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RESEARCH ARTICLE

The Impact of Digital Technology Development on Learning

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ABSTRACT

The paper substantiates the relevance of a game design-oriented approach to developing academic courses at universities. The study notes that the game design-oriented approach has to change the view on planning, carrying out, and controlling the learning process. This, in turn, creates the effect of full presence both on the part of the teacher as the game designer and the student experiencing the role of a player. A phased methodology for the development of a game design-oriented course is proposed. The relevance of the topic is confirmed by the results of a study of students taking an academic course designed with the game design-oriented approach and studying it the traditional way. The experiment involved 91 students. The pedagogical experiment revealed that students who took the course designed with the game design-oriented approach had higher academic performance compared to those who studied the traditional course. The article concluded that the elements of the game design-oriented approach not only increased motivation, engagement, and interest in learning and enhanced the positive effects of studying the discipline, but also drastically changed the ideology of learning and its structure. Teachers can capitalize on game design as an effective foundation to update courses and find and eliminate their shortcomings.

INTRODUCTION

Today, the technical ease of generating information and the easy and ubiquitous access to it lead to a reassessment of the essence of knowledge as a superdynamic system and the main value in the information economy, as well as to a revision of the content of education and teaching methods. The current level of informatization of education and the emergence of an informational lifestyle make it possible to continuously and systematically introduce new teaching methods in the Internet environment. This has given rise to extensive discussions of the various aspects of online learning and a search for the most effective and flexible teaching methods. Among other things, such discussions touch upon the introduction of computer games and the project-oriented approach into the educational process to optimize the process of achieving educational goals (Nah et al., 2014).

The main problem in the transformation of education in the context of informatization and gamification lies in overcoming a number of established views on the role of games per se and computer games in particular in learning, as well as on the importance of the cyber environment as an educational space. Fundamental to our research is the scientific definition of the game as a way of satisfying desires and a form of activity aimed at reproducing and assimilating social experience in all its forms: knowledge, skills, abilities, and emotional assessment activities (Maraffi et al., 2017).

The second problem is the challenge of introducing cyber technologies into the academic learning system. This challenge consists in the time required for the teacher to develop electronic courses (e.g.,

filling the Moodle system with educational content) and the lack of necessary skills, as few teachers know the art of speaking in front of a camera and conducting webinars or developing educational video games. Furthermore, traditional educational systems (school, college, and university) currently lack the technical and organizational platform to develop this important area of learning. Oftentimes, there is also scientific criticism of computer-mediated training and reservations against the passion for virtual communication and training (Hamari et al., 2014).

However, the process of informatization is irreversible and exponential, as it not only dramatically changes the forms of informational interaction but offers a new ideology of life and knowledge of the world. For example, remote forms of knowledge acquisition mediated by Internet technologies (e-learning, webinars, questinars, video lectures, educational video games, etc.) can be widely implemented in the traditional educational system within the framework of the concepts:

- inverted learning (Bergmann, Sams, 2008) — a pedagogical model in which a typical lecture and elements of independent work or homework have changed places;

- in-depth learning as a set of interrelated competencies (Mthethwa-Kunene et al., 2022): learning to think critically and solve problems, autonomous learning, learning from mistakes, collaboration, effective communication, developing academic thinking, learning through the application of new knowledge in real situations (industrial practice, cases, simulation games, role-playing games, life situations). The above competencies became a basis for the latest directions of teaching methodologies.

The third problem has to do with the prejudice against computer games and their appropriateness in the educational process. There have been a variety of outlooks on video games: purely children's entertainment, a threat of addiction and cruelty, and a social norm today. Video games serve as tools in following healthy lifestyles, e-sports, business, and education. Computer-mediated gamified learning as a synthetic learning environment (Bouras et al., 2005) has been recognized as an important alternative or adjunct to traditional classroom learning (Kiili, 2005).

The substantiation of the role of computer games as tutors (Dondlinger, 2007) promoted the recognition of the value of digital video games and their individual principles in the learning process. Thus formed a new direction in the development of educational technologies — game-based learning (GBL), or training based on the principles of computer games, a kind of game that drives the results of learning (Kucher, 2021; Papastergiou, 2009).

