Learning space conceptual model for computing games developers

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Abstract—**The article is devoted to the construction of learning space conceptual model for preparation of GameHub computer game developers in higher education institutions. The concept consists of three main components: a methodological or pedagogical component, a technological component, an information component. The article describes processes scheme for developing of learning space infrastructure and reflects the interactions between GameHub participants. The article presents an example of such a scheme for magistracy students, bachelor's degree students and free listeners from one of the Ukrainian universities. An approach to the student knowledge diagnosis is described on the basis of writing and testing analysis. Highlighted results in this paper are useful as a guide for step-by-step organization and for supporting the functioning of game educational hubs in higher education institutions. The described concept includes basic tools that are necessary for effective student training organizing on the principles of computer game development. Learning space conceptual model can serve as foundation for the formation of professionals training implementation roadmap in gaming industry. The concept is proposed for implementation by universities and private IT companies interested in Serious Games industry development.**

Keywords—Learning Space, Game Development, GameHub.

I. INTRODUCTION

The state of gaming industry development in the world is characterized by perspectivity and dynamism for many, especially international, companies that are engaged in the development of gaming applications on various operating systems [1]. The most important trends that are currently being observed on the market [2]:

• Widespread use of gaming principles, that is, the use of game techniques in non-gaming tasks solving (for studying, corporate culture supporting, quality of work performance assessing, conducting interviews and assessing motivation.

• The development of indie genre games, which are usually created by independent developers. The rapid development of this kind of games is associated with the affordability and effectiveness of their monetization through Steam, AppStore, Google Play.

• The emergence of the growth effect of developer profits despite the cost of gaming.

• Unification of engines for computer games development and creation of effective mechanisms for their monetization.

• Creation of educational games in which graphic and sound effects, as well as game scenario, assimilates the theoretical aspects and practical skills of pupils and students from certain disciplines [3–7]. A separate focus is the creation of mobile training application that does not require separate installation and is supported on various mobile devices [8]. In [9], criteria for choosing online games are considered.

Analysis results of Ukrainian gaming industry state shows that the industry is characterized by promising, thanks to a satisfactory level of education in this direction and relatively inexpensive labor force. The average wage per month of a programmer and developer of gaming applications over the past few years has increased from $ 500 to $ 2,000 [10]. The obtained results testify to the significant potential of the gaming industry in Ukraine. The Ukrainian IT industry has proven its efficiency and ability to create and promote high-quality products in the last decade. Difficulties in this direction, which are tracked on the IT market today – it is not enough accredited specialties and specializations, which are aimed at preparing of gaming applications developers, specialists in the work with sound, graphics, scriptwriters, etc. Many universities in Ukraine has lack of necessary specific software and hardware, and laboratories to train specialists of this level, there are no developed curricula and work programs of disciplines related to the development of competences and skills for work in gaming companies. The needs of IT market

in EU and Ukraine are forcing entrepreneurship and universities to cooperate with a view to overcoming these difficulties on a mutually beneficial basis. Development of gaming industry in Ukraine is not a local interest of gaming companies and independent developers, the benefits of game development industry growth can be successfully used by managers of different sectors, marketers, trainers, etc.

