

# Gamification and the Ontological Approach in Information Learning Systems\*

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## Abstract

The paper considers the use of different types of computer games and various gamification elements in information learning systems. The proposed approach to a formalized description of educational processes is based on the ontologies of the corresponding subject areas. Ontological modeling of information learning systems with gamification elements fully reflects the pragmatics of the studied subject area. The proposed ontological model of an information learning system with gamification elements records and structures fragments of the learning content of the course being studied. This ensures logical consistency between individual ontologies when combining them to create learning content (fragment of learning content) of the corresponding online course) with a wider range of topics and tasks. The use of ontological modeling, and the formation of individual ontological models (of learning content, test tasks, ontologies of student results and actions, student knowledge assessments, and gamification components) contribute to the design of a unified information and educational environment within which information training systems using gamification elements operate. The proposed approach, based on gamification and ontological modeling, helps to increase the efficiency of learning processes and maintain interest and motivation to study the proposed learning content of the relevant course. The result of using elements of gamification and ontological modeling in information learning systems is the ability to make the necessary adjustments to the goals and objectives of the educational process, the learning process, the course of learning, and the requirements for the level and competencies of students. The problems and prospects of using gamification in information learning systems are considered.

## Keywords

information learning system, ontological model, learning content, gamification, computer game

## 1. Introduction

Games and gamification are important as cultural and historical phenomena of education [1, 2]. Video games, real-time role-playing games, and alternative reality games reflect the specifics and educational possibilities of games as special conditional realities. Video games (due to their ontological closure) are the basis for the development of serious games and alternative reality games (due to their ontological openness) are the basis for the gamification of learning [3].

The difference between the *Necessity of Work* and the *Pleasure of the Game* determines the difference between games and gamification.

Games are based on the opposition of the *Necessity of Work* and *Pleasure of the Game*, and gamification is built on the harmonization of different elements of the learning process.

This (in comparison with games) determines the more universal nature of gamification in learning (if we do not reduce it to the model of “points, badges, and leaderboards”), especially for adult students.

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The game, turning boring (necessary, obligatory) activity into entertainment, has been used since ancient times as a model of situations, a method of solving problems, an approach to discussions, and a way to involve people in this activity.

Enjoyment of the game is the key point responsible for achieving the goal of the game—increasing involvement, which is especially important for the learning process.

The use of modern information technology in the learning process has opened up new opportunities, one of which is gamification technology.

## 2. Games and learning

Play (game) and learning are inextricably linked: through play, children learn to understand the world around them and develop social skills.

Plato noted the connection between play and learning, considering play a form of skill training.

However, attention is often paid to play and its role in the upbringing and education of children, and not adults.

Only in the last century did the active introduction of game elements in adult education begin [2, 4].

This trend has intensified in our time, which is due, in particular, to:

- The development of the trend of continuous education necessitates the presence of effective and simple teaching methods.
- The growth of entertainment and gaming technologies contributes to the penetration of the gaming component into various spheres of life.
- The availability of information technology.
- The growth of communication needs and opportunities caused the involvement of more and more participants in the game, which led to the mass character and popularization of gaming activities.
- An increase in interest in learning games, as people strive to combine rest and benefit.
- The game is a function that is filled with the corresponding meaning.

Nowadays, it is necessary to change the paradigm of education to fit into the cultural context of new generations [1, 5].

Large amounts of information that a student can receive and perceive independently if desired, reorients the paradigm of education from the transfer of knowledge to the generation of a desire to receive this knowledge, involving students in the process of game learning.

The cultural characteristics of generations born and raised in the digital environment, the development of information technology, and the change in the paradigm of learning have made games and gamification relevant to the learning process.

By play, we mean a certain free activity, which is perceived as:

- Special conditional reality, not connected with everyday life, and capable of completely captivating the player.
- Not conditioned by any material interests or benefits.
- Existing in the process of interaction of its participants.
- Proceeding in a special space and time, in an orderly manner and by certain rules, which are accepted by the players voluntarily, unconditionally, and joyfully.
- Giving rise to social associations that surround themselves with secrecy or emphasize their special position to the ordinary world.
- Voluntary attempt to overcome unnecessary obstacles.

Another interpretation of the concept of play is given in [6], where play is understood as a system in which players participate (students) in an abstract challenge determined by rules, interactivity, and feedback, which leads to a quantitatively determined result, often causing an emotional reaction.

In [7], play is understood as a goal, rules, a feedback system, and voluntary participation. Everything else is an attempt to strengthen and enhance these basic elements.

The main characteristics of any game are freedom, voluntary participation, involvement of participants, absence of expectation of material utility, conventionality of reality, spatial and temporal boundaries, and presence of feedback and unnecessary obstacles.

The conventionality of games distinguishes them from real reality. In ordinary games, unlike digital games, the boundary with real reality is functional, not ontological.

