: Basic for the achieved result 30–50 %, and Advanced for the achieved result >50 %.

After exploring student's categories of learning style according to the results of *FS ILSQ* and assessment of students' general knowledge prior to playing, process of students profile development is continued by mapping the acquired results to the value of the personalization vector game genre. The vector presents metadata which provide teaching strategy for making personalized game-based learning experience, according to the requirements described in Table 3 for understanding visual design, including physical techniques such as balance and symmetry.

Values of the recommended genre shown in the table above as teaching strategies are based on the assumption of the authors and their experience in utilization of such genre of teaching material in teaching strategy. In order to test the validity of proposed teaching strategy, after playing of given genre we have tested students for the same teaching unit with the same set of questions as in the pre-test. This test in the experiment is labelled as post-test. Comparison of the knowledge on the pre-test and acquired one on the post-test, is presented as the value of the accomplished learning progress after the game. Average progress accomplished for each learning style group is shown in the Fig. 2. Students with average knowledge are marked with A, and students with basic knowledge with B.

Analyzing the results, we could come to the conclusion that the strategy of certain game genre application, as given in the table, has significant influence to two

Table 3 Teaching strategies of gaming for the student towards his learning style and knowledge level

Learning style	Description of learning style	Previous knowledge level	Teaching strategy
Act	• Interactive curriculum type • Curriculum processing—individually routed steps for the realization of the task • Level of system feedback—particular or feedback on demand • Presentation of lessons with lots of interactivity and collaboration	Basic	Subtractive colors
		Advanced	Light bot
Sen	• Lot of practical work (simulations and games, learning based on problems and role playing, role playing, discussion panel, brainstorming)	Basic	Light bot
		Advanced	Light bot
Vi	• Presentation of lessons by multimedia, including videos and animation, simulations and games, charts, algorithms	Basic	Subtractive colors
		Advanced	Light bot
Seq	• Course organization in linear way. The content is presented orderly, step by step, consist of small orderly steps that are logically associated to the problems being solved	Basic	Subtractive colors
		Advanced	Subtractive colors

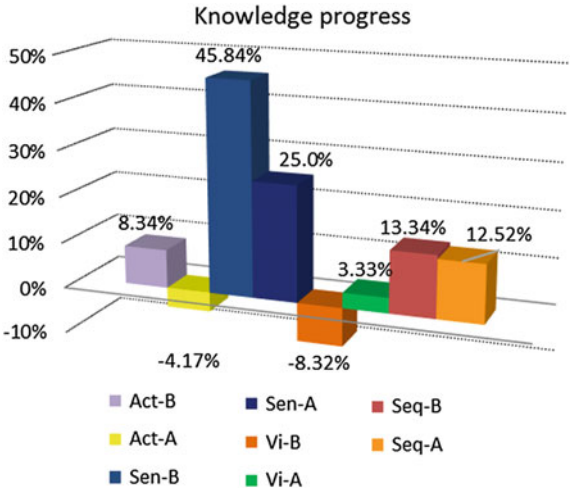

Fig. 2 The comparative knowledge progress for various learning styles after gaming

groups of students with learning style marked as *Sen* and *Seq*. High level of perception with Sensitive students and a high level of understanding of the information with the sequential students played important roles in achieving these results. Such statement leads to the conclusion that selecting game genre for this type of students does not affect the current knowledge level of the teaching unit, but that implementation of any game will certainly help in better understanding of the teaching

material. On the grounds of the example of given teaching strategy and on the basis of the results from the Fig. 2, we can notice that there was no progress achieved at the Advanced level with style marked as *Act* and the Basic level with *Vi* learning style, so these two cases were expelled from the final conclusion. Other set values in the teaching strategy gave positive results so by simple counting in most cases we can issue a recommendation.

Recommendations for utilization of the following game genres on the basis of performed experiments are the following:

- For the knowledge level Basic—students with the learning style group *Act*/*Seq* are useful to use puzzle type of the game,
- For the knowledge level Advanced—students with the learning style group *Vi*/*Sen* are useful to use action/platformer type of the game.

