Design and Evaluation of a Computer Based Game for Education

María Julian Mateos,
Pedro J. Muñoz-Merino,
Carlos Delgado Kloos
Universidad Carlos III de Madrid
mariajulianmateos@gmail.com,
{pedmume, cdk}@it.uc3m.es

Davinia Hernández-Leo
Universidad Pompeu Fabra,
davinia.hernandez@upf.edu

Diego Redondo-Martínez
Centro para Adultos CEPA Distrito Centro, Spain,
diegoredondo13@gmail.com

***Abstract*— The use of computer based games for education can improve the learning process. The design of computer based games and the way the users might interact with them is an important and open issue as there are many possibilities and variables to take into account. This paper describes the design and evaluation of shopC, an educational computer board game driven by technology, based on the traditional well-known Monopoly game. Three different dimensions are considered: motivation, learning and gaming. We show the introduction and the evaluation of the game in a pilot study with 58 students from primary school interacting with the computer based game. This evaluation validates the design of the computer based game regarding the three dimensions (motivation, learning and gaming) and suggests a positive effect in the learning process.**

Keywords— computer based games; game design; user interfaces; evaluation; motivation.

I. INTRODUCTION

There are many arguments in favor of the use of games in education. For example, Butler [1] states that students can learn faster but the amount of concepts learned is not bigger than with other methods, and that the socialization is improved because of the interaction among peers.

Prensky [2] states that students can acquire knowledge and skills playing games. In the same direction of positive effects, Estallo [3] claimed that people who play games develop more intellectual skills and De Aguilera [4] believes that playing produces a positive effect on concentration, logical thinking and problem solving skills.

Therefore, games are considered to be a very important learning tool. Playing develops capacities and aptitudes that contribute to the formation of personality. The game is a way of learning as a consequence of the increase of motivation. Different games have demonstrated to motivate students, e.g. [5] and the relationship of motivation with learning outcomes has been studied [6].

The implementation of educational games as computer programs can enhance the user experience compared with non-computer versions of the games, because the computer-based versions can present nicer interface possibilities including e.g. multimedia resources, and the computers can execute different complex processing tasks, e.g. the assignment of opponents based on some algorithm. An interesting open issue is the design of computer games for education, as the commented benefits of games for the learning process depend a lot on the features and philosophy of the games. Specifically, a prominent area is the design of new computer based educational games based on existing traditional games which are not related to education. Different traditional games have already been adapted to education, for addressing specific learning topics or with a more general educational scope. For example, Reinhardt [7] describes an educational game based in the TV programme "Who wants to be a millionaire?". Traditional well-known games offer the benefit of being already familiar to many learners who already know their basic mechanisms and have proved to being engaging. However, in many cases they are mostly focused on entertainment and their educational value is very limited or non-existent. There are a lot of prominent games that require adaptations if they are to be used in the educational domain.

When integrating computer based games in education, a key aspect is how to include learning mechanics into traditional games in order to develop well-designed educational games and get the benefits of both: from the learning and the gaming areas. The design of a good computer educational game is difficult. One of the difficulties is to find the right balance between fun and learning. If the instruction predominates over entertainment, the game can be boring. On the contrary, if fun prevails over learning features, the game would not have an educational impact [8].

This work focuses specifically on board games, which are one of the more extended types. Board games is a category where players enjoy, compete and learn from each other [9], can use iterative learning [10] and students can evaluate their own level of learning because students identify concepts that should deepen [11].

The objective of this work is to make a successful adaptation of a famous traditional board game, the Monopoly, in order to transform it into a computer educational game, taking into account different learning mechanics. The reported research includes an evaluation with 58 students from primary school interacting with this adapted computer game to analyze the successful achievement of the proposed adaption.

II. GAMES IN EDUCATION AND COMPUTER BASED GAMES

A lot of educational games have been used in schools and universities [12] [13] [14]. There are plenty of educational games for education; each one has different rules, and there are different experiments with them in the classroom with different purposes. However, there is path to create new interesting games that make an impact for learning.

