Developing a 3D quest game for career guidance to estimate students' digital competences

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Abstract. This paper reveals the process of creating a career guidance 3D quest game for applicants who aim to apply for IT departments. The game bases on 3D model of computer science and information technologies department in the National Aerospace University "Kharkiv Aviation Institute". The quest challenges aim to assess the digital competency level of the applicants and first-year students. The paper features leveraged software tools, development stages, implementation challenges, and the gaming application scenario. The game scenario provides for a virtual tour around a department of the 3D university. As far as the game replicates the real-life objects, applicants can see the department's equipment and class-rooms. For the gaming application development team utilized C# and C++, Unity 3D, and Source Engine. For object modeling, we leveraged Hammer Editor, Agisoft PhotoScan Pro, and the photogrammetry technology, that allowed for realistic gameplay. Players are offered various formats of assessment of digital competencies: test task, puzzle, assembling a computer and setting up an IT-specialist workplace. The experiment conducted at the open house day proved the 3D quest game efficiency. The results of digital competence evaluation do not depend on the testing format. The applicants mostly preferred to take a 3D quest, as more up-to-date and attractive engagement.

Keywords: virtual reality, quest game, 3D model, career guidance, computer science, higher education.

1 Introduction

Augmented and virtual reality (AR and VR) are popular tools to introduce any concept more attractively or interactively. Utilizing AR and VR are most common for medicine, geospatial applications, manufacturing, tourism, and cultural heritage [7; 13; 22].

The choice of technology and how to apply it, in particular in the higher education field, depends on the research subject, resourcing, and the teachers' and students' competency. The experimental research on digital competency proved: the readiness level to start digital education is high enough [12]. Thus, arises a question of creating virtual objects and a methodology on how to utilize them in the educational process. For instance, the paper by Detlef Thürkow, Cornelia Gläßer, and Sebastian Kratsch [23] explains the experience of utilizing landscapes and excursions as a means of training in geography. Also, the research by Anoop Patiar, Sandie Leonie Kensbock, Emily Ma and Russell Cox [18] describes the students' experience with an innovative virtual field trip around hotels.

Among the virtual objects' representation formats, the gamification gains special importance, since it provides for additional motivation and active participation of the student [24; 25; 27].

The training games include quests, arcades, simulator games, virtual simulators, and interactive courses [4; 5; 11; 15; 19]. We considered quests to be the most interesting genre among the above mentioned [2; 3; 21]. Sergi Villagrasa and Jaume Duran [26] analyses the effectiveness of utilizing gamification to motivate Spanish students into studying with a 3D visualization as support for Problem-Based Learning (PBL) and Quest-Based Learning (QBL) to students' collaborative work. Yolanda A. Rankin, Rachel Gold and Bruce Gooch investigated the cognitive and motivational influence of 3D games on studying the second language and creating a digital learning environment for second language acquisition (SLA) [20]. Though, 3D games do not only boost motivation to study but also the motivation to build models and processes that the students go researching [9; 10; 16].

Since the career guidance of the future specialist is on-trend today, universities suggest many formats of how students can get to know the university, and use various forms of online communication with applicants. The career guidance is now on-demand, and recommendations on how to pursue a career path, in particular how to prepare for external independent evaluation, or recommendations on informal education, can be beneficial helping students to manage their education and career. This can influence the students' consciousness and help to improve the educational system's effectiveness, as well as the equation of demand and supply at the labor market [17].

The aim of the research is to create a career guidance 3D quest game to estimate the students' competency, and as well to attract more applicants and increase the visibility of the department.

2 The project implementation

2.1 Problem definition

The gamified application “Passcode” is a 3D quest game that bases on the 3D model of the computer science and information technologies department in the National Aerospace University “Kharkiv Aviation Institute”.

Target audience:

- applicants: assessing the digital competency level to understand if the applicant is ready to enter the computer science department, career guidance, department promotion;
- first-year students: assessing the digital competency level to adjust the program of education, introducing the department’ activities, career guidance;
- developers of the gamified applications: specification to the technical implementation of the gamified application “Passcode”.

The technical implementation defines the following scope of tasks:

- free movement, acting and selecting players according to the game scenario;
- analyzing data on the users’ actions;
- assessing users’ actions, demonstrating the users’ progress;
- the current score showing and saving feature;
- utilizing a database to simulate challenges.