Since October, 2015 the work on the International project "GameHub: Cooperation of universities-enterprises in gaming industry in Ukraine" is underway. (Capacity Building in Higher Education 56128-EPP-1-2015-1-ES-EPPKA2-CBHE-JP), which is being implemented through Erasmus + KA2 projects for innovation and exchange of best practices [11, 12]. The project is being implemented by a consortium: University of Deusto (Bilbao), AGH University of Science and Technology (Krakow), FH Joanneum (University of Applied Sciences in Graz), Quality Austria (Vienna), Fundacion Virtualware Labs (Bilbao), Fundacion of Deusto, Donetsk National Technical University (DonNTU) (Pokrovsk), Vasyl Stefanyk Precarpathian National University (PNU) (Ivano-Frankivsk), Kherson National Technical University (KhNTU), Kyiv National University of Construction and Architecture (KNUCA), Kharkiv Polytechnic Institute (NTU "KhPI"), Odessa National Polytechnic University (ONPU), Ukrainian Association of Information Technology Professionals (UAITP) (Kyiv). This international project is aimed at the creation of the so-called GameHub infrastructure in Ukrainian universities (project partners), which will enable interested people to learn, improve the skills and competences that are necessary for the gaming industry. The project is aimed at the creation of tools, methods and organization of training students, ATO (Antiterrorist operation) veterans, unemployed engineers in the competences and skills for creating computer games. The main tasks of the project are [13, 14]: developing a map of competencies that can determine a professional profile in the gaming industry, as well as developing tools for monitoring proficiency profiles; training of staff in higher education institutions (more than 180 teachers and scientists from Ukrainian universities are involved in the project) and training selected target groups of students, ATO veterans and unemployed engineers (500 students and 150 unemployed (including ATO veterans)); development of more than 18 training modules; realization of long-term cooperation between Ukrainian universities and IT companies, ATO veterans' organizations, regional employment centers; increasing the relevance of universities curricula and their orientation to the labor market.

To accomplish the tasks it is important to build such an infrastructure of the learning space, which would ensure effective interaction between all participants in the educational process. Under the infrastructure of educational facilities is understood the complex of organizational systems, networks and processes, software and hardware, human resources, which provides a long-term operation of the learning space. Such learning space may include specific components, depending on the purpose of its construction. The paper considers the infrastructure of the learning space, which is intended for the training of specialists in the development of computer games (designers, game programmers, sound engineers, etc.). Nevertheless, due to its relevance, the study proposed in this paper is useful and will serve as a fertile map for the introduction of similar infrastructures or conceptual models in other higher educational institutions both in Ukraine and abroad.

The research purposes are creating a conceptual model and describing the educational infrastructure components of computer game developers training; creating a scheme for interactions and allocation of authority in this infrastructure, consideration of knowledge diagnostics characteristics of those who learn, on the basis of analysis of written work and test results.

II. THE PRIMARY RESEARCH MATHERIALS

The GameHub learning space is a collection of three main components:

1. Pedagogical component, which includes the methodology of students and other listeners training to create gaming applications in accordance with the developed training modules.

2. Technological component, which includes creation and maintenance of GameLab educational game laboratory work.

3. Information component, which consists in information links providing between such main links of GameHub participants: trainers on the one hand and students on the other; leadership of universities on the one hand and representatives of the gaming industry, employers, employment center, etc.; scientists and the scientific community. In addition, this component takes into account communications of technician, system administrator and laboratory assistant to provide technical support and operation of the gaming laboratory.

The process of GameHub learning space organizing includes (see Fig.1):

• Analysis conducting of the gaming industry.

• Assessment of students 'and teachers' knowledge and skills in the university.

• Formation of teams for the GameHub implementation concepts in the university.

• Providing communication between teams of participants, as well as maintaining links on the lines of the teacher - student, management and administrative staff of the university - representatives of industry, employers, employment fund, scientists - the scientific community. Communication can be done using information resources (portal, forum, etc.).

• Creation and maintenance of GameLab Training Game Laboratory at the University, which includes organizing of hardware and software purchases, staff for maintenance and support recruiting, equipment and testing launching, installing and testing of software that is required for professionals in the gaming industry.

- Development of curricula and work programs for the training of specialists. Training can be provided on relevant training platforms, such as Moodle.

Each university that implements an educational hub can have its own vision of the concept of learning space organizing, but the basic provisions in the concept have to be taken into account. These include the following [15]:

- Descriptive part, which includes an overview of the relevance, utility, principles, goals, outcomes and risks of a regional or university GameHub.

- Technological component of GameHub. Description of the goals, results, principles of the training game laboratory,

inventories of material resources, equipment and software of the gaming laboratory, as well as technical personnel, which will ensure the establishment and maintenance of the laboratory, for example, the laboratory assistant, the system administrator (technician), etc.