The presence of feedback makes games irresistible not only to them but also to real reality.

Feedback in games is designed to make their worlds as engaging as possible so that even failures and obstacles stimulate continued interaction. Feedback from real reality is rarely stimulating.

One of the tools for managing students' learning activities is gamification, which stimulates innovative learning, generates interest in completing assignments and studying learning content, develops creativity, and provides an opportunity for self-realization.

The specificity of gamification, described in [8], is the use of game design elements in non-game contexts.

Many authors consider the main task of gamification to be the implementation of the psychology of the game [9].

This is practically related to the development of game thinking based on the use of game practices.

Gamification encourages students to actively and enthusiastically engage in various types of learning activities.

The *Necessity of the Work* implies involuntary, mandatory activity necessary for survival.

The *Pleasure of the Game* implies a freely chosen, voluntary activity, internally motivated and without external goals.

It is interesting to play for pure pleasure, and not for status, money, or obligations.

There is no obligation, no alternative, and no hopelessness in the game.

This is precisely its appeal.

The complexity and activity inherent in play make us feel alive (we are much happier spending time living it than killing it).

Games, unlike ordinary reality, satisfy the desire for more satisfying work, a better chance of success, a stronger social connection, and more meaning [7, 10].

What is an annoying obstacle or problem in *Necessity of the Work* becomes a motivating stimulus in *Pleasure of the Game*.

Games that are not limited to play and leisure activities, but describe a sphere of freedom and desire, will compete with real reality for the attention of their users as long as it is associated with *Necessity of the Work*.

### 3. Classification of games used in education

The appeal of video games lies not only in their interactivity but also in their ontological nature as a closed conditional reality, which is abstract and has some advantages over ordinary (real) reality:

- Cause and effect can be more clearly identified.
- Extraneous elements of reality are removed to keep the player focused on the essence of the game.
- The feeling of powerful control over the world is given.
- A risk-free environment is created.

All this makes video games an ideal environment for learning:

- Intrigue in the development of the plot, which is not inferior in entertainment to works of art.
- Control over what is happening.
- Opportunity to demonstrate your knowledge, skills, imagination, and unconventional thinking.
- Right to fail without dangerous consequences.
- Presence of feedback that ensures the correction of actions; competitive nature.

All this is important both for the effectiveness of learning and for motivation to learn [11, 12].

### **3.1. Live-action role-playing games**

Live Action Role-Playing Games (LARPGs) operate in the real world and therefore lack many of the advantages of video games. This is due to:

- The impossibility of constructing appropriate computer simulators on their basis.
- An advantage for practicing interpersonal interaction and teamwork skills, which are widely used in war games.
- Supporting a sense of real danger, which is almost absent in video games and simulators.

The educational aspect of LARPGs is not limited to the level of individual knowledge and skills but also reaches the level of meta-subject competencies.

LARPG participants learn to communicate, role-play, and get used to characters.

They develop imaginative thinking, as well as the ability to interact in a team.

### **3.2. Alternate reality games**

Video games are characterized by the so-called “objectification” of fictional and fantasy worlds, and Alternate Reality Games (ARGs) are the exit of computer games from virtual reality to the real world.

ARGs blur the distinction between the game space and the real world.

Therefore, the central place in ARGs is occupied by the concept of TINAG (this is not a game).

ARGs embody a reaction to unsatisfactory roles (e.g., a passive Participant of everyday reality, or an active Observer of virtual reality).

Instead of taking the player out of the real world into a fictional world, ARGs introduce the player into the real world.

To create ARGs, hardware, and software specific to computer games are used as a platform, as well as objects from everyday life, onto which a fictional game world is superimposed.

City blocks, objects that can be found in the city, real people (actors performing certain tasks), etc. can be used as game elements.

ARGs are computer-based, making extensive use of information technology, Internet, programs for coordinating the actions of players (students) in the real world, and the points they earn in the fictional game world.

The computer component of ARGs is beyond doubt, although the visual component is often weaker than that of classic computer games.

ARGs should not be confused with virtual reality games (VRGs). VRGs attempt to immerse the player (student) in a fictional world that is not connected to the real world.

The alternative reality does not break away from the real reality, it interferes with it and can even change it somehow.

Among ARGs, which include games that use everyday objects as elements of the game world, we highlight: ambient games, pervasive games, and immersive games.

Ambient games provide the player with the opportunity to exist at different levels of immersion in an alternative world, without remaining on any of them all the time.

The player can at some point become more immersed in the game, and then perceive it simply as a background, but the game will continue.

What such games and gamification have in common is immersion directly in those interactions that are considered non-game.

An example of such a game is the game *Ambient Quest: Pedometer*, created by D. Pinchbeck and M. Iles.

