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Serious Games: Evaluation of the Learning Outcomes

Abstract. The article is devoted to the further development of the methodology of serious games. To ensure the effectiveness of serious games it is necessary to consider the problems of finding the balance between making «learning fun» and the acquisition of learning outcomes. To achieve this balance it is proposed to conduct assessment in two areas: estimation of the participants' involvement in the game and evaluation of the degree of learning outcomes achievement. This paper presents the mechanism of a conceptual framework improvement for serious games through the implementation of embedding assessments that includes formative and summative evaluation of learning outcomes and motivational games mechanisms.

Keywords: serious games, learning outcomes, game attributes, embedding assessments, evaluation model. Аннотация.

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Серьезные игры: оценка результатов обучения

Аннотация. Статья посвящена дальнейшему развитию методологии серьезных игр. Для обеспечения эффективности серьезных игр необходимо рассмотреть проблемы нахождения баланса между созданием «обучения» и приключением результатов обучения. Для достижения этого баланса предлагается провести оценку по двум направлениям: оценка участия участников в игре и оценки степени достижения результатов обучения. Эта статья представляет механизм концептуальной основы улучшения для Сери-ОЕ игр посредством осуществления вложения оценок, который включает формирующую и итоговую оценку результатов обучения и мотивационные механизмы игры.

Ключевые слова: серьезные игры, результаты обучения, атрибуты игры, вложение в-essments, модели оценки.

The problem of increasing of the training effectiveness specifically professional higher education becomes very important today. The obvious is the need to improve the formation and students' steady practical skills, and the level of development information technologies allows to create interactive, electronic, video and educational content to simulate as much as possible actual production situations and scenarios of various business processes in today's labor market. It's necessary to focus on the active training forms, namely training, based on games or incorporating elements of the game. In this case, the learning process takes place not only in the form of a passive listening or reading but in the form of steps, so-called "learning through doing". An important feature of the game for educational is their ability to motivate student learning, promote their development, enabling the test in practice and develop their skills and abilities. The use of games opens up many new opportunities for complex skills learning in higher education. These games were called serious games. The definition of "Serious Games" (SGs) appeared long time before the diffusion of computer technology in everyday life. In 1970s Clark Abt used this expression in his book entitled exactly "Serious Games" where he also gave a first definition of what is a serious game: "reduced to its formal essence, a game is an activity among two or more independent decision-makers seeking to achieve their objectives in some limiting context. A more conventional definition would say that a game is a context with rules among adversaries trying to win objectives. We are concerned with serious games in the sense that these games have an explicit and carefully thought out educational purpose and are not intended to be played primarily for amusement" [1]. This definition frustrates some within the industry as "games" are inherently also meant to be fun. To simplify matters we will continue with the definition that Serious Games are in fact games that have either been developed or re-purposed with an objective other than pure entertainment in mind. In addition they are a wonderful tool for improving the acquired skills: «If you make a mistake, you will not die (pilot training), you will not lose your case (lawyer role-playing) and you will not feel dumb. This is the beauty of games. They are separate from reality and this separation provides a confidence for players to make mistakes whilst learning

and not being afraid of the consequences. The more a game is played, mistakes get made less frequently and a player's efficiency begins to grow [2].

There is no single definition for the term "serious games", but all agree that this is the game "in order." In other words, they extend from the entertainment itself to the implementation of learning in a broader sense within the interactive environment.

The game will be considered as a serious game on condition of the availability of game attributes, given problem and system of positive or negative encouraging. These characteristics distinguish them from entertaining games.

Serious games are often used for non-formal education and adult education, but in the field of professional education, they are not popular enough. Why there's a such situation? It is necessary to analyze the essence of the meaning and characteristics of serious games that the situation will become clearer. Using this term, you must always remember the pedagogical basis of serious games and the principles of their use.

The phrase «serious games» accurately reflects the essence of the product: on the one hand - this is a game aimed at creating interest, and on the other hand - this is training aimed at solving serious problems.