Expected results of using the gamified application “Passcode”:

- enlarging the target audience to provide for career guidance activities;
- boosting the applicants’ motivation to study and providing them with career guidance;
- assessing digital competency of intendant IT-specialists for further adjusting the educational plans to suit their skills and level of knowledge;
- assisting in the development of gamified applications that utilize 3D models.

2.2 Means of technical implementation

To develop our 3D application, we leveraged Unity as the main engine [6]. Unity is a cross-platform tool for developing 2D and 3D games and applications that support several operating systems. We developed a game for MS Windows. The main language we use was C#, though we also utilized JavaScript and Boo for simple scripts. Also, we utilized the DirectX library, where the main shader language is Cg (C for Graphics) developed by NVidia.

The input data is not only the users’ actions but the current condition of the game world, as the game is a sequence of conditions, where each iteration defines the following one. The artificial intelligence that controls the game characters, random events, and the game mechanics mathematical tool influence the game as well.

The game objects (including the characters, items, etc.) are samples of classes that define their behavior. The game actions (effects, scenes, etc.) are defined by scripts. The game process is defined by the combined action of managers where each controls a certain part of the gameplay:

- GameManager – controls the game cycle and serves as a linker for the elements of game architecture;
- InterfaceManager – controls the user interface, including the graphical interface and the input equipment;
- PlayerManager – controls the main character's behavior and condition (main character here is the one controlled by the player);
- UnitManager – controls the units;
- SceneManager – controls the game levels.

All of the managers are implemented based on the Singleton pattern. They are universal for the whole game, and each exists in a single copy. The managers are called by type. The main game objects base on the Finite State Machine pattern, that allows for easily controlling the game object and controlling its behavior.

The computer game is a complicated system build of separate subsystems integrated into a program architecture. Our game application has the following subsystems: for finding a way for a character; for user graphic interface; for objects interaction and an additional control subsystem.

We implemented the application in several stages and each stage has its tasks (table 1). In addition to Unity, we also utilized the Source Engine. Due to the utilities stated in table 1, we created an application for OS Windows and Android, and also WebGL library for running in browsers.

Table 1. Tasks and tools for implementation.

Tasks	Tools
Creating 3D models of rooms	Source Engine, Agisoft PhotoScan Pro, GUI StudioMDL
Editing objects	Hammer World Editor, MilkShape 3D
Creating the objects' textures	Adobe Photoshop, VTF Edit
Creating levels and lightning for some items	Hammer World Editor
Scenes editing, processing and exporting to the format	3D Studio MAX, plugin Wall Worm
Scenes optimization	Unity
Adding the physical model of connection	
Creating game objects and events	
Developing the game manager, interface manager, player, units, and levels	
Scripts writing	

2.3 Aspects of technical implementation

Creating the classrooms 3D models was the most complicated part of the development that is why further we describe some implementation details.

To create the classrooms' 3D models, we leveraged separate models of special photos made in advance. Then we utilized Agisoft PhotoScan, which provides for the photogrammetry function [1]. Due to some technology constraints at the moment, building a fully-featured rooms model was a complicated task. Every gleam, as well as translucent materials, causes significant miscalculations. That can be fixed with a flattening spray, though that won't work for rooms and that cost a penny. Thus, we utilized the photogrammetry technology to get objects of correct shapes and sizes (fig. 1). Also, we modeled the objects' textures, those we edited via Adobe Photoshop and attached to the models. Using Agisoft PhotoScan we created the model of a classroom and a model of a computer architecture showcase.

Figure 1 demonstrates the 3D-modeled output level of the department rooms. The rooms modeling was done by brushing geometry, as thus no additional physical attachment model is required.

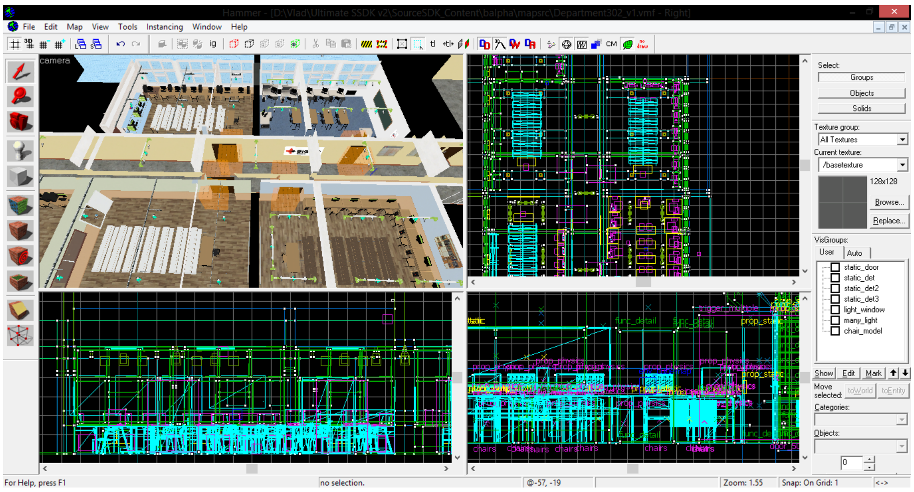

Fig. 1. Hammer Editor with a model of department rooms.