It is the emphasis on computer games that distinguishes GBL from traditional pedagogical and psychological theories of educational entertainment. Whereas traditional educational techniques teach to observe how a certain specialty works, GBL teaches to be specialists in real time (Bal, 2019). In the traditional system, the results of learning are distanced in time, that is, are achieved and tested in an indefinite future. In contrast, under GBL, the results of learning are apparent in the here and now. GBL combines the process of researching the subject with the gamified real-life application of the obtained knowledge (Perignat, Katz-Buonincontro, 2019). Importantly, GBL presents an integrated worldview and methodological system of "action-experience-knowledge" and thus cannot be reduced to the introduction of individual game elements in learning, such as puzzles, crosswords, riddles, outdoor games, etc. (Alaswad, Nadolny, 2015). Here lies the difference between GBL and gamification, the latter being essentially a marketing technique of stimulating consumer activity by introducing game elements and mechanics (bonuses, ratings, competitions, win-win lottery, visualizations of success) into a non-gaming context (business, trade, banking, personnel management, etc.) (Deterding et al., 2011).

At the same time, the GBL system has become associated with the process of introducing computer games into training. Researchers are convinced that GBL should not be interpreted as an imperative to turn learning into a game entirely. On the contrary, the balance of play and non-play must be preserved (Ismail, Rabu, 2018). If the teacher does not use video games in training, they should at least apply their fundamental principles to build the competencies necessary for future specialists and simply successful people — the so-called "heavy skills, soft skills, and engagement." In this way, it is expedient for the methodology of developing academic courses to make use of the practices of game design.

Overall, our literature analysis suggests that the topic under study combines the scientific developments of methodological support for disciplines in the framework of GBL (Setyaningrum et al., 2018; Sung, Hwang, 2013), the issues of gamification of learning (Deterding et al., 2011; Johns et al., 2018), and the theory and practice of game design (Andaló et al., 2017; Ibrahim, Jaafar, 2009). Scientists draw attention to the problem of synergy between pedagogy and GBL (Gilliam et al., 2016), the integration of educational theory and aspects of game design, and the development of a game model based on the theory of experiential learning and game design (Akcaoglu, 2014). The experience of introducing digital games into the practice of secondary (An, 2016) and higher education (Roungas, 2016) has also been investigated. Researchers have analyzed requirements for the development of educational games in online education and proposed a general method of game design considering the specifics of adaptation and assessment (Malliarakis et al., 2014). Burgers et al. (2015) have proposed a model of educational games that is described as an internal connection between motivation, an effective learning environment, and an educational game. Within this interconnection, only certain elements of gamification were highlighted as motivating learning mechanisms: leaderboards, insignia, and level and experience bonuses. Game mechanics and dynamics are associated by the authors not with a system of rules but with elements of student motivation and engagement.

The topic of gamification in education is one of the most actively discussed in pedagogical science. However, research has not yet addressed the issues of applying the principles, models, and elements of game design in developing academic courses for higher education institutions (universities) and the peculiarities of educational and methodological support and teaching in the context of gamification of learning. There is no experimental justification for the advisability of borrowing game design elements in the process of developing university disciplines.

The goal of the present study was to justify the feasibility of the game design-oriented approach to the development of educational courses in higher education institutions, which in the future will become the basis for the introduction of virtual educational entertainment environments. From this goal stem the following research objectives: to describe the structural model of a gamified course, to determine the stages and features of introducing game design elements into the methodology of higher education, and to experimentally confirm the effectiveness of the game design-oriented approach to the development and teaching of academic courses.

Research hypothesis: as a result of the development and implementation of a game-oriented academic course in the educational process, academic performance significantly increased.

METHODS

To achieve the research goal, the study employed a set of theoretical and empirical methods. The theoretical methods included analysis, the summary of the current state of the research problem, and the generalization of theoretical approaches to the main concepts.