Focusing on authoring of board educational games, some examples include the one reported in [9], which describes a model for creating e-learning board games. That work allows teachers to create e-learning board games using the ELG environment and can be used for self-assessment purposes.

An example of board game is Troplay [15] which simulates a board game with different levels of difficulty, keeping the game within the limits of each student. Another example is in [16], which proposes the integration of quizzes in a board as a safe navigation approach to present and interact with course material.

The board metaphor has been also used in mobile learning games [17]. For example, QuesTInSitu: The Game applies design elements of puzzle board games to facilitate the design of geo-located question-and-answer activities in a way that promotes engagement and reflection [18]. MAPLE is a software that combines m-learning with games and it has been created using educational theories how constructivist learning or situated learning. Also it includes features of gamification like challenges, feedback or rewards and additional features to foster student motivation [19].

The competition factor has usually been included in educational games. This is the case e.g. of ISCARE [20], a computer based competition system where questions and peers are adapted depending on the student level; Joyce [21] which is a competition system based on a board where to move forward depends to the questions´ success; or QUEST [22] that rewards students depending on the time they last in answering some questions or challenges.

III. DESIGN OF THE SHOPC COMPUTER BASED GAME

The challenge is to transform or modify a successful game in a computer based educational game using a proper combination of educational goals / practices and entertainment design principles. The three considered design principles and their related features are explained below in the first three subsections, while the fourth subsection is devoted to relate these three design principles with our designed shopC computer based educational tool. The three presented design principles (motivation, learning and gaming) build on top of the work by [19], who made an extensive review of the literature in m-learning game based learning. Several of the aspects related to each one of these three design principles are taken from that review. The design principles considered are complemented with the model by [12], which goes beyond m-learning analyzing globally the learning mechanics for serious games.

A. Motivational Features

Motivation takes students to play the game and to try to overcome the adversities (e.g. to learn better). From the literature review at [19], there are three features that can bring motivation:

- Flow. This can be defined as an enjoyable and pleasant state for players where the challenges are according to performance [2] [23] [24].
- Curiosity. The curiosity consists of sensory curiosity and cognitive curiosity. The sensory curiosity stimulates the senses and the cognitive curiosity consists of non-deterministic results [25] [26].
- Players‘ autonomy. Players should have the control for their actions [27].

In addition, we include two other features (rewards and feedback) as motivational factors which are also considered as gaming features in [18]. Moreover, we include competition as a feature of this list:

- Rewards, which are intended to give a positive feedback that reinforces an action. Different authors demonstrated that rewarding students for correct actions increases their motivation in education [28] [29] [30].
- Feedback allows players to seek improvements and guides them to reach their goals [31].
- Competition as a social scenario with established constraints that require students to plan their strategy [32].

B. Learning Features

The learning features are not selected in this case from [19]. They are based instead on the Learning Mechanics-Game Mechanics model (LM-GM) [12]. This model aggregates pedagogical elements abstracted from literature on game studies and learning theories on 21st century pedagogy (e.g., constructivism, behaviorism, personalism, etc.). In particular, the constituent mechanics that support learning through game are:

- Question & Answer: Strategy to engage students in a solving-problem situation [33]. Other additional strategies like the use of hints of different types can be used in combination with questions [34].
- Instructional guidance: Plan captured in the navigation proposed by the board and the design of the questions themselves. It should be aligned with the previous knowledge of the students [35].
- Action/task describes how students learn better with practical applications of concepts [36].
- Repetition and Reflection: Iterative learning [37].
- Self-assessment and accountability of their own learning. Students can estimate their own level of learning and progress, indentifying the aspects they need to revise [38].

Identify applicable sponsor/s here. If no sponsors, delete this text box (*sponsors*).

According to the LM-GM model, these mechanisms support the development of thinking skills such as "creating" (planning), "evaluating" (self-assessment, reflection), "applying" (action/task, competition), "understanding" (question & answer), "retention" (instruction, guidance, repetition) [12].