Figure 2 demonstrates a part of the level, one of the departments' classrooms. Most of the detailed parts were converted into special mdl format for models to allow for optimizing objects in a scene.

The detailed objects in figure 3 were converted into mdl via the propper plugin. After that, we could utilize the graphics power with the model reduction in distance technology – LOD.

When the scene is settled, we can import it into 3DS Max utilizing the WallWorm plugin (fig. 4).

3DS Max allows for exporting the scene in FBX format compatible with the Unity engine. In addition to the model itself, it stores data about lightning, materials, and structures.

To make sure that the scene was imported correctly we utilized the projection reflection modes. In figure 5 we can see that the grid is in its normal state.

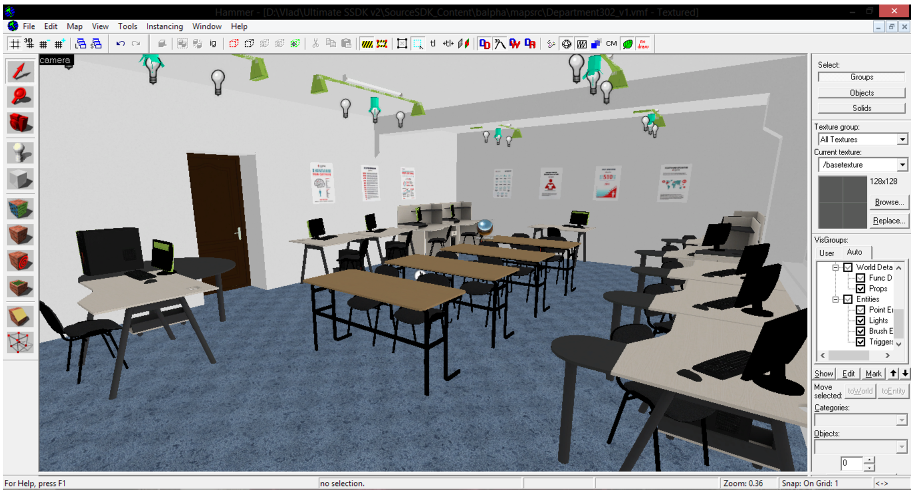

Fig. 2. Hammer Editor with a model of a classroom.

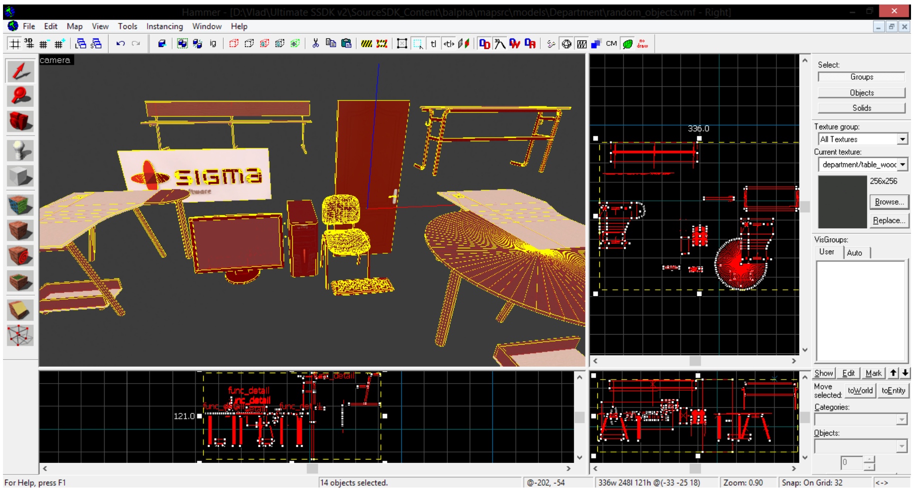

Fig. 3. Hammer Editor. The final objects and the grid.