The gameplay consisted of players hanging a pedometer on themselves, which measured the number of steps they took each day.

They could use this number of steps to move their avatar in virtual space.

The more you walk in a day, the further the game character moves.

The developers tested *Pedometer* on participants of one of the conferences dedicated to video games.

As a result, the game changed the nature of completely non-game interactions at the conference: conference participants began to visit many more different audiences to gain more steps.

Thus, “*Pedometer*” can change the nature of interactions between players (students, teachers, scientists, etc.), forcing them to be more interested in areas lying outside their immediate specialization.

Pervasive games in their mechanics are not much different from ambient games.

They differ only in that they assume active immersion of players throughout the game.

The most famous example of such a game is *Foursquare*.

This mobile application turns a simple visit to various places in physical space into an action performed by the player in the alternative space of the game, realized as receiving points and “badges”.

At the same time, the processes occurring in the alternative world of the game can have a reverse effect on the real world.

In immersive games, in addition to integrating the game into our everyday space, rhetoric is added, consisting of the meta-message “This is not a game”.

This enhances the immersion of players (students) in the alternative world of the game since they begin to consider the relationship between the alternative world and the real world.

An example of such a game is *Ingress*, developed by Google for mobile devices based on Android. It is made immersive by the slogan that accompanies it: “This is not a game”.

The game at the meta-level tells players that they are collecting energy, opening portals, etc.

Therefore, for immersive games, it is not only the procedures that create the gameplay that are important but also the extensive use of stories that these games tell.

In *Foursquare*, the game comes down to following the rules and getting points.

The game *The Beast* was created by the Microsoft team to promote Spielberg’s film “*Artificial Intelligence*”.

Players found hints on the game’s websites to other websites or real places, having reached which they received a task by phone or even from a real person.

Tasks could be encrypted in advertising, TV shows, or sent by mail.

This forced players to always be on the alert, looking for information intended for them in the most unexpected places.

All this was done as if the tasks were not a game, but an activity to decipher a real message—all in full accordance with the rhetoric of any immersive game, which consists of the message “This is not a game”.

The violation of the boundary between the game and everyday life in immersive games is due to the game's desire to present its content as non-fictional.

For the actions of players (students) to acquire the status of a non-game, an additional level is needed, where they act as if the game is a non-game.

By accepting this level, players gain the ability to:

- Not notice events that happen in reality.
- Interpret what is happening in the right way, etc.

The absence of an ontological boundary with the actual reality in ARGs and LARPGs, from which they are fenced off by a functional boundary, makes them less safe than video games.

They allow you to participate in everyday life (including the learning process) just as fully and improve it.

The game is perceived as an activity that has little in common with everyday life and everyday worries and responsibilities; on the contrary, it offers an escape from them.

Adding game elements to utilitarian activities can create the pleasure and involvement inherent in-game activities.

This is achieved with the help of gamification technology.

It is gamification that acts as one of the ways to overcome some contradiction between the *Necessity of Work* and the *Pleasure of the Game* through a harmonious combination of learning and game elements.

#### 4. The concept of gamification in education

Gamification is a relatively new concept. The term “gamification” was proposed in 2002 by N. Pelling to describe game-based accelerated user interface design. Nowadays, gamification is understood as the use of game design elements in non-game contexts [13].

The problem with gamification is that it is often reduced to elements of game mechanics (“points, icons, and leaderboards”), i.e. to the PBL model (points/badges/leaderboards) [14].

The choice of these elements is since PBL is focused on development and achievement, which implies the internal desire for progress, skill development, achieving mastery, and overcoming upcoming problems.

The point-rating system for assessing knowledge and competencies adopted in universities is based on the PBL model.

Due to its simplicity and intuitiveness, it has become widespread, although it hinders the promotion of more complex and motivating types of gamification.

The constituent components of gamification should include: game mechanics and game approach, aesthetics, game thinking, involvement, motivation for action, assistance in learning, and problem-solving [6].

Gamification of the learning process is designed to change the modality of learning activities, presenting it as a game (pleasure, freedom), and not as work (obligation, necessity, duty).

There is a difference between gamification and serious games.

Although they coincide in that they do not function for entertainment purposes, gamification, and serious games differ respectively as a part/whole.

A game is a holistic conditional reality, gamification is a learning tool that creates only a shell for that real reality.

Therefore, gamification takes up the entire education/training/learning/teaching process (spreads over the entire course, academic discipline), and the game is limited to one topic, one or several lessons.

The ratio of gamification, entertaining, and serious games is presented in Table 1.

**Table 1**

Ratio of gamification and games

Parameter of Game	Entertainment game	Serious game	Gamification
Level	Whimsical level	Controlled risk level	Emotional level
Goal	Entertainment	Practice	Motivation
Result C	Pleasure, fun	Skills, abilities	Self-esteem and social capital

Due to its simplicity, gamification differs from video games, as it does not have complex virtual worlds with high-quality animation, simulations, and avatars.