C. *Gaming Features*

The use of game in non-recreational environments and applications to enhance motivation, concentration, effort and other positive values is a common feature to all games [39]. The goals of gaming principle are to entertain and amuse players. There are different constituents' principles for gaming [19]:

- Goals to be achieved and rules to achieve those goals. These should be clear and simple.
- Player´s control to lead students the mastery of subject matter. This also improves the attitude towards learning activities [40].
- Challenge to improve students' attention and students effort [41].

D. *Relationship with shopC*

The commented three design dimensions have been applied to create our shopC educational game. Table 1 shows how the different motivational, learning and gaming mechanics and the aspects which have been inserted within the shopC game. This table 1, which summarizes the main design principles for the design of our shopC game, is adapted from two articles [12] [19]:

TABLE I. SUMMARY OF THE RELATIONSHIP OF OUR SHOPC EDUCATIONAL GAME WITH THE DIFFERENT DESIGN PRINCIPLES

Design principles	**Main Features**	**Adaptation of Constituent Principles in *shopC***
Motivation		
	Flow	The questions that are proposed to students should be challenges which are not too difficult or too easy. The fact of answering correctly the questions allows students to have better chances in the game but there is a balance between chance and answering questions correctly to have better options in the game.
	Curiosity	The main type of curiosity is the cognitive one. Different squares in the game with different graphics about shops. Each square has different properties students have to explore (price of the shops, go stairs upwards, special actions, etc.)
	Players' autonomy	Players can choose different configuration options such as the number of players, the tabs' color or the name of the player. In addition, each player is responsible of his/her own strategy and makes several decisions (e.g. buying or not a shop or the path they should follow on the board).
	Reward	When students answer correctly to questions, they are rewarded with virtual money
	Feedback	The application shows the correct answers and indicates outcomes of students' actions.
	Competition	Students compete against other peers in order to get more virtual money, more properties, etc. If they learn more, then it is more probable that they can be more successful, although chance has also an influence. In addition, students interact with each other and can view the status of their opponents at all times with a clear objective to win the match.
Learning		
	Question & Answer	Questions that the students should solve providing answers
	Instructional / Guidance	Teachers can create learning challenges about different topics. The questions are designed to enable reflection around the challenges. The board structure and the decomposition of the challenge into questions provide students the path to learn.
	Repetition and Reflection	Combining classroom learning and different questions of game, students reinforce and construct their knowledge. Some questions are repeated during the game so that students can reflect about them.
	Action/Task	The game offers a learning activity which requires the active participation of the students in their learning.
	Self assessment	Students can evaluate themselves by answering questions.
Gaming		
	Goals and rules	The goal is to get the greatest amount of money at the end and the rules are clear and simple. Students can buy properties (lose money at this moment) but they can recover it later when other classmates go into this box of the board.
	Player´s control	Players/students will decide what to do in many parts of the game among different options
	Challenge	Players/students must answer the questions better than the opponents. The money depends on the correct resolution of exercises but also on the correct strategy

IV. DESCRIPTION OF THE SHOPC COMPUTER BASED GAME

Fig. 1 shows the main window of the educational game shopC, which we have implemented.

Fig.1 Main window of the shopC computer based game

The shopC application allows the option to select the number of players (from one up to four), to load previously saved games, and to save several games. On the left of the game main window (fig. 1), there is a player`s panel, which contains four components for each player (as illustrated in fig.2): the name and colour tab chosen by the player, the

remaining money and the list of the properties purchased ("shopping list").

Fig.2 Player's pannel in shopC

The board of the game simulates a shopping centre where each of the squares is a shop, restaurant or part of a shopping centre. There are two types of square on the game:

- Squares for sale: they represent a shop or a restaurant. Some examples are the bar, the butcher´s, the pastry`s, or the jeweller's shop. When a player falls into one of these squares, he/she can buy the shop. In this buying process, the student has to answer a number of questions about a subject and depending on the number of correct answers; he/she will pay more or less money for that property.
- Squares which are not for sale:
    - Parking: it is the first square on the board. If a player falls on this, he/she will pay 10M.
    - Square of information: it is one corner square on the board. If a player falls into it, he/she will receive 10M.
    - Toilet: it is two corners square on the board. If a player falls into it, he/she will pay money, specifically 10M. Moreover, the next player will lose his turn or would have to pay 5M, passing the turn to the next player.