5 Intelligent Agents in LMS Moodle via Activities Game Block

Moodle platform is used by many reputed educational institutes for managing their curriculum. All information in a course is organized in separate blocks. Activities block is used by the teacher to add an activity (a forum, an assignment, quizzes and so on). Activity modules are activities that teachers add to their courses to supply resources for students. Assignment activity has two items and a point of information in the common module setting. One of them is the visible—assignment activity which chooses whether to "show" or "hide" the assignment. Usually, teachers or trainers can sort submissions by group or view all course participants, but the task of the intelligent agent itself is to create the two necessary groups. If a grouping is selected, students assigned to groups within the grouping will be able to see together one of the presented games.

While there are many factors to consider when designing a gamification experience in *LMS* Moodle, a very important first step is to target learning styles group membership. If there are differences in learning styles between groups of students, then intelligent agent must use learning style information to aid their planning and preparation for organized activity module activities. Knowledge of game genre preferences can provide a bridge to course success in a game education Moodle mode. Based on the present recommendations in previous section, the task of implemented intelligent agent is to determine group membership for each student/participant for the course. Enabling user group setting allows the intelligent agent to automatically add students to groups in Moodle courses based on learning style membership.

The Index of Learning Styles (*ILS*) questionnaire is a 44-question multiple-choice survey, and each of the paired learning dimensions have eleven questions designated to them. Every question provides two answer options; these answers represent both aspects of the paired dimension. The output from the *ILS*

Table 4 Relevant patterns for each learning style dimension developed by Sabine Graf

Active/Reflective	Sensing/Intuitive	Visual/Verbal	Sequential/Global
content_visit (−)	content_visit (−)	content_visit (−)	outline_visit (−)
content_stay (−)	content_stay (−)	ques_graphics (+)	outline_stay (−)
outline_stay (−)	example_visit (+)	ques_text (−)	ques_detail (+)
example_stay (−)	example_stay (+)	forum_visit (−)	ques_overview (−)
selfass_visit (+)	selfass_visit (+)	forum_stay (−)	ques_interpret (−)
selfass_stay (−)	selfass_stay (+)	forum_post (−)	ques_develop (−)
selfass_twice_wrong (+)	exercise_visit (+)		navigation_skip (−)
exercise_visit (+)	ques_detail (+)		navigation_overview_visit (−)
exercise_stay (+)	ques_facts (+)		navigation_overview_stay (−)
quiz_stay_results (−)	ques_concepts (−)		
	ques_develop (−)		
forum_visit (−)	quiz_revisions (+)		
forum_post (+)	quiz_stay_results (+)		

questionnaire results in a user's score for particular learning style preferences, ranging from −11 to 11 for each axis. Learning Styles Tests module (*LSTest*) [15] from 2009 is very useful in evaluating learning styles as Moodle plugin. The problem with this module is that it was developed for older versions of Moodle.

However, while the questionnaire asks students about how they think they prefer to behave and learn, the proposed approach gathers data about how students really behave and learn by observing them during their learning process. Sabine Graf et al. [16] proposes an automatic approach for identifying students' learning styles in *LMSs* as well as a tool that supports teachers in applying this approach. Their system *DeLeS* is based on Moodle futures which include content objects, outlines, examples, self-assessment tests, exercises, and discussion forums.

The author is using "+" and "−" for indicating a high and low occurrence of the respective pattern from the viewpoint of an active, sensing, visual, and sequential learning style which present on Table 4. Based on this, information and formulas for the respective learning style in DeLeS can be used to get hints for detecting students' learning styles by intelligent agent. After that the agent itself generates two groups of students: Group A—*ct/Seq* and Group B—*Vi/Sen*, adding each student to the group according to the learning style preferences. Then, some informal feedback testing from a sample of knowledge level is done.