The primary empirical research method was a pedagogical experiment, which was conducted during the second semester of the 2023-2024 academic year. Experimental and control groups (EG and CG) were formed from existing academic groups.

In total, the pedagogical experiment involved 91 students of 3 years of study. The EG and CG were formed from existing academic groups. EG students studied the course designed via the game design-oriented approach. CG students studied the course following traditional methodology.

The experiment is carried out in several stages (Table 1).

Table 1: Stages of the pedagogical experiment

Stage	Stage content
Preparatory	Determining the relevance, goal, objectives, object, and subject of the experiment
Organizational	Preparing methodological tools for the experiment, selecting participants
Practical	Developing a game design-oriented course and introducing it in the learning process
Summarizing	Testing the results (determining the dynamics of students' academic performance)

The literature review has demonstrated that the game-oriented approach to the development and teaching of academic disciplines has to change the understanding of the planning, implementation, and control of the learning process. A prerequisite for this is a state of immersion and the effect of full

presence, both on the part of the teacher-methodologist as the game designer (constructing the game reality of the course) and on the part of the student as the player gaining experience (skills and knowledge) in the educational environment of the game (or in the educational game world). In this process, it is important to balance learning and entertainment so as to ensure that the process of mastering the course does not turn into a game but acquires its important features (Table 2).

Table 2: Game design as a basis for teaching methodology

Game design	Teaching methods (teacher)	Learning process (student)
Game rules	Learning and assessment criteria	Limitations and rewards
Game world	Educational content	Academic and instructional communication
Game levels	Dynamics of learning	Learning progress
Game balance	Critical thinking	Balance of learning and recreation, effort and reward.
Entertainment	Hedonic function of learning: the joy of knowledge, pleasure, entertainment, and challenge.	

Proceeding from the analysis of scientific literature, the game design of an academic course can be presented as a complex system with a number of subsystems (Table 3).

Table 3: Game design of an academic course as a system

Game design course subsystems	System content	Game motives	Game genre	Educational methodology components
Subsystem satisfying the need for information	The connection between educational and game content	Solving riddles, communicating with others, heroic reincarnations, travel, learning	Quest, quiz, adventure, role-playing, logic games	Lectures
Subsystem satisfying the need for action	Practical learning tasks and game missions	Collecting artifacts, dodging dangers, destroying objects, competing, racing	Platformer, stealth, fighting, racing	Practical and laboratory classes
Subsystem satisfying the need for control	Instructional influence and motivation (student management)	Creating objects, indirect control, coordination of participants' interaction, planning actions	Strategy: economic, military, board games	Motivation, engagement, progress maps, leadership tables

The methodology for developing a game design-oriented course contains several stages (Table 4).

Table 4: Development methodology for a game design-oriented course

Stage	Stage title	Stage content
1	Formalization of course structure	The course is formalized by creating its structural model in accordance with the peculiarities of regulatory documents such as the MEP and the curriculum, as well as the needs and interests of students as future specialists and the demands of employers. The above shape the basis of course competencies, which guide the development of the rules of for the gamified course
2	Formalization of organizational requirements	The organizational requirements of the discipline are formalized to be used as the basis of game rules, i.e., the requirements and conditions for successfully finishing the course. The results create a motivation system and are visualized on the student progress map
3	Gamification of course structure	The structural model of the course is gamified and transformed into a game world
4	Formalization of content requirements	A set of requirements and criteria is formed to assess knowledge, skills, and abilities as part of the course. The source of this formalization is the set of competencies defined at the first stage. The outcome is a base of game rules as the specific interactions with educational materials required of students to achieve the main goal, i.e., master the required competencies and pass the final test or exam. The game rules complement the progress map, the outline of the game world of the course. To demonstrate the dynamics of the gamified course and its development, the rules shape the outline of the game levels

5	Formalization of course content	Course content is formalized by creating databases of theoretical materials and practical tasks
6	Gamification of course content	Involves creating a base of game scenarios. The outcome of this stage is a collection of stories and legends for the game. At the same time, the game rules are metaphorized in accordance with the plot and scenario of the gamified course
7	Prototyping	Allows for the creation of a prototype, partially using the tools of basic game design. However, it is possible to use game prototype constructors, which have their own software and visual limitations

Academic performance in the course was determined by the results of exams for the previous and current semesters based on the criteria of absolute and qualitative academic performance, where:

- absolute academic performance, or performance % = (number of "Excellent" + number of "Good" + number of "Satisfactory") x 100%/ (total number of students);

- qualitative academic performance, or knowledge quality % = (number of "Excellent" + number of "Good") x 100%/(total number of students).