- The GameHub's pedagogical, academic and methodological component that includes the description of the target groups involved in the training, tools and teaching methods, types of training with a list of training modules and positions (teacher, trainer, researcher).

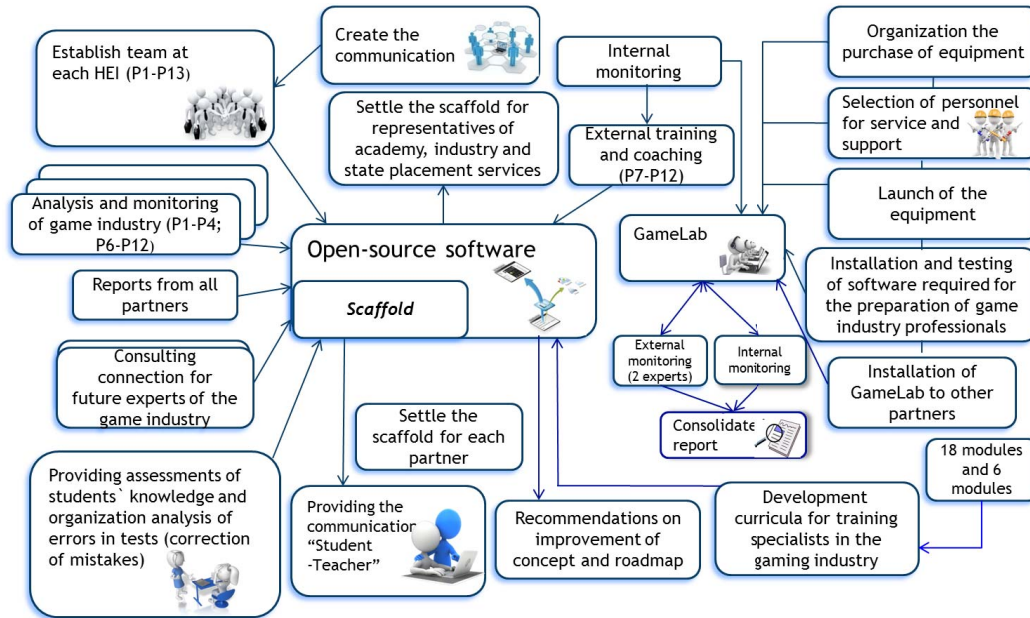- Administrative and management component.

Fig. 1. The Conceptual Model of the GameHub Learning Space

To ensure the organization of infrastructure and effective operation of the GameHub learning space in accordance with the concept, the following provisions must be met:

- At the core of teams at universities there is a manager who provides communication with administrative staff, teachers, researchers and technical staff, as well as managers from other universities. His main functions are: internal control and division of tasks in a team; connections ensuring between partners; internal monitoring of tasks.

- Administrative staff provides communication with representatives of the gaming industry, employers, the employment fund to implement the tasks of the learning space and to formulate a road map for the development of the environment in the future. His functions are: signing of agreements and documentary support; internal management and financial control.

- Researchers provide a link to the GameHub environment with the scientific community. Their functions are: internal monitoring and discussion on the GameHub tasks implementation; GameHub results dissemination at national

and international levels, using different channels of presentation; organizing conferences, information days, workshops on popularizing GameHub results among academics, stakeholders from the gaming industry, people interested in learning.

- Teachers and trainers develop training modules, plans and programs, as well as directly implement training and knowledge control. According to the concept, communication between the teachers and students is provided, and can be implemented including by means of the educational information resource Moodle, edX, and others.

- Technical staff (system administrator, laboratory assistant) provide support for the installation of equipment, software installation of the educational gaming laboratory (ensure the creation and operation of the laboratory).