In our implemented shopC game, all the players start the game on the square "Parking" and roll a dice in order. When rolling the dice, the result is random (from 1 to 6). The number indicated by the dice will be the number of squares that the player's tab will advance clockwise. When a student falls into a square, the player can decide to buy the property if that property was not previously purchased by another player that fell into that square before. The price of the property is written on the board, giving the information of the different amount of money to pay depending on the number of correct answers to some educational questions. If the property is already sold, this is also indicated (Fig. 3).

Fig.3 Information panel of a shop or property in shopC

Some questions are formulated and the final price will depend on the number of questions the student answered well. Next, a panel appears to inform the player about the price of the property depending on the number of questions the student answered correctly. In any case, students can view the correct answers to the questions after they submit their responses. Fig. 4 shows an example of three types of questions presented to players. Each student rolls the dice once and, then, the turn goes to the next player in order.

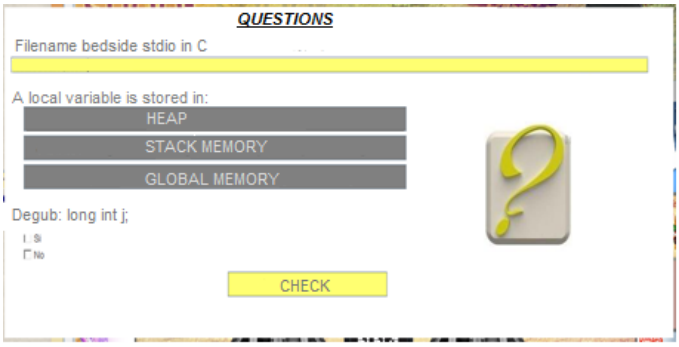

Fig.4 Three different types of questions in shopC

In addition, there are two escalators on the board, for going up and down. When a player passes through them, a message will appear asking whether the student wants to modify his usual path to go up or down using the escalators.

If a shop or property square is sold and the player who owns it falls into it, then he/she will earn money. In case he/she is not the owner but another player, then the student must answer a question. If the solution is correct, the player will not pay any money but if the solution is incorrect, he/she will pay 25% of the total price of the property.

The game finishes when a player loses all his money or after fifty turns for each player. The number of turns is configurable but has been selected as a trade-off on one hand for being able to finish the game and making enough number of exercises, and on the other hand for stopping the game if after some number of turns no one has wined.

When the game ends, the system opens a window with information about the ratings of players. The order in the rating depends on the amount of money of each player at that moment (the total amount of properties is not considered). Fig. 5 shows the panel for the end of a game with just two players.

Fig.5 Final rating panel at the end of the game in shopC

V. Comparisson of SHOPC with other Educational Games

The following section summarizes the goals of related educational games and discusses the most significant differences with our implemented shopC educational game.

The article by [15] describes a computer game that simulates a board with a dice and squares where a player can move forward if a student responds well some questions. The presented shopC game adds the possibility of buying or handling money as well as the option of making additional strategies and different interfaces. The game proposed by [42] is also based on the Monopoly game but the rules and framework is very different to the one presented here, e.g. there is no dice, the domination of squares depends on obtaining higher scores, there are squares that are related or the framework is not a shopping center.

The game presented in [43] turns students into virtual pets while the shopC game let students play imitating the real life, because it is like going shopping and use fictitious money. Moreover, there are also differences in the strategy and purpose of both games.

The research described in [21] [44] [45] are other examples of educational games. The game described in [21] describes a game based of questions. The most significant difference with this games is that shopC has different rules, strategies and type of competition. The work in [44] describes JGomas, which simulates a 3D world. The students play in two groups, they compete with the other group and cooperate with each other to achieve the objective. In that game, there are not questions or money and students compete modifying programing code, which is another form of learning. In It-Adventures [45] apart from other differences, groups of students compete among them, the contrary of shopC, where the pupils compete individually. Competition in groups might decrease bad feelings among losers but individual competition enables e.g. a more precise evaluation of each student individually as the grade is not related to the whole group.