In the paper [3] are emphasized the possibility of serious games as a tool integrated in the important educational elements: «Model of serious games using and simulations in e-learning - is designed concept that visually represents what possibilities in terms of technology, training, gameplay and learning process have computer simulations and "serious games"»

In the paper [4] is noted: There are two key themes common to the development of games for education, namely:

1. The desire to harness the motivational power of games in order to "making learning fun".

2. A belief that 'learning through doing' in games such as simulations offers a powerful learning tool.

Thus, the use of serious games for educational purposes is based on the following:

Motivational component as needed to achieve any educational purposes is provided by four essential characteristics of good games: control, challenge, fantasy, and curiosity [5].

The educational component is more difficult and complex and it requires more detailed research.

It should be noted that in most games the focus lies on the development of soft skills like logical thinking, ability to make decisions based on the analysis of situations, the ability to lead, that is, management skills.

In this paper we want to expand the boundaries of understanding of some serious games. For full characteristic of serious games as an educational tool, it's necessary to add their focus on the development of Hard skills and competence, that is, skills and abilities to use them in any area.

In addition, there is a need to develop a methodology of serious games, as the most challenging aspect is to find a balance between entertaining aspect of an addictive game and teaching aspect aimed at achieving of the learning outcomes.

The purpose of this article is to improve the methodology for developing serious games, namely aspects related to finding a balance between making learning fun and achievement of learning outcomes.

The basis of the balance between making «learning fun» and the acquisition of learning outcomes is the assumption that 'good' games embody 'good' pedagogy.

In our opinion, in this direction should be conducted the study as to reach the point where mastery of skills is fun, is a victory over the human psychology, especially in young age and adolescence.

We'll analyze the technology training and technology development of serious games.

A mandatory step in the methodology of the learning process is the stage of evaluation of the learning outcomes achievement. If we consider the serious games as an educational tool, the technology development of serious games must include evaluation stage.

Many educators believe that serious games have the potentials to turn the education process around by motivating students to learn as they play. However, the lack of efficacy assessment research in serious games has prompted critics to question its worth in the supposed education reform [6]. Lacking clear empirical data, it will be impossible to calculate the cost-benefit ratio of serious games, meaning its effectiveness will always remain suspect.

At the heart of any game is included a mechanism of evaluation (balls, bonuses, shift to a new level, etc.). However, the question arises: how to use the well-known assessment mechanisms for evaluation learning outcomes in serious games.

Planning of serious games can embody all elements of the model was suggested by Robert Mills Gagne [7]. This model include nine general steps of instruction for learning are:

1. Gain attention (present a good problem, a new situation, use a multimedia advertisement, ask questions). This helps to ground the lesson, and to motivate.

2. Describe the goal (state what students will be able to accomplish and how they will be able to use the knowledge, give a demonstration if appropriate). Allows students to frame information, i.e. treat it better.

3. Stimulate recall of prior knowledge (remind the student of prior knowledge relevant to the current lesson (facts, rules, procedures or skills). Show how knowledge is connected, provide the student with a framework that helps learning and remembering). Tests can be included.

4. Present the material to be learned (text, graphics, simulations, figures, pictures, sound, etc. Chunk information (avoid memory overload, recall information)).

5. Provide guidance for learning (presentation of content is different from instructions on how to learn. Use of different channel (e.g. side-boxes))

6. Elicit performance "practice" (let the learner do something with the newly acquired behavior, practice skills or apply knowledge. At least use MCQ's)

7. Provide informative feedback , show correctness of the trainee's response, analyze learner's behavior, maybe present a good (step-by-step) solution of the problem

8. Assess performance test, if the lesson has been learned. Also give sometimes general progress information

9. Enhance retention and transfer: inform the learner about similar problem situations, provide additional practice. Put the learner in a transfer situation. Maybe let the learner review the lesson.

For the successful integration of elements of the model (of instruction for learning) in serious games is necessary to consider technology design of serious games.