The information links between the GameHub participants in accordance with the project GameHub are shown on Fig. 2. To ensure the functioning of the links can be created relevant information resources that serve as information dissemination, as well as informing the public about events occurring on the

basis of the GameHub learning space. A separate module of these resources should be a reference to an educational resource, where interested persons will be able to familiarize themselves with curricula and work programs, to create their own office (such offices should be for each teacher and learner). Also, this resource must provide a mechanism for independent tests conducting and passing the certification exam of the appropriate level. An example of such information resource can be open source software Moodle. Communication between teachers and students in this case can be done by means of personal offices and private messages, as well as by an open forum where general tasks and peculiarities of their realization, etc. can be discussed. The maximum visualization of learning outcomes should also be ensured to stimulate the motivation of those who study.

In addition to the information component, GameHub's learning space also includes a technological component that

involves the implementation of the GameLab Learning Game Laboratory. GameLab is a laboratory that should consist of the most modern gaming software and hardware that is designed to conduct gaming design exercises, work with sound and graphics, game application development and their testing.

The basic principles of organizing the GameLab laboratory should be as follows: openness – the GameLab activity should be open to stakeholders: IT companies, teachers, people interested in learning, gaming industry specialists, etc.; transparency – the GameLab laboratory should be transparent and understandable to the public, should be widely covered in the media; accessibility – the availability of GameLab's gaming laboratory for participation in training, conducting research in the gaming sector for the relevant target groups; utility – the activity of the GameLab laboratory is based on providing maximum profit and return. Utility can be outlined in academic, pedagogical (training) and technological areas.
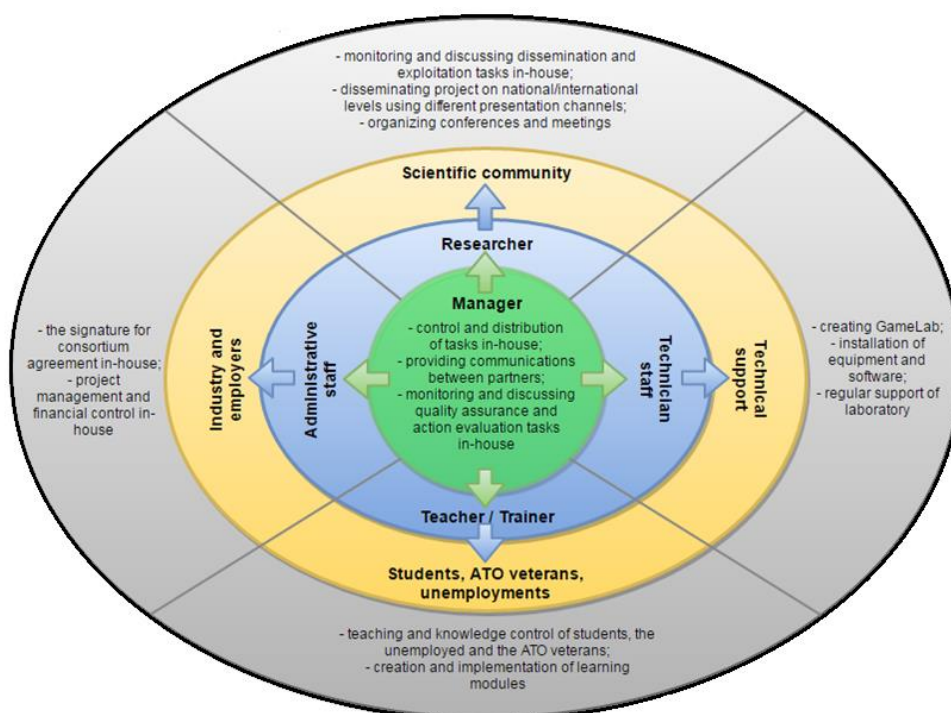

Fig. 2.   Structural model of information interactions between GameHub participants according to the project "GameHub: Cooperation of universities-enterprises in gaming industry in Ukraine" (The model assumes the functioning of a similar structure in each of the universities).