Gamification (as a method of digital interaction) does not coincide with LARPGs, which are limited to personal interaction.

The only type of games that can be confused with gamification (due to their ontological similarity) are ARGs.

## 5. The educational potential of games and gamification

You should not consider game-based learning a panacea and base all learning on it.

Otherwise, an illusion will be formed that learning should always be easy, enjoyable, entertaining, and exciting.

Learning involves the ability to overcome yourself, to act through “I don’t want to”, despite laziness, and disinclination, without the support of incentives (external and internal).

This is the educational role of learning, which often turns out to be more important for life than the information acquired during learning, which can quickly become outdated.

In addition, the introduction of a game approach into the learning process can:

- This leads to the fact that the learner (student).
- Having become satiated with game practices.
- Often loses the taste for the games themselves.
- Other active types of activity that give Pleasure of the Game.

Students stop appreciating what makes games so attractive: freedom, spontaneity, pure pleasure.

These advantages can be lost in game practices since their introduction into the learning process often leads to their instrumentalization.

But at the same time, all this does not cancel out the usefulness of the game in education.

In general, gamification is a way of balancing the elements of:

- *Pleasure of the Game*  
and
- *Necessity of the Work*

is a more universal practice for building the educational process (especially for adult students) than regular games.

The difference between games and gamification (the entertaining nature of the former and the dual nature of the latter) leads to the fact that in school education, preference is given to games, and in higher education—to gamification.

This choice is also explained by the different meanings of games for different age groups:

- For children games serve to adapt to the reality in which they will grow up.
- For adults, they serve mainly to escape from the surrounding reality.

## 6. Use gamification in education

### 6.1. Principles of gamification in education

The main principles of gamification that are used in modern learning processes are, in particular:

- The principle of status, which sets the level of the player's position in the group, determines the rights and responsibilities of the learner in this system.
- The player receives his rank in the gamification system, acquires a resource for stimulating motivation and developing self-esteem as a basis for moving forward, demonstrating his advantages, and is guided by the behavioral model that he has tested.
- The principle of reward, states that rewards (badges, praise, prizes, reward cycles, random gifts, insignia, etc.) increase not only involvement in gaming activities but also motivation to participate.
- The principle of unexpected discoveries and rewards, which includes a special state of the subjects of gaming activities (emotions, curiosity, creativity, desire to participate in the game/competition/task, etc.).
- The principle of motivation, which involves the use of the following rules:
  - Use strong motivators of gaming activities: getting pleasure, using rewards, and recognizing successes.
  - Rely on sensory motives—the desire for a source of pleasure.
  - Comprehend the uniqueness of life and its fullness of cultural values.
  - Strive for positive interaction.
  - Change life for the better.

The principles of the gamification system emphasize the most significant provisions, the use of which will allow you to get a result, which implies, in particular, an increase in the status of students, the presence of incentives, and motivation.

The use of gamification in education has three main reasons [15]: involvement, experiment, and result.

Gamification has a special meaning since it stimulates activities that direct participants to solve new problems.

All this is associated with a special state of a person in the game—the pleasure that arises in the process of game/non-game victories, incentives, and approval of others.

This is expressed in the development of internal motivation when the person strives for the result.

These are the characteristics of involvement. Experimenting as a reason for gamification is the basis for the self-improvement of the game participant and improving his results.

One of the reasons for using gamification can be the result. Experience with gamification shows that new knowledge is gained and new skills are mastered. Gamification has a unique set of game mechanics and dynamics, techniques, and practices.

The main gamification techniques are, in particular [16]:

1. Storytelling—telling stories.  
In the context of gamification, storytelling qualitatively conveys a “captivating” story. This helps to reveal the necessary information: influencing emotions and feelings, entertaining the audience, capturing attention, and stimulating the active attitude of the learner (student).
2. Fragmentation of *information includes mini-levels* when dividing information in the learning process.  
Each subsequent mini-level is more difficult than the previous one, which helps to move forward, and this is better and more interesting than immediately offering participants a



high difficulty level (hard), without which the learner will lose interest in both the game and the learning.

3. *Elements of competition*—this technique gives gamification special emotions, the tension of rivalry for achieving the best result, stimulates interest in players.

The technique of encouragement also emotionally reveals its internal potential.

Game cups and virtual points cause no less strong emotions than grades in education since game signs are perceived in an emotionally vivid game action.

4. *Communication*. Games that use the potential of communicative activity are the most popular and allow students to discuss the development of game ideas, and the process of completing a task (for example, a group project/task).

## 6.2. Problems of using gamification in education

The boundary between everyday life and a game is determined by considering empirical concepts that directly precede the stage/level at which the player (student) is located.