VI. Evaluation

To evaluate this application and its design, quantitative and qualitative methods have been applied. Next, there is a description of the participants (first subsection), the methodology applied (second subsection) and the obtained results (third subsection).

A. Participants

The experience involved a total of 58 students at the High School level divided in two different groups depending on the timetable for each group of students. Although students were of High School level, the students were adults (greater than 18 age years old) because the school where the experience took place is a special one for education of adults who were not able to obtain the High School level before.

The selected subject was Technology within the scientific-technological scope.

It is also important to note that adults enrolled in High Schools centers have a lack of digital competences in general.

Two teachers of the Technology subject at High School were in charge of designing the challenge to tackle with game and create the required educational resources, i.e. the set of questions to be embedded in the shopC educational game.

B. Methodology

The selected didactic unit for the experiment was related to the process of resolution of technological problems. This didactic unit has a total of 9 sessions, each one of one hour of duration. During the first six sessions, students had theoretical and practical activities about the technological process, computer aid design or inventions. Sessions number 7 and 8 were devoted to the interaction with the shopC tool. This way, students had already covered all the topics about the resolution of technological problems and should be in a position to be able to solve the proposed exercises within the tool. Finally, session number 9 is for the global evaluation without the shopC tool.

At the end of session 8 (when the interaction with the shopC finished), students had to fill in a survey about the game. In addition, teachers observed the experience and asked for students opinions in order to have an additional qualitative evaluation. The survey is designed to cover the three different parts of the design principles of the educational game (motivation, learning and gaming) so that these three components can be evaluated. Table 2 shows the different survey questions related to the different three categories.

The total number of questions designed by teachers to be used in shopC was 100. Each time that a student falls into a square and has to answer a question, the question is selected completely randomly, so students can repeat some questions. The total number of questions that a student answers during a game depends on the number of squares the student falls in during the match. This depends on when the game ends, which is established by the first student who run out of money or arrives to the end of the total number of turns.

Based on pedagogical reasons, students competed in pairs of two, and each pair was sitted in the same computer. This way, the number of players in each computer is two and there is a guarantee that the game is fair, because other way (with more than two players in a game), a student might go bankrupt enabling another friend to win but there might be another classmate with better perspectives to win (e.g more properties).

C. Results and Discussion

At the end of the interaction with shopC, students had to rate from 1 (strongly disagree) to 5 (strongly agree) the questions of table 2 about the shopC game tool. The survey questions include the three different dimensions of design of the tool as we want to evaluate these three different dimensions (motivation, learning, gaming). The mean, and standard deviation of students answering each survey question (N=58) is shown in table 2.

TABLE II. SURVEY QUESTIONS AND RESULTS (N=58 FOR ALL THE QUESTIONS)

Design principles	***Statements***	***Mean***	***Std. dev.***
Motivation			
	The use of this game has increased my motivation and interest for the course	*3.55*	*1.029*
	I would like to repeat this experience	4.02	1.304
Learning			
	I have had the impression that this game complements or help to improve my knowledge, skills and experience.	4.07	1.057
	I think I can learn more with this game than with a traditional system of questions with a piece of paper	4.02	0.982
Gaming			
	I like the objectives, rules and philosophy of the game	3.83	1.142
	It has been easy to understand the different functionality of the game	4.38	0.988
General			
	The tool has a nice interface	3.81	1.162
	I liked the game used	3.98	1.132

The fact that students want to repeat the experience with shopC might be an indicator that students felt motivated with the game. The motivation of the students with the game is reinforced strongly with the qualitative students' opinions based on interviews. The students' answers in these interviews state that learning by playing with shopC is more motivating because the class sessions are more funny and enjoyable. Moreover, students pointed out that playing with other classmates enables a challenge in which they want to play better than their classmates, so they increase their effort and motivation. However, this motivation with the game is not directly reflected in motivation with the course. A mean of 3.55 of increase of motivation and interest due to the game is obtained. Although there is a moderate increase of motivation for the course for students, the general motivation with the shopC game might be better but this is not directly reflected in increase of motivation towards the course (the later was asked in the survey). This might also be because the activity is only done for one didactic unit but not for all the didactic units of the course, so the activity is very specific but the survey question was related to the general course.