In the work [8] is noted that problem faced by many instructional designers and technologists is the lack of a development model for serious games (as interactive learning instructions). The author [8] proposes 10 steps of Serious Games development, namely:

1. Determining Target Audience and Learning Content*
2. Determining the Amount of Funding and Time Available
3. Writing Game Narratives
4. Selecting the GDK/Game Bundle
5. Video Game Design and Game Mechanics
6. Interactive Learning Instruction Design*
7. The Game Development Cycle
8. Beta Testing and Usability Testing
9. Public Release
10. Efficacy Assessment*

Serious game development components that are not found in video game development are distinguished using asterisk (*) marks.

Other authors consider a serious game development technology, which consists of seven consecutive steps [9]:

1. Specification of the pedagogical objectives

2. Choice of the Serious Game model (board game, investigation game, puzzle and adventure game)
3. General description of the scenario and virtual environment
4. Searching for reusable software components
5. Detailed description of the scenario
6. Pedagogical quality control
7. Precise specifications for subcontractors

To minimize the testing phases, we set up a pre-evaluation of the SG before it is actually produced. A first set of tests can be run on the SG scenario graph to make sure there are no dead-end paths and that all paths insure that the learners acquire the main pedagogical objectives. For a more thorough testing, we can model virtual players that will act in accordance to their level of knowledge and their specific behavioral profile (curious, prudent, hasty, confident...) [10]. For the time being, this method exists only for board game type SGs that have a very formalized and simple structure, but it should be applicable to other types. The objective of these simulations is to statistically evaluate the SG in terms of pedagogical gain. With this system, we should be more efficient than when testing is only done on real people at the end of the production, which usually results in going through the production chain again.

However, despite that fact that each of the model has its evaluation procedure Efficacy Assessment or Pedagogical quality control, should be noted that it's given a little attention to the estimation procedure.

Due to a lack of clear standards and guidelines for game developers, it is difficult to justify claims that a specific game meets the learner's requirements and/or expectations. Paper [11] eliminates this gap and defines a conceptual model for serious games that will contribute to their design and the measurement of achievement in meeting their learning outcomes.

The conceptual framework for serious games based on pedagogical principles and include next elements: capability; instructional content; intended learning outcomes; game attributes; learning activity; reflection; games genre; game mechanics; game achievement.

An element in this evaluation model is the feedback, which binds Game achievement and Learning activity: «The learning activities can be modified based on the game achievement's feedback. The game achievement or score would indicate the level of learner knowledge while playing games and, if necessary, newly chosen learning activities should be changed to suit the learner level» [11].

The complexity of the assessment is a recognized fact in the educational games. For researchers in the field of serious games it's necessary to establish mechanisms for meeting the needs of the educational community. But for the moment teachers are engaged in estimation of success of the gaming experiences of their students, which takes additional time that could be spent on achieving concrete results

We support the concept of Embedding assessments, which is detailed in the [12]. It's noted that embedding assessments within such immersive games would permit us to monitor a player's current level on valued competencies, and then use that information as the basis for adjusting game features, such as the difficulty of challenges. This is intended to maximize both our "flow" and "grow" (i.e., learning) goals. Integrating the flow state of immersive games with learning theories has tremendous potential to enhance students' learning-both in the short- and long-term). The idea is to exploit animation and immersive characteristics of game environments to create the flow needed to keep the students engaged in solving progressively more complex learning tasks. In other words, we want to use the flow to facilitate the growth in terms of students' acquisition of valued proficiencies. As more and more researchers are pointing out

It should focus on the fact that the value of the game for the educational process is determined by the degree of achievement of learning outcomes. In turn, the learning outcomes will be achieved with a greater degree of efficiency only if the game will be interesting for the participant.

Taking into attention the previous information it is proposed:

1. To conduct assessment in two areas:

estimation of the participants' involvement in the game;

evaluation of the degree of learning outcomes achievement.

2. To organize the evaluation process not only as a summative assessment (or summative evaluation refers to the assessment of participants where the focus is on the outcome of a program.