The gamifying distribution of experience and badges is not a given (and as if “fixed”) system of levels for subsequent organizations.

Therefore, within the framework of work on another project (a learning task that is performed by a group of students), the main one may be the one who previously occupied a subordinate position.

An important feature of organizing the process of game-type learning is instructionalness, which includes the idea that each student should have the opportunity to receive all relevant information about all group members (for a group task) and/or all tasks that he should complete while studying the educational content of the corresponding learning course.

This is implemented by dividing all students by competencies: abilities, levels of basic and specialized knowledge, and as well as so-called “points” of empirical experience.

Dividing all students into groups (projects, tasks, etc.) involves collecting and archiving information about:

- What projects do they participate in
- What group/individual tasks did they complete
- What symbolic “achievements” do they have (similar to those that players receive for completing certain game missions)?

All this information is shared with course authors, experts, and educational process managers implementing instruction in the structure of universities.

Thanks to this instruction, it is easy to establish a network principle that supports the possibility of continuous professional growth of students.

Maintaining a list of achievements and skills allows you to identify creative leaders who come up with innovative ideas, expert leaders who provide recommendations to groups working on individual projects, etc.

Gamification turns social relationships into exciting game-like interactions, making their real logic invisible.

The real process of the game is not limited to completing tasks and the transition of the learner (within the framework of the relevant information learning system) from state 1 to:

- State 2 (positively assessed by the player (win))  
or
- State 3 (negatively assessed by the player (loss)).

The problems of gamification, for example, are intrinsic motivation of learners, grouping, the need for cooperation between characters with different skills or professions, learning game content, and dominance/competition between players.

A critical attitude towards gamification implies that for each specific gamification project in the information learning system, it is necessary to determine the boundaries within which it retains its creativity and appropriateness.

Such a definition of the conditions for the possibility of using gamification in the education/training/learning/teaching processes implies the definition of the conditions of impossibility (inappropriateness) of its application.

### **6.3. Use of computer games in learning and training processes**

The use of game forms of activity in the processes of teaching various academic disciplines (courses) for different audiences (by age, gender, level of training, etc.) shows its effectiveness and great potential.

Currently, game forms of activity (processes of gamification, gamification, gamification) have become popular.

By gamification, we will understand the use of game practices and mechanisms in a non-game context to involve end users in solving problems [16].

Game forms of activity in learning often boil down to the use of, for example, game technology, and game methodology.

The meaningful use of the game in the learning process requires the use of such moments of the game that are difficult (and sometimes impossible) to technologize.

Among the factors influencing a person's self-identification in the game, one can single out the virtualization of the "I", which in the space of computer games is compensation for the excessive rationality of the modern world [3].

Teachers, introducing game elements into their subjects, should carefully approach the use of game forms in teaching courses.

The special conditions of teaching in higher education institutions are, in particular, increased interest in technical means of learning, information technology, and at the same time emotional underdevelopment, and low communicative competence of students, especially specialties in the sphere of information technology.

But emotional intelligence, and the competencies related to it: communication, the ability to empathize, etc., are an important component of achieving successful self-realization.

Effective methods for forming emotional intelligence are games with elements of art technologies.

When using game technologies in the learning process, attention should be focused on the ability of games to train the cognitive sphere, to make possible joint experience and reconstruction of experience.

This allows us to see the positive and useful in games.

One of the problems of using games and gamification in the learning process is the problem of the limits of the application of game forms.

The specificity of many learning disciplines (individual topics) is intellectual tension, detachment, self-absorption, self-control, and seriousness.

The use of game forms of learning requires compliance of learning questions with game forms.

Simple computer games implemented in learning information systems are advisable to use when checking acquired knowledge, for example, using such forms as online quizzes, crosswords, and rebuses.

But computer games often distract from more important "real" activities.

Interactivity creates the illusion of ease of performing actions with one "click", and disorients in the mixing of real and virtual worlds.

The game process, although it contributes to the assimilation of new knowledge, does not form the integrity of ideas, but causes the risk of creating mosaic knowledge of the subject.

Computer learning games allow you to combine many learning tasks and form the necessary competencies in students.

The use of games is an excellent means of studying such disciplines as logic, methodology of scientific activity, etc., thanks to which it is possible to increase: the culture of scientific thinking, communication, and scientific research.

#### 6.4. Use of competence-oriented games in education

Competence-oriented game is aimed at ensuring a certain level of professional competence in the implementation of scenarios determined by models of processes of the subject area (including business processes, training/learning/teaching/education processes).

The result of the corresponding process is represented by the function:

$$L_k = F(L, Q_{CL}, Q_{MP}), \quad (1)$$

where  $R$  is the result of the process;  $L$  is the level of competence of learners (students, company employees, cadets, etc.);  $Q_{CL}$  is the quality of input materials or resources (fragments of learning content);  $Q_{MP}$  is process management quality (education/training/learning/teaching process, business process, etc.).