One more integral part of the GameHub learning space is the pedagogical component that involves creating of curricula, work programs and materials for conducting training and evaluating its results. The implementation of this component to a large extent depends not only on state norms, but also on the requirements and traditions of the university that implements this concept. It is also important to take into account the European standards of higher education, which are oriented towards the application of a competent approach to learning, for example Tuning Academy [16]. On Fig. 3. as an example, a diagram of training modules designed to develop computer skills in the KNUCA is depicted. The construction of such schemes for a logical understanding of disciplines modules presentation sequence is an important part of the

successful implementation of the concept pedagogical part of learning space infrastructure organizing for the preparation of computer game developers. No less important is the definition of a model for diagnosing knowledge of course listeners. The result of module passing can be in the form of presentation of group projects, testing and execution of course or individual written work. Group projects, presented by listeners using multimedia, successfully develop students' special, social skills and personal qualities. Evaluation of the results of a group project can be assessed both by course lecturers and directly by the students. Details on methods for evaluation of teachers and scientists in this case are described in the papers [17–19].
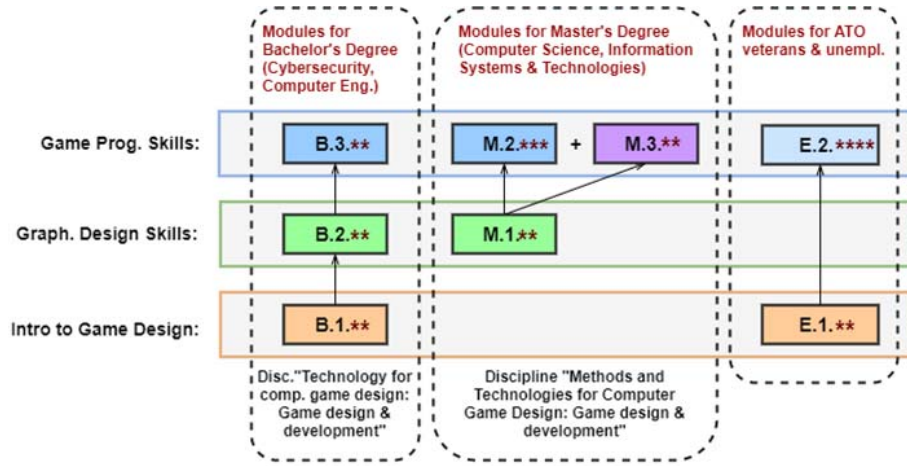
Fig. 3. Scheme of training modules that are designed to develop skills in computer games creation (on the example of Kyiv National University of Construction and Architecture). Markings: B.1., E.1. are modules «The theory of computer games», B.2., M.2. are modules «Digital Media Development», B.3., M.2. are modules «Computer games using Inreal Engine 4», M.3. is the module «Technology development of multiplayer computer games», E.2. is the module «Technology of computer games development using Unreal Engine 4», * is the amount of ECTS credits (* shows 1 ECTS credit, ** shows 2 ECTS credit etc.).

In case if the result of mastering the course is the performance of individual written or term papers, the assessment is usually carried out by a teacher who is a professional on the listener's subject of study. In addition, in order to ensure the necessary uniqueness of the work submitted for inspection, it is proposed to use a system based on methods that allow identifying incomplete duplicates or similarities between text or graphic information fragments. As a result, each student's work of the course will be as unique as possible, thus making it impossible to use third-party information without a link. Details on methods for detecting incomplete duplicates are described in the papers [20, 21].

Let's consider the method of knowledge diagnosing in case of testing use to control the learning outcomes. If we consider the test tasks from the point of view of the "complexity of the task", then one task seems more complex than the other if the probability of a correct answer to the first problem is less than the second, regardless of who performs them. If you evaluate the tested student knowledge degree by the "level of preparedness", then it is obvious that a more trained student is more likely to correctly answer all the tasks than less prepared. As a model for tests evaluation, which is characterized by one parameter of the level of knowledge for each subject and one complexity parameter for each task, it is expedient to use the one-parameter Rasch model, for which there are convenient computational procedures for checking its adequacy [22]. Statistical treatment of test results on the basis of this model has important advantages. The model converts measurements made on dichotomous and ordinal scales into linear measurements, resulting in qualitative data being analyzed using quantitative methods that allows the use of a wide range of statistical procedures. The evaluation of the complexity of test tasks doesn't depend on a sample of subjects that were received, and an assessment of the level of knowledge of the testers doesn't depend on the set of test tasks used.