Unity does not automatically create objects' physical models as it does not allow for brushing geometry. We have to optimize the model in the Unity scene and add a physical model of a connection mesh collider or box collider. The WebGL technology allows for running the project in the internet browser. This technology is yet imperfect, however, if we optimize the scene it will work well. The mobile systems require the controls to let the user run the game, for the mobile devices do not have keyboards and a mouse pointing device. Figure 6 demonstrates the controlling elements, the motion controls on the left, and the sight controls on the right.

The home screen interface is a menu that includes options "New game", "Load a game", "Settings", "Exit". After the user loads the game the menu extends with more options. The players can move with the mouse and the keyboard, or via sensor controls. The controls can be set in Settings, in the Keyboard tab. The graphical interface is an upper layer of the graphical system that allows for creating realistic 3D scenes on that basis. These scenes can have own scenario that may be changeable depending on the users' actions. The game's current version has a static background, though it can dynamically change to another background after each time the player reloads the game (fig. 7). Also, the vital part of the application development process was the scenario creation and quest development.

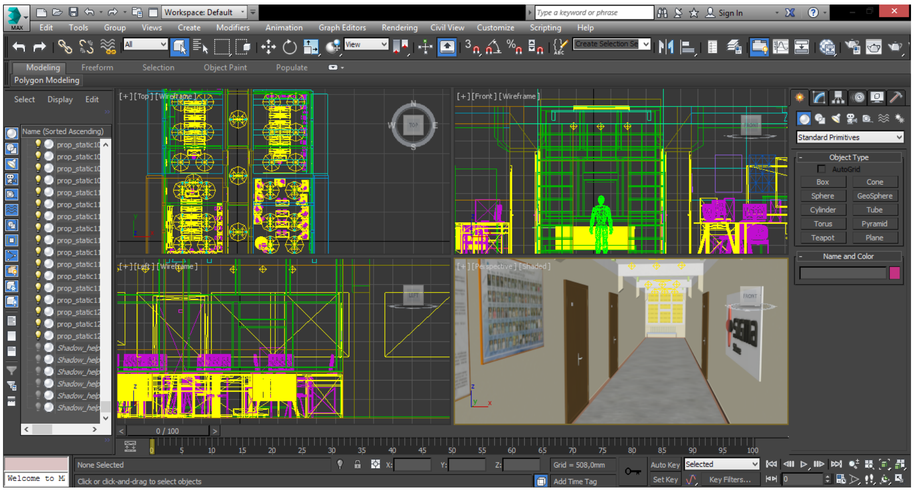

Fig. 4. 3D Studio MAX. Preparation and exporting into the Unity format.

Fig. 5. The Unity environment: Shaded Wireframe grid.

Fig. 6. The project runs on Android.

Fig. 7. Screenshots with different backgrounds after the game reload.

The scenario development: the game challenges utilize various objects, such as *scripted_sequence* that allows the characters for moving and performing the required actions; *logic_relay* that is used to create the series of events started with some item when it's necessary; *point_template* – a container for storing task objects; *ambient_generic* – used to play audio; *logic_compare* – compares the numbers to decide on what to do next; *info_node* – creates the navigation grid nodes for the non-game characters (the way searching system utilizes the key *info_node* elements), etc. We implemented these elements based on the Finite State Machine pattern, which allows for controlling the game object condition and its behavior. For the quest development there are several algorithms to utilize, though since the game model is 3D, we implemented the way search via the navigation grids algorithm.

The Navmesh or Node Graph navigation grid is an abstract data structure that is usually utilized by the AI applications, to allow the movement agents through big and geometrically complicated 3D objects. AI considers that objects that are not static to be a dynamic hindrance. This is another advantage of utilizing our approach to solve the challenge of searching the right way. The agents that can approach the navigation grid do not count these hindrances when building their track. Thus, the navigation grids method allows us to shorten expenses on calculations and makes finding the agents that encounter dynamic hindrances less pricey. The navigation grids are usually implemented as graphs, so we can utilize them for several algorithms defined for those structures. Figure 8 demonstrates the navigation grid utilized to calculate the way for non-game characters.