Regarding the learning dimension, it is clear from the survey results that the game has a positive effect in students' perception about their learning. This effect does not seem to only rely on their active participation in the question & answer activity and the instructional design of the questions, but also on the repetition of questions (and the derived reflection) and game mechanisms. Students think that they can learn more with this game rather than with a traditional questions/answer system in a piece of paper. Therefore, it was a success the introduction of this game in the classroom instead of a traditional session of learning exercises to be solved in a piece of paper.

The gaming design was also positive as revealed by the two survey questions. Students liked the different gaming functionalities of the game and felt that they were easy to use.

The application of the qualitative analysis reinforces the positive results over these three dimensions of the design. The interviews with students reveals that students had fun, entertaining and were motivated with the game (motivation dimension), students learnt (learning dimension), the interfaces are nice, rules are logical and simple (gaming dimension). However, students requested for more complex rules, the inclusion of more dices or more cards. They would also like music and animations and think these things would make the game more entertaining and motivating. Therefore, these are some identified functionality to improve the game in the future.

All in all, we can say that based on the evaluation, the three dimensions of the design of the game were appropriate. Therefore, we achieved a well balance between motivation, learning and gaming for the shopC game, achieving a good adaptation of the traditional Monopoly game for the learning area. This is also reflected in the general evaluation of the game in which students stated that they like the game.

VII. CONCLUSIONS

The use of computer games for educational purposes is an important aspect that can improve the learning process. An important issue is how to adapt well established traditional games within the learning process using computer based educational games. There are many ways to adapt a game for making it an educational one. Existing design theories and pedagogical foundations should be used to convert a traditional game into an educational one.

In order to make the adaptation of traditional games into computer based educational ones, this work proposes to follow the three design dimensions (motivation, learning, gaming) found in [20] as a result of the analysis of different works of the state of the art, and adapt their related features with our own ideas and additional related works such as [12]. We show how to adapt the traditional Monopoly game to a computer based educational game (shopC) following these three design principles.

The shopC game has been successfully implemented and tested with students. We show the different screens, rules, inserted learning questions, etc. of the game. The adaptation of the game followed the motivation, learning and gaming design principles. Sometimes, some design principles are opposite (e.g. for learning or gaming) but a trade-of is necessary for the

decisions and we have tried to make the different decisions so that the three dimensions can obtain a benefit.

The shopC game has been evaluated with more than 50 students in a pilot experience in High School with very positive results. There was a high satisfaction of students and the results regarding the three different dimensions (motivation, learning and gaming) were very positive. This means that the introduction of the shopC game can be of benefit for the learning process as well as motivating and having good gaming rules.

However, there is room for improvement, for example taking into account students' comments to make the rules of the game more complex. One of the interesting future research directions is the comparison of this game with other game tools for education to know which of them are more valuable for students.

ACKNOWLEDGMENT

Work partially funded by the RESET project under grant no. TIN2014-53199-C3-1-R (funded by the Spanish Ministry of Economy and Competitiveness), the SHEILA project under grant 562080-EPP-1-2015-BE-EPPKA3-PI-FORWARD (funded by the European Commission) and the "eMadrid" project (Regional Government of Madrid) under grant no. S2013/ICE-2715.

REFERENCES

[1] T. Butler, Games and Simulations: Creative Educational Alternatives, vol. 33, 1988.

[2] M. Prensky, Don't bother me, mom, I'm learning!, St. Paul, MN: Paragon House, 2006.

[3] J.A. Estallo, Los videojuegos. Juicios e prejuicios, Barcelona: Planeta, 1995

[4] M. De Aguilera, and A. Mendiz, "Video games and Education," Computers in entertainment , vol. 1, no. 1, pp. 1—14, 2003.