Let's assume that the test consists of K different binary type tasks (the trainee receiving the test receives 1 point, if answered correctly and 0 points with an incorrect answer).

The test is performed by N students. As a result, we get the matrix of response $A_{nk} = (a_{ij})$, which consists of N rows and K columns, $i = \overline{1, N}$, $j = \overline{1, K}$. The number b_i, which is equal to the sum of the points in the i-line, is called the initial point of the i-th student who is being tested (it is equal to the number of his correct answers): $b_i = a_{i1} + a_{i2} + \ldots + a_{iK}$ where a_{ij} is matrix elements A_{nk}. Suppose there are two listeners A and B, who are testing, with preparedness levels equal to S_A and S_B respectively, than

$$\frac{S_A}{S_B} = \frac{p_{At} q_{At}}{q_{At} p_{Bt}}$$

where $q_{At} = 1 - p_{At}$, $q_{Bt} = 1 - p_{Bt}$, p_{At} and p_{Bt} is probability of fulfilling the task of the difficulty level t by participants A and B, q_{At} and q_{Bt} is the probability of not fulfilling the task of the difficulty level t by A and B. The task difficulty level for a given model t is defined as the ratio of the probability that some standard test participant with a unit level of q_{1t} will not perform this task to probability p_{1t}.

The single level of training and complexity are linked by:

$$\frac{S_A}{S_B} = \frac{p_{A1} q_{A1}}{q_{A1} p_{B1}} = \frac{p_{A1}}{(1 - p_{A1})} \frac{(1 - p_{B1})}{p_{B1}}.$$

If $S_B = 1$, the level of preparedness of participant A is:

$$S_A = \frac{p_{At}}{(1 - p_{At})} t$$

where t is the difficulty level of the task.

This model allows you to link the level of complexity of some task and the level of preparedness of some participant with the probability of correct execution of the task, which is valid for tasks of any level of complexity. Considered

provisions are contributions to the realization of the goal: strengthening the potential of higher education in the gaming industry in Ukraine and ensuring employment.

III. CONCLUSION

As a result of conducted research the conceptual model was created and the components of the learning space for the specialists training in GameHub computer games development were described. It was found that the effective operation of GameHub learning space is possible only through information links between GameHub process participants (employers, academics, teachers and trainers, students). A scheme of interaction and distribution of authority in GameHub learning space model was created. An example of constructing a modules teaching scheme is given, which are designed to develop the skills of creating computer games, and are a part of GameHub pedagogical component. The features of knowledge diagnostics for those who learn on the basis of writing and testing analysis are described.

Curriculums and work programs that are described in the concept have passed the international evaluation by the Quality Ukraine company, the official partner of the European auditor Quality Austria company. The concept proposed in the article was introduced in the KNUCA in the 2017-2018 academic year. Training for unemployed, including ATO veterans (modules E.1 and E.2.), as well as bachelor degree students in "Cybersecurity" and "Computer Eng." (modules B.1., B.2. and B.3.) and master degree students in "Computer Science" and "Inform. Systems and Technologies" (modules M.1., M.2. and M.3.) was organized on the basis of GameLab laboratory installed in KNUCA. Studying was attended by 98 listeners (unemployed, ATO veterans and students), they have been certified after the course. The concept will continue to operate in KNUCA and partners of the project. The concepts covered in this paper include the necessary tools and provisions that can serve as learning space with unique infrastructures as the basis for the introduction of powerful game educational hubs in universities of Ukraine and other countries. These infrastructures envisage the possibility of uniting universities into a common communicative space for the purpose of creating a successful environment for learning game design of students, unemployed, ATO veterans. The results described in this article are part of the Erasmus+KA2 project "GameHub: Cooperation of universities-enterprises in gaming industry in Ukraine" No. 56128-EPP-1-2015-1-ES-EPPKA2-CBHE-JP.

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