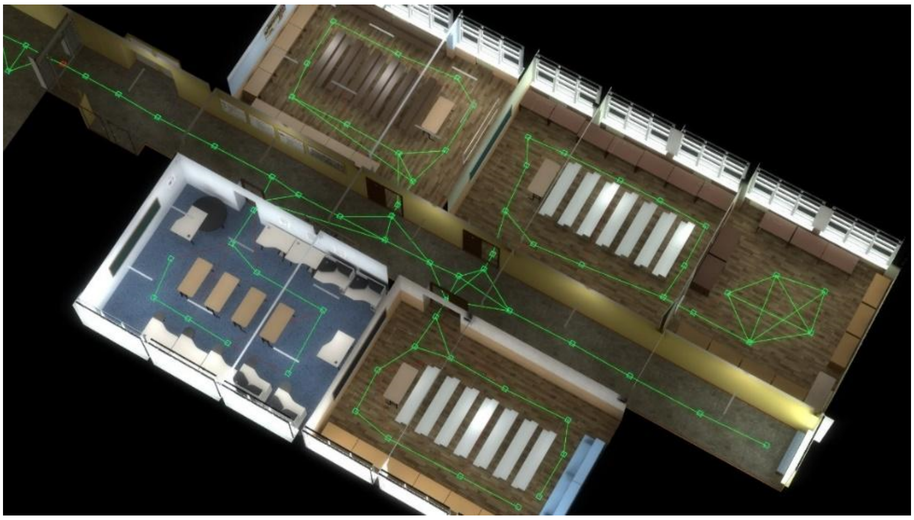

Fig. 8. Navigation grid.

2.4 Application scenario

The 3D quest "Passcode" can be downloaded via the following link: https://afly.co/xxn2. To start the quest, the user selects the language, as the game contains tips and subtitles, adjusts the keyboard settings, and on-demand can go to help for instructions in the corresponding menu section.

The quest contained different challenges to evaluate different groups of digital competences. For instance, estimating the level of competence working with data, the users have to answer on closed test questions that cover the information competency. These tests can have from two to four questions depending on the test. When the user selects an answer, it is supplied with a corresponding comment and highlighted red (for incorrect answers) or green (for correct answers). For both cases, the user receives a text message with the correct answer. After the user completed test questions, the program counts correct and incorrect answers and displays the results in a message, and voices it over.

To estimate the users' competence in problem solving and communication, we developed the "Find the academic record book" challenge (Fig. 9). The scenario supposes the user to communicate with the Student character, ask her questions on the educational process and decide where to go to find the academic record book. To provide for an additional challenge, this item randomly appears in one of the departments.

Fig. 9. The user got the task to find the academic record book and completed it.

When the user finds the object, he receives a message about discovery and he can go find the Student. After he gets the academic record book in his hands, he leaves the department and the challenge is over. The game counts the number of steps the user made to complete the task.

"Clean the classroom" challenge (fig. 10) aims to evaluate the user's ability to solve technical problems, follow the rules of safety, and treat the technical equipment and computers. The user has to place computers, screens, mouses, and keyboards around the classroom to the right places. The game counts the number of steps the user made to complete the task.

In another classroom, the user has to set up a computer out of suggested elements (the computer cabinet, processing unit, mother card, power source, cooler, graphics adapter, RAM, etc.). This challenge counts the order; thus, user can't place the cooler before settling the processing unit into the mother card. After the computer was set up, the user is told the number of a room where to take the computer. The task is considered to be complete when the user takes the computer to the given classroom.

To evaluate the users' abilities for self-education and career guidance, the user has to put together the "IT specialist jigsaw puzzle". The task is to group 30 suggested elements according to 10 given IT-related occupations: Mobile Developer Android, Mobile developer iOS, Frontend developer, Backend developer, Project manager, Java developer, .NET developer, UX/UI designer, QA tester, Database developer. The number of pieces for each occupation varies from 3 to 6, similar pieces can belong to different occupations. The order in this challenge doesn't matter, and the number of attempts is not limited. The pieces that do not match automatically drops away, denoting the mistake. The challenge is complete after all the pieces are together (fig. 11). During the challenge, the user can get tip messages by clicking the occupation name, and it shows up for 10 seconds. The tips number is limited, and the game counts how many of that user took.

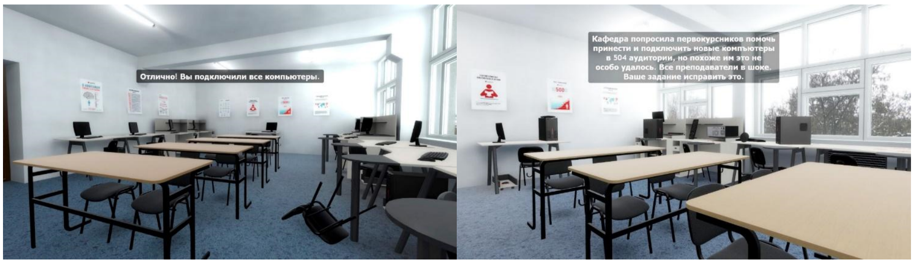

Fig. 10. The user got the task to settle the classroom and completed it.