As given in the previous section, a crucial factor for the agent's decision is also a student's current level of knowledge for the lesson unit in which game module is included to supplement the lesson's regular topics [17]. The standard quiz reports are located under the Results. The *Grade/x* column of quiz attempts can give us the information about current knowledge level of a lesson unit. Two values *Grade* and *X* determine the knowledge level, which helps the agent to group the students in Basic or Advanced group.

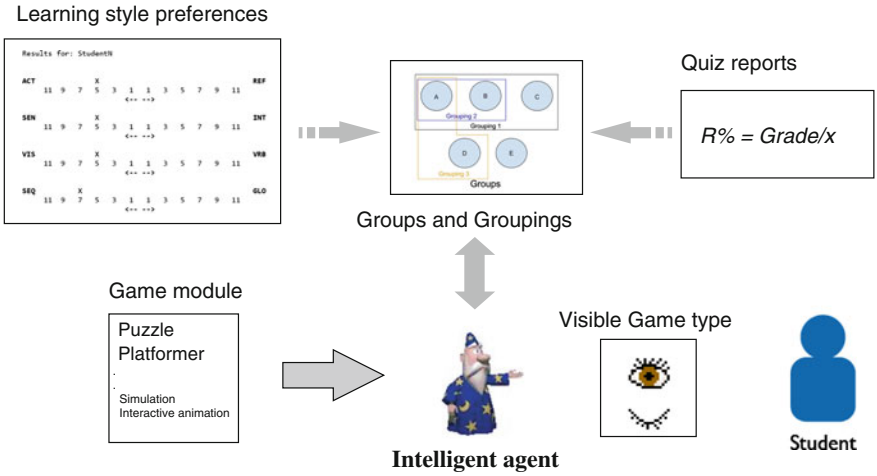

Fig. 3 A concept of intelligent agent in LMS with game module

The parameters can be taken from the test results database—self assignment tests for lesson unit. Afterwards, the agent decides about displaying a certain game from the game set based on the teaching strategies given in Table 1. Implement agent in our approach can be realized by groups (see Fig. 3). In Moodle, groups can be separate (the work of the group is visible only to group members) or visible (group work is visible to the entire class). A grouping consists of one or more groups. With groupings we can restrict access to content or activities to a specific set of groups. Agent will definitely let you know what students like, so even informal focus groups can be very helpful in deciding on player association's gaming strategy. The agent's decision is based on the following two *IF THEN* rule:

$$IF\ group = Act\ or\ Seq\ and\ knowledge\_level = Basic\ THEN\ type\_game = Puzzle \quad (1)$$

$$IF\ group = Vi\ or\ Sen\ and\ knowledge\_level = Advanced\ THEN\ type\_game = Platformer \quad (2)$$

6 Conclusion

Educational researches have shown Moodle as a good *LMS* platform of multimedia. It can be used effectively for the 21st century students. The most used contribution method is activity modules, but there is no unique method of using good educational resources via Moodle activity modules. The most effective approach depends upon the task, context and learner's personality. The learning will be more effective if learners can choose from a wide range of possible learning methods, if they know

when to apply them and which approach is the most convenient for their perusal. The proposed taxonomy of selected genres implies the approximation of different learning styles with different game components through the agent's strategy. In that manner the implementation of adequate game strategy is enabled representing the personalized teaching material for certain number of students with common learning style/styles.

In order to develop an effective educational resource with computer games, we need to take into consideration different game genres, learning activities and techniques, and learning styles. Games like puzzle and action-platformer can be successfully combined in order to create new advanced educational resources for teaching today's generation of higher education students. With respect to various learning styles, this paper attempts to present cooperation and establish a relationship between different educational game genres, learning styles and teaching strategies. The whole process is based on the model of students that is in the case of game represented as the player model, both in the other approaches to personalization, and in case of intelligent agent. Also, this paper presents implementation agent in *LMS* Moodle as personal guide to classification games in library of *Explore Learning Gizmos* math and science simulations.

In the future our research will be focused on making an approach for automatic identifying teaching strategies of gaming. The approach will be based on inferring students' gaming styles from different teaching methods behavior in an online course for college grade level and IT discipline.

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