Subsequently, the results of the pedagogical experiment were processed using mathematical statistics. The objective was to identify differences in the distribution of a particular characteristic (learning success) when comparing two empirical distributions. For this, Pearson's $\chi 2$ test was employed. The measurement scale had two categories ("success" and "fail"); hence, the number of degrees of freedom was $v = 1$.

Null hypothesis H0: There are no differences in academic performance between the CG and EG.

Alternative hypothesis H1: There are significant differences in academic performance between the CG and EG.

RESULTS

Before implementing the proposed assessment system, the academic performance of the EG and CG over the previous semester was analyzed. As a result, the two groups were found to have almost identical performance (72% and 74%, respectively). After the completion of the pedagogical experiment, the overall level of knowledge quality in the EG and CG, according to the final test, was 85% and 77%, respectively (Table 5).

Table 5: Comparative analysis of CG and EG academic performance

Group	**Number of students**	**Academic performance, %**			
		Absolute academic performance, %		**Qualitative academic performance, %**	
		Previous semester	Current semester	Previous semester	Current semester
CG	46	71.5%	74.6%	64.2%	65.4%
EG	45	72.7%	86.3%	62.5%	78.2%

As can be seen in Table 5, pedagogical effect in terms of absolute academic performance amounts to 13.6% in the EG versus 3.1% in the CG. Pedagogical effect in qualitative academic performance is 15.7% in the EG against 1.2% in the CG. These results prove the pedagogical effectiveness of the game design-oriented approach to academic course design.

From the table of $\chi 2$ values for the significance level of $\alpha = 0.05$ and the number of degrees of freedom $v = 1$, the critical value of the statistic is $\chi 2_{crit} = 3.841$. Considering learning outcomes prior to the pedagogical experiment, the value calculated for absolute academic performance is $\chi 2_{emp} < \chi 2_{crit}$ ($1.876 < 3.841$) and the value for qualitative performance is $\chi 2_{emo} < \chi 2_{crit}$ ($1.952 < 3.841$). Thus, at the beginning of the experiment, the CG and EG did not differ significantly in the two criteria.

Calculations of $\chi 2$ for the CG and EG after the pedagogical experiment reveal that for absolute academic performance $\chi 2_{emp} > \chi 2_{crit}$ ($19.472 > 3.841$) and for qualitative academic performance $\chi 2_{emp} > \chi 2_{crit}$ ($22.518 > 3.841$).

These results give grounds to reject the null hypothesis H0. Accepting the alternative hypothesis H1, we can assert that the samples have statistically significant differences.

DISCUSSION

Given that EG students studied the academic course designed under the game design-oriented approach, it can be argued that this was what contributed to their higher results. Thus, the hypothesis put forward can be considered experimentally confirmed.

It is worth noting that the introduction of game design elements into the structural model of the discipline can be viewed as a process of convergence of different branches of pedagogy, in particular, teaching methods and game design.

The components of the training method include the forms of organization of training (training sessions, practical training, independent work, control measures), types of training (lectures, seminars, practical, individual, and laboratory classes, consultations, educational and industrial practice), teaching methods and techniques, and educational and methodological support (curriculum of disciplines, lecture notes, methodological instructions for laboratory work, practical and seminar classes, and students' exam preparation; the completion of reports, course and final papers, and projects; versions of exams and modular tests, teaching aids, etc.). Together, all these elements constitute a multi-level complex system, the elements of which must be connected both in content and organizationally. However, there is still no comprehensive software tool that would both visualize the methodology and instantly cover this entire significant methodological conglomerate, identify shortcomings in it, optimize it, and evaluate the effects both from the point of view of the teacher-developer and the student as a user.