$L$  is an integral characteristic of human resources, which determines the result of the corresponding process.

$L$  consists of the levels of elementary competencies of individual resources that are associated with elementary operations of the business process:

$$L = \sum_{i=1}^N k_i^p \times 1/ks_i, \quad (2)$$

where  $k_i^p$  is the level of the  $i^{\text{th}}$  elementary competence in the process  $p$ ,  $ks_i$  is the coefficient of complexity of the  $i^{\text{th}}$  elementary operation.

Each elementary competence  $k_i^p$ , in general, can have  $m$  levels, where  $m$  depends on the opinion of the developers (experts, authors) of the information learning system and can take different meanings.

Each elementary operation can have  $k_c$  levels of complexity, which can also be determined by an expert.

For any elementary competence  $k_i^p$ , which supports the elementary operation  $\mu_i^p$ , there is test  $T$ :

$$T = \langle T_1, T_2, \dots, T_j, \dots, T_n \rangle, \quad (3)$$

where  $T_j$  is the  $j^{\text{th}}$  question of the test.

Any process (business process, education/training/learning/teaching process) performed to obtain a result for a finite number of elementary operations can be represented by an oriented graph [3]:

$$G = \langle N, U \rangle, \quad (4)$$

where  $G$  is a process graph;  $N$  is the set of graph nodes associated with elementary operations  $\mu_i^p$ ;  $U$  is the set of edges of the graph associated with connections (relationships) of elementary operations.

Any elementary competence  $k_i^p$  can be constructed during the traversal of the graph  $G$ .

The traversal can be performed multiple times. The process of acquisition (formation) of competencies will be called the process of training.

When building a model of the learning process, it is necessary to:

1. Conduct a system analysis of the subject area.
2. Build an ontology of the subject area.

3. Build a model of the  $G^u$  learning process using the concepts and rules of ontology derivation.

The process must be represented by a graph with several paths without cycles.

The nodes of the graph represent elementary operations of basic and additional processes (education/training/ learning/teaching processes, enterprise business processes, management processes, etc.).

Each path of the graph defines the steps that the player must take to complete the process.

Each path is an alternative to the other paths.

To build (form) competencies applicable to a similar organization, the graph must be a combination of all possible paths of processes:

$$G^E = \bigcup_i^n G_i^P, \quad (5)$$

where  $G^E$  is the graph of the learning process;  $G_i^P$  are the paths of the real graph of the  $i^{\text{th}}$  learning process.

4. Build a model of the  $E^u$  educational process, using concepts and rules of ontology derivation.

This graph should represent the processes of training management and reflect the logic of the development of competencies in the education/training/learning/teaching processes.

Such a graph can contain cycles and different types of nodes (initial node, condition node, operation node, end node).

5. The education/training/learning/teaching management process is expressed as follows:

$$E^U = \bigcup_i^n (E_i^P, E_i^L), \quad (6)$$

where  $E^U$  is the graph of the learning management process;  $E_i^P$  are paths of the real graph of the  $i^{\text{th}}$  education/training/learning/teaching management process;  $E_i^L$  are paths of the graph of the  $i^{\text{th}}$  process, reflecting the logic of competencies.

A correspondence can be established between the set of paths of the learning process graph and the sets of competencies.

This correspondence can be organized in the form of a matrix of traceability of the learning process graph by competencies (competency matrix, CM).

The row of the matrix of competencies determines the paths in  $G^E$  and  $E^U$ , necessary for building a set of competencies  $k_i^P$  ( $i= 1, 2, \dots, n$ ).

The totality of these paths will be called a training scenario, which should consist of procedural instructions, hardware, information, software, scenarios, and tests.

To check the level of acquired/improved competencies.

Competency-based business games are expediently developed within the framework of an appropriate information learning system (ILS), which can be described as:

$$G_{ILS} = \langle Cl, Es \rangle, \quad (7)$$

where  $Cl$  is a set of fragments of learning content;  $Es$  is a set of elements related to the information system (hardware, software, and information support, training script, etc.).

Competence  $k_i^P$  can be successfully obtained if the corresponding business game adequately expresses the concepts of the subject area.

For this purpose, the subject area should be described with the help of the appropriate ontology.

The ontology of the subject area can be represented as [2, 17]:

$$O = \langle D, R_s, F_I \rangle, \quad (8)$$

where  $D$  is the set of terms for the subject area of the training course;  $R_s$  is a set of semantically significant relations between the elements of the set  $D$ ;  $F_I$  is a set of interpretation functions.

An ontology is a set of concepts used by developers (experts) to create models of the learning process and relationships between its components.