[5] P.J. Muñoz-Merino, M. Fernández-Molina, M. Muñoz-Organero, C. Delgado Kloos, "Motivation and Emotions in Competition Systems for Education: An empirical study," IEEE Transactions on Education, vol. 57, no. 3, pp. 182-187, 2014

[6] J.D. Jones, M.C. Paretti, S.F. Hein, T.W. Knott, "An Analysis of Motivation Constructs with First-Year Engineering Students: Relationships Among Expectancies, Values, Achievement, and Career Plans," Journal of Eng. Education, vol. 99, no. 4, pp. 319--336 , 2010.

[7] G. Reinhardt, L. Cook, "Is This a Game or a Learning Moment? Decision Sciences Journal of Innovative Education," vol. 4, no. 2, pp. 301—304, 2006.

[8] M. Minović, M. Milovanović, D. Starčević, "Modelling Knowledge and Game Based Learning: Model Driven Approach," Journal of Universal Computer Science, vol. 17, no. 9, 2011.

[9] S. Retalis, "Creating Adaptive e-Learning Board Games for School Settings Using the ELG Environment," Journal of Universal Computer Science, vol. 14, no. 17, pp. 2897—2908, 2008.

[10] C.V. Helliar, R. Michaelson, D.M. Power, and C.D. Sinclair, "Using a portfolio management game (Finesse) to teach finance," Accounting Education, vol. 9, no. 1, pp. 37-51, 2000.

[11] A.P. Massey, S.A. Brown, and J.D. Johnston, "It's all fun and games…until students learn," Journal of information Systems Education., 2005

[12] S. Arnab, T. Lim, M.B. Carvalho, F. Bellotti, S. de Freitas, S. Louchart, N. Suttie, R. Berta, A. De Gloria, "Mappling learning and game mechanics for serious game analysis," British Journal of Educational Technology, 2014

[13] Games-to-Teach Team, "Design principles of next-generation digital gaming for education," Educational Technology, vol. 43, no. 5, pp. 17-33, 2003

[14] J.P. Gee, "Game-like learning: An Example of situated learning and implications for opportunity to learn", http://www.academiccolab.org/resources/documents/Game-Like Learning.rev.pdf (2005)

[15] C. Giménez, C. Pagés, and J.J. Martínez, "Diseño y desarrollo de un juego educativo para ordenador sobre enfermedades tropicales y salud internacional: una herramienta docente más de apoyo al profesor universitario," Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, pp. 221—228, 2011.

[16] P. Georges, and C. Thornton, "Cognitive Psychology: Increasing Adult Technology Knowledge," Journal of Cross-Disciplinary Perspectives in Education, vol. 4, no. 1, pp. 34-40, 2011

[17] C. Schlieder, P. Kiefer, and S. Matyas, "Geogames: Designing Location-based games from classic board games," IEEE Intelligent Systems, vol. 21, no. 5, pp. 40–46, 2006.

[18] J. Melero, D. Hernández-Leo (in press), "A Model for the Design of Puzzle-based Games including Virtual and Physical Objects," Educational Technology & Society, 2015.

[19] A.Y.K. Chua, R.S. Balkunje, "An Exploratory Study of Game-based M-learning for Software Project Management," Journal of Universal Computer Science," vol. 18, no. 14, pp. 1933-1949, 2012.

[20] P.J. Muñoz-Merino, M. Fernández Molina, M. Muñoz-Organero, and C. Delgado Kloos, "An Adaptive and Innovative Question-driven Competition-based Intelligent Tutoring System for Learning," Expert Systems With Applications, vol 39, no 8, pp. 6932-6948, 2012.

[21] L. Chang, J. Yang, F. Yu, "Development and evaluation of multiple competitive activities in a synchronous quiz game system," Innovations in Education & Training International, vol. 40, no. 1, pp. 16—26, 2003.

[22] LM. Regueras, E. Verdu, M.F. Munoz, M.A. Perez, J.P. de Castro, M.J. Verdu, "Effects of Competitive E-Learning Tools on Higher Education Students: A Case Study," IEEE Transactions on Education, vol. 52, no. 2, pp. 279–285, 2009.

[23] W. Admiraal, J. Huizenga, S. Akkerman, G. ten Dama, G., "The concept of flow in collaborative game-based learning," Computers in Human Behavior, vol. 27, pp. 1185–1194, 2011.