The set task is solved by introducing into the practice of teaching such principles of game design as: a focus on the student-user, visualizing and detailing the goal, designing the game world as an educational space, managing the student through a motivation system (instead of rules, i.e., the organizational and educational requirements for the course), selecting educational content, continuously providing feedback, offering alternative learning routes, encapsulating experience, mapping knowledge, introducing entertainment elements, and balancing the system.

When developing a course (preparing a working program and curriculum, lecture notes, guides for practical classes, etc.), the teacher usually focuses on the requirements of the standard of higher education (if any), the vocational education program, as well as the accumulated theoretical and practical knowledge of the discipline and the experience of teaching it in other higher education institutions. Game design methodology should primarily focus on end users — the student as a future specialist and employers who create demand in the labor market (which is aided, in particular, by the development of professional qualification standards). It is the interests and needs of these actors that need to be considered when developing the content of the discipline and highlighting educational issues.

Therefore, the modern model of an academic discipline should consist of two components. The fundamental component (internal, "background"), aligning with educational standards and norms, embodies the vision of the teacher-developer. On the other hand, the user component (external, close to the concept of "interface") embodies the student-user's vision of the structure, course, and features of the discipline.

There can be different combinations of the elements of learning and play in a method based on game design:

1) learning before play, where the game serves the funciton of knowledge testing (certain educational material has to be mastered to complete the game and its levels);

2) play before learning, where the game motivates to study;

3) play during learning:

- the game as entertainment in learning reduces psychological stress when acquiring new knowledge;

- the game as research allows the student to act as a game designer; the student independently creates games on a specific educational topic, exploring it as a system, learning the content, and developing problem-solving skills (Andaló et al., 2017);

4) the game as a tutor and structure of learning ("tacit game-learning") — the discipline is designed according to the principles and techniques of game design, but does not turn into pure entertainment. While games as elements of learning are palpable and recognizable (the student realizes they are playing an educational game), a game design technique becomes an internal property of learning, in which game components dissolve within the system of the academic course and are not immediately apparent to students.

CONCLUSIONS

The development of a course with the principles and methods of game design stands at the intersection of various branches of knowledge and seeks to create a synergy of teaching methods, game cyberculture, project activities, and marketing. The introduction of game design principles (user-orientedness, visualization and detailing of the goal, continuous and systemic feedback, alternative learning routes, encapsulation of experience, knowledge mapping, motivation management, balancing, and entertainment elements) opens up new opportunities for the implementation of the integrativeness, interdisciplinarity, intersectorality, personalization, and humanization of learning. This approach not only increases motivation, engagement, and interest in learning and enhances the positive effects of studying the discipline, but also dramatically changes the ideology of learning, its structure, and behavior as a system.

The elements of the game design-oriented approach help create the conditions for immersion in the world of the academic subject, for its intensive study and design. For teachers, game design can become an effective basis for updating the course and finding and eliminating its shortcomings (e.g., the inefficiency of report and homework assignments, lack of inter-thematic and inter-subject connections, outdated educational content, etc.). Game design of academic courses is the first step towards creating an electronic educational gaming environment for the university.

From the perspective of this topic, it is promising to investigate the structural model for the implementation of game design elements at all levels of education, provide scientific justification for and create consolidating virtual game environments and design and implement them at all levels of education, and explore the paradigms of lifelong learning and advanced learning. It is expedient to research the possibilities of gamification of humanitarian and technical disciplines and disciplines of different professional profiles and to create detailed descriptions of the relational database structures formed in the process of applying game design components. The issues of adaptive game design in the educational system and the possibilities of introducing augmented reality elements into educational entertainment are also promising.

Prospects for further research in game design-oriented learning include the development of guidelines for teachers at higher education institutions, the creation of training modules for the gamification of education in the framework of academic disciplines, and the creation of game prototypes for educational disciplines.

The limitations of the study include the size and age composition of the participants in the pedagogical experiment.

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