The ontology allows the reuse of the same concepts to define different processes. Moreover, it is possible to integrate several ontologies (within the framework of meta-ontology), thereby describing parts of a larger subject area.

The use of ontologies makes it possible to separate knowledge of the subject area from operational knowledge.

Ontology development involves: the definition of ontology classes, hierarchical organization of classes, definition of attributes (properties) and description of the values of these attributes, and filling in the attributes of an instance (in the terminology of ontologies—of an individual).

If the problem is presented in terms of the result  $R$ , given data and known  $D_i$ , the solution method  $M$ :

$$Z = \langle R, D_i, M \rangle, \quad (9)$$

then the ontology should include all alternative ways of presenting [18]: results, data, decision methods, obtaining data, storing data etc.

Such information should be organized in structures that allow using the ontology.

This concerns both  $Ok$  (organizational component) and  $Tk$  (technical component).

The implementation of the  $Tk$  component creates several problems, such as the problem of presenting the student's activity and the problem of managing the activity by the logic of the subject area, which serves the purpose of developing a given level of competence.

The solution to these problems is closely related to the division of the model of the  $G_{ILS}$  information learning system into submodels:

- The first submodel is built taking into account the scenario, the graph of the unified process of learning and its management, as well as the ontology of the subject area.
- The second submodel uses the unified management process graph and the ontology of the subject area.

The main goal of the information training system is the formation of a given level of competence  $k_i^p$  in the learner (student).

To achieve this goal, the student interacts with the  $Tk$  component, which includes: both submodels, the testing system, and the competency matrix.

The student uses many fragments of learning content  $Cl$ .

The testing system includes: means and methods of building testing resources, Information about the formed competencies, and the ontology of the subject area.

During the game, part of the testing system is used to assess the level of the formed competence.

This part includes test resources, which are pre-loaded into the ontological model of the subject area of the information learning system.

## 6.5. Gamification resources in education

Each teacher and each student can choose the methods of work in the learning process.

When choosing gamification, subjects of the learning process can be involved in the education/training/learning/teaching process of acquiring knowledge, developing skills, and professional qualities at the level of innovative solutions.

An important aspect of gamification is building appropriate strategies and tactics for behavior with students.

The use of gamification in the education/training/learning/teaching process (game mechanics, plot, and scenario of the game) causes motivation and involvement, and changes in student behavior.

The introduction of gamification into the learning process will be effective if, in particular, uses the internal and external motivation of students, regulation of student behavior, and inclusion of a system of various gaming practices in the learning process.

The features of gamification of education/training/learning/teaching processes, in particular, are as follows, Gamification should be part of the learning information space to show its specificity and possible methods/directions of development, the gamification system should have unifying components (plot, narrative), the presence of a system of relationships that emphasize constructive connections between the subjects of educational activity, stimulating the development of systems for assessing students' competencies, the presence of various incentives in the gamification system, the presence of an algorithm for achieving the goal (taking into account the increase in the level of the game), emotional features of interaction: students among themselves, for example, when completing joint projects/completing group assignments, the student (group of students) and the teacher, and the student/teacher and an information training system (information learning system).

Gamification as a process of using game elements and game processes in a non-game context is considered in [19, 20].

The idea of the game is considered the "Pyramid of Elements" and includes three categories of game design elements: dynamics, mechanics, and components.

Dynamics in an information training system with elements of gamification and occupies a conceptual level, since it includes: game scenarios, constraints, emotions, narrative, progress, and relationships.

Mechanics are a set of rules by which the system operates and moves forward. Mechanics include: challenges, chances, competition, cooperation, feedback, resource acquisition, and rewards.

The basic level of gamification consists of components that include: achievements, avatars, badges, collections, content unlocks, gifts, leaderboards, levels, points, virtual goods, etc.

If points are used in the context of gamification, they create a sense of movement, and progress (dynamics) and provide a reward (mechanics).

To determine the strengths of the gamification system, one can imagine a model of changing the behavior of groups of people in a game, which is described in [20, 21].

The components of the behavior change model in gamification conditions use a variety of techniques that stimulate the game activity of students.

Gamification itself in this case will contribute to the formation of new skills, abilities, and habits of the player (student) which can be used in real activities. Gamification includes: game patterns and principles, methods and techniques, technologies, and techniques and mechanics that are used to manage the motivation and behavior of subjects of educational activities [22].

The 6D concept (6 steps to gamification) [1, 19] allows for the gradual introduction of gamification into the learning process:

1. *Formulating gamification goals.* For this, you can use the SMART technology, which emphasizes the rules for defining goals: specificity, measurability, achievability, relevance, and time limitation.
2. *Determining the type of activity* of students and their target behavior (what activity brings game participants closer to achieving their goals, how to measure the activity of students, what indicators to use).