In contrast to formative assessment, which summarizes their development at a particular time) but as formative assessment (including diagnostic testing is a range of formal and informal assessment procedures employed by teachers during the learning process in order to modify teaching and learning activities to improve student attainment. It typically involves qualitative feedback (rather than scores) for both student and teacher that focuses on the details of content and performance. It is commonly contrasted with summative assessment, which seeks to monitor educational outcomes, often for purposes of external accountability [13].

It's proposed to improve the conceptual framework for serious games (Fig.1)

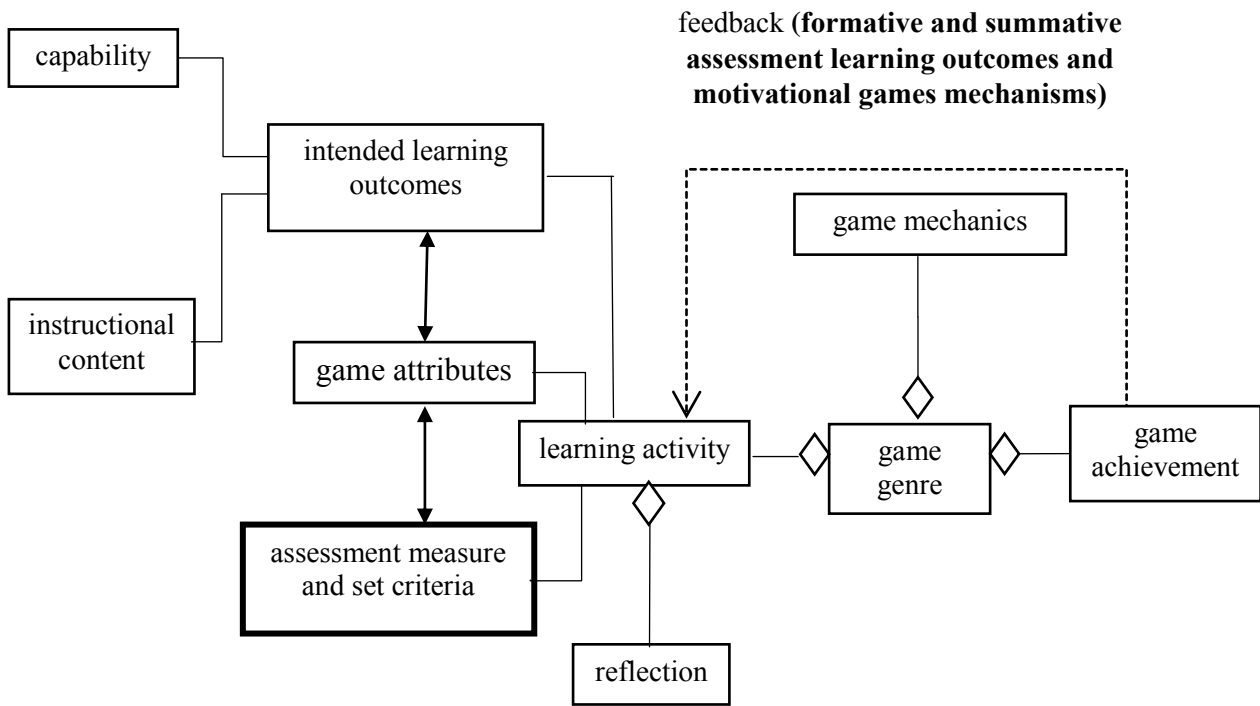


Fig. 1. An Improved Conceptual Framework for Serious Games

An improved conceptual framework for serious games involves the new elements which named an assessment measure and set criteria. This element is associated with intended learning outcomes and game attributes. Relationship between these third elements provides a focus of learning activity on the effective achievement of learning goals. In addition the feedback got the specific name such as Formative and Summative assessment learning outcomes and motivational games mechanisms. It emphasizes that the feedback is not a one-time act, but a system process. The learning activities can be modified based on the game achievement's feedback. The game achievement's feedback must include not only evaluation of the level of learner knowledge but also assessment of the motivational games mechanisms. Introduction of embedding assessments should begin with the development of learning outcomes. Learning outcomes are defined as statements of what a learner knows, understands and is able to do upon completion of a learning process. In the European Qualifications Framework (EQF), learning outcomes are therefore defined in terms of knowledge, skills and competence [14]. This learning outcomes and game attributes must be developed for the separate stages of serious game (Table 1).