[24] M. Csikszentmihalyi, Flow: The psychology of optimal experience, New York: Harper-Perennial, 1990.

[25] T. Malone, "Toward a theory of intrinsically motivating instruction," Cognitive Science, vol. 4, pp. 333–369, 1981

[26] M. Pivec, O. Dziabenko, "Game-Based Learning in Universities and Lifelong Learning: UniGame: Social Skills and Knowledge Training. Game Concept," Journal of Universal Computer Science, vol. 10, no. 1, pp. 14-26, 2004.

[27] D. Charles, T. Charles, M. McNeill, D. Bustard, and M. Black, "Game-based feedback for educational multi-user virtual environments," British Journal of Educational Technology, 2011

[28] B. Skinner, Teaching Machines. Science 128, pp. 969–977, 1958.

[29] K. Squire, "Video games in education," International Journal of Intelligent Simulations and Gaming, vol. 2, no. 1, pp. 49-62, 2003.

[30] E. Thorndike, Education: A first book, Macmillan, 1912

[31] E.D. Wagner, In support of a functional definition of interaction. American Journal of Distance Education, vol. 8, no. 2., 1994.

[32] J. Lave, and E. Wenger, Situated Learning. Legitimate peripheral participation, Cambridge: University of Cambridge Press., 1991.

[33] S. Sendag, H.F. Odabasi, "Effects of an on-line problem based learning course on content knowledge acquisition and critical thinking skills," Computers & Education, vol. 53, pp. 132—141, 2009.

[34] P.J. Muñoz Merino, C. Delgado Kloos, "A software player for providing hints in problem-based learning according to a new specification," Computer Applications in Engineering Education, vol. 17, no. 3, pp. 272-284 , 2009.

[35] P. Georges, and C. Thornton, "Cognitive Psychology: Increasing Adult Technology Knowledge," Journal of Cross-Disciplinary Perspectives in Education vol. 4, no 1, pp. 34—40, 2011.

[36] D.A. Kolb, Experiential Learning: Experience as the Source of Learning and Development. Prentice-Hall, Inc., Englewood Cliffs, N.J., 1984.

[37] C.V. Helliar, R. Michaelson, D.M. Power, C.D. Sinclair, "Using a portfolio management game (Finesse) to teach finance," Accounting Education, vol. 9, no. 1, pp. 37—51, 2000.

[38] A.P. Massey, S.A. Brown, and J.D. Johnston, "It's all fun and games…until students learn," Journal of information Systems Education., 2005.

[39] Gamificación S.L (2013) http://www.gamificacion.com/que-es-la-gamificacion.

[40] P. Blumenfeld, T. Kempler, J. Krajcik, "Motivation and cognitive engagement in learning,". In R. K. Sawyer (Ed.), Cambridge handbook of the learning sciences, Cambridge: Cambridge University, pp. 475–488, 2006.

[41] L.S. Vygotsky, Mind in society: the development of higher psychological processes, Cambridge, MA: Harvard University Press., 1978.

[42] I. Hsiao, and Y. Lin, "Cyber Java Monopoly: Game-based approach of collaborative programming language learning," UCLA, Los Angeles, CA, Feb 28- March 1, 2008,3rd iConference, 2008.

[43] Z. Chen, C.Y. Liao, T. Chan, "Learning by Pet-training Competition: Alleviating Negative Influences of Direction Competition by Training Pets to Compete in Game-based Environments," Proc. of the 10th IEEE International Conference on Advanced Learning Technologies, Sousse, pp. 411-413, 2010.

[44] A. Barella, S. Valero, and C. Carrascosa, "JGOMAS:New Approach to AI Teaching," IEEE Transactions on education, vol. 52, no. 2, pp. 228-235, 2009.

[45] J.A. Rursch, A. Luse, J. Doug, "IT-Adventures: A Program to Spark IT Interest in High School Students Using Inquiry-Based Learning With Cyber Defense, Game Design, and Robotics," IEEE Transactions on education," vol. 53, no. 1, pp. 71—79, 2010.