Description of players: their characteristics, roles, expectations, attitude to traditions, and innovations.

An accurate description will allow you to select interesting content, the optimal structure of the game, and the principles of interaction.

3. *Developing activity cycles.* At the micro level, chains are created  
"motivation to act → act → feedback"

The activity becomes more complex as the activity improves.

"Player's journey" occurs at the macro level. In this case, we are talking about a fascinating story, which is the basis of the gamification system.

4. *Determining the level of interest for participants*, the possibility of relying on internal motivation, and using game resources for entertainment.

*Finding appropriate tools*: discovery of new content, collecting, points, social interaction, quests, and virtual goods, etc. for the operation of the gaming system.

The resources of the gamification system should be used to the fullest to involve students in educational activities in much the same way as they are involved in a computer game and improve their skills and abilities, which can be transferred to the real process.

## 6.6. Gamification practice in education

Using gamification in the learning process: requires a lot of work related to the preparation of game elements and techniques for organizing students' educational activities and allows you to organize, evaluate, and encourage current student success, introduce game elements into the learning process, and maintain the spirit and atmosphere of healthy competition.

Learning work organized in this way allows you to increase the cognitive activity of students, develops motivation, stimulates successful work, and directs the activities of students to achieve higher results.

The use of game elements and mechanics in education/training/learning/teaching processes allows the teacher to make the learning process more dynamic and interesting for students, monitor students' learning progress using tools embedded in-game mechanics, organize students' independent work in the format of group and joint activities in an electronic environment, develop students' skills in cooperation and teamwork, and form and maintain comfortable and trusting relationships between participants in the learning process [19].

In modern conditions, gamification is most clearly expressed in the process of using information learning systems. Gamification is increasingly being used in the education/training/learning/teaching processes. Electronic resources used in the educational process: Bubbl.us, Quizlet, Learnis, Zunal, Quizizz, Genially, etc. Gamification in professional education is used as the process in which significant characteristics of future activities are presented.

These characteristics allow one to understand the specifics of professional actions and prospects, which can be very meaningful, since students: develop personal experience in a gaming educational environment (mental processes: thinking, imagination, and speech are actively stimulated, which contributes to the vision of both the holistic learning process and its parts, in particular, gaming components) and the team spirit of participants in gaming activities is developed.

Problems of introducing gamification into the learning process: use of external motivation of students in gaming activities: points, badges, icons, and awards, instead of developing internal motivation, increase in the workload of both teachers and students in preparation for gaming activities, development and implementation of a new model of "teacher-student" relationships, the possibility of developing psychological dependence on computer games, lack of well-thought-out technical support, etc.

Gamification is the process of using game elements and game creation technologies in a non-game context. We are talking about:

- Game components—points, icons, avatars, levels, ratings, awards, missions, etc.
- Game creation technologies (game design)—the process of organizing game components using the practical skills of a game designer.
- Non-game context—professional activities, the goals of which are in the education/training/learning/teaching process, that is, outside the game (for example, fragments of learning content).

Gamification includes such resources as the initially used creativity, the involvement of students in the game, the education/training/learning/teaching process, an emotional atmosphere, improvisation, the opportunity to communicate with partners, and, at the same time, the spirit of competition, voluntary participation, etc.

Of particular value when using gamification is the accuracy of the formulation of goals, the definition of rules in game situations, the feedback system, the presence of clear instructions, etc.

## Conclusions

Gamification is one of the components of the ideology of modern education, based on the values of collaboration and innovation, which are among the main goals of “playing reality”.

When using gamification in education (in each specific implementation of the gamification project), it is necessary to look for opportunities to go beyond standard teaching methods and alternatives to achieve the set learning goals as effectively and optimally as possible (taking into account the individualization and structuring of both the learning content and the gamification elements used).

Gamification processes must be fully controlled. Their use should be dosed. Gamification should not be an end in itself, but only the method and way of improving the education/training/learning/teaching process. Games activate and cultivate emotional intelligence and a sense of empathy in students.

The introduction of gamification into the education system ensures: stimulating students' desire to join professional knowledge and skills for using them in a creative format, taking into account the interests of the subjects of the learning process, studying the characteristics of the so-called “digital natives” to define a new educational paradigm, develop students' cognitive and professional interests, learn to make original professional decisions, master communicative, adaptive, creative practices in education, look for meaning in solving everyday problems, etc.

The use of gamification resources demonstrates its advantages such as high-quality work with information, taking into account the interests of students, which ensures the effectiveness of acquiring knowledge, and skills, and developing competence.

The universality of gaming activities, which are used for different age groups, for most areas of personnel education/training/learning/teaching.

## Declaration on Generative AI

While preparing this work, the authors used the AI programs Grammarly Pro to correct text grammar and Strike Plagiarism to search for possible plagiarism. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the publication's content.

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