Table 1. Relationships between learning outcomes, stages of the game and game attributes

Stages of the game	Learning outcomes			Game attributes	
	knowledge	skills			competence
		soft	hard		
Stage 1					
Stage 2					
Stage 3					
Stage n					

Assessment measure or set criteria must also be attached to the stage of the game and cover the four areas proposed in [15]. According to the Kirkpatrick model, evaluation can encompass four levels: learners' reactions; learning; behavior; results.

Evaluating learners' reactions means understanding how those who participate in the program react to it, if they participate actively and if they like the course. This can be measured through questionnaires and surveys, which are usually submitted to learners at the end of the course. In facilitated e-learning, learners' participation is monitored by the facilitator throughout the course period.

Evaluation (or assessment) of learning measures the achievement of intended learning objectives. Depending on the type of course, this can imply that participants have increased knowledge, developed skills, and/or changed attitudes as a result of attending the course. Learning can be assessed through direct observation, assignments and tests.

Evaluating behavior means understanding the extent to which participants' behavior has changed because of the training program: for example, if they use the acquired knowledge and skills on the job or in other practical situations. This can be done by observing learners' performance on the job.

Finally, evaluating results consists of identifying the final results that occurred in the organization because the participants attended the programme. The final results can include increased production, improved quality, decreased costs, and fewer accidents.

The relationship between the Stage of the game and the assessment measure or set criteria is shown in Table 2.

Table 2. Relationships between learning outcomes, assessment measure (set criteria) and evaluation tools

Assessment measure or set criteria	Learning outcomes			
	knowledge	skills		competence
		soft	hard	
learners' reactions	Questionnaire			
learning			Testing (H)	
behavior		Testing (S)		

results				Case Study

Questionnaire should be used for determining the theoretical training and for identifying the opinion of the participants about the game (connected questions in the questionnaire should be formulated thereby to reveal the extent of the game fascination).

Testing (S) should be used for identifying soft skills. These tests are designed to assess how participants' behavior changed as a result of learning how they can make their own decisions how justified their choice (discount situation (similar to game scenes) and options for their solutions, students need not only to choose the solution, but comment on it).

Testing (H) must be used for identifying hard skills. Such tests should assess the professional abilities of participants in a particular area.

Case Study is the most effective way for testing competence by performing learning exercises (situational tasks), developed with the scenarios of the game.

It's proposed to observe the following rules do not allow to assess formally:

At the design stage of the game scenarios it should be allocated stages in the game and then stop the game and ask the participants to go through the assessment procedure

It's necessary to motivate the participants to the evaluation: to allow the transition to higher levels of the game, or to assign additional points.

To form a final assessment regarding the effectiveness of SG it should be carried confirmative evaluation. After that, it will be possible to make a definitive conclusion about the effectiveness of SG and develop areas for improvement.

3 Summaries Efficiency of SG is checked by using the evaluation procedure. However, evaluation should be seen not as a one-time act of finishing the learning process. The article offers an advanced conceptual framework for serious games through the introduction of built-in evaluation. Evaluation can be done to accomplish specific learning outcomes. A qualitative assessment should be multi-dimensional and it must be aimed at evaluation of the level of interest in the game and at

achievement of different learning outcomes (knowledge, soft skills, hard skills, competence). In other words, you may want to evaluate learning process and outcomes: during the development stage, to improve SG (formative evaluation); during or immediately after the implementation stage, to measure the effectiveness of education, training and learning (summative evaluation); some time after the course has been implemented, to understand if it is still valid or needs to be updated or modified (confirmative evaluation). The future of serious games as an educational tool depends on their improved support for completion assessment, in-process assessment, and teacher evaluation. Designers and developers will need to reach beyond simple multiple-choice questions and incorporate the best of video game tutorials with sound educational and psychometric techniques.

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