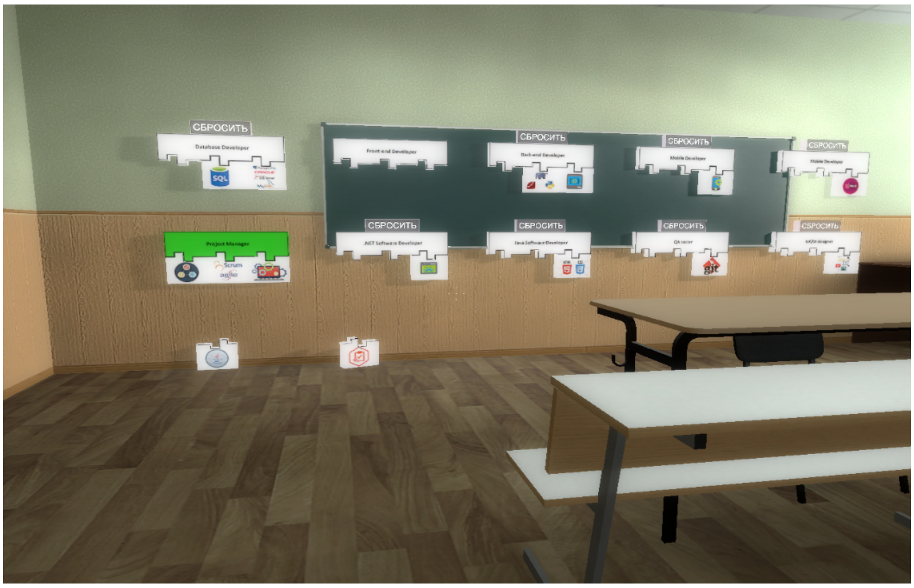

Fig. 11. The user processing the jigsaw puzzle task.

The tasks are meant not only to evaluate the users' digital competence but also to learn about the faculty life and educational system as the game models reflect real objects.

At the moment, the quest has 10 challenges, though we have an opportunity to make changes to the tasks pull. To succeed, the user has to complete all of the challenges, yet the order can be random. To choose the challenge the user just picks one with clicking on it, and the voice behind the scene explains the message and the point for him to go. As the user reaches the right classroom the voice behind the scene provides detailed instructions for the challenge. When already moving, the quit option becomes available for the user. To disrupt the challenge the user should press the corresponding button in the classroom or use a keyboard shortcut.

Completing each task is always written, its color changes from red to green. During the process, the user sees the score of the challenges he completed. There are certain evaluation criteria, though every task is scored 2 points. The maximum score is 20 points. Depending on the complexity the tasks value differently. The system defines the applicants who scored less than 10 points to have a low level of digital competence, from 10 to 15 points – the middle level, and those who scored above 15 – to have a high level of digital competence. Also, each challenge has no time limits, yet the quest time was limited. Thus, we could evaluate the users' ability to plan their time and decide on the order and timing for the challenges they take.

3 The experiment results

To evaluate the quest efficiency we held an experiment at the IT championship for the applicants at the computer science and information technologies department in the National Aerospace University "Kharkiv Aviation Institute" (https://sites.google.com/view/khai-itcup-2019). In 2019 the championship occurred in the University in the third time, and the applicants were suggested with a challenge. They had a choice, either to take a 3D quest game or to go take it in real life (go to the department, take their paper tests, complete a puzzle, set up a real computer). 115 applicants participated in the experiment, and 57 decided to complete the task in real life, with the guidance of elder students (this task was assessed with real measures, and 58 applicants completed these tasks via the application (https://is.gd/QvsDXN). The students split into two groups randomly.

There were 90 boys that equal to 78,3% and 25 girls that equals to 21,7% of participants. The group working with real equipment counted 12 girls (48%) and 45 (50%) boys. The group that chose the 3D quest counted 13 (52%) girls and 45 (50%) boys. Thus, the selection was homogenous and representative enough to research on (the measurement error is less than 10%). To process the overall applicants' results we applied statistical analysis from the SPSS package [8; 14]. We calculated the average for each group, and also the average for girls and boys. The obtained results are stored in table 2. Mostly, the applicants demonstrated middle-level digital competence. According to results in the table, the is almost no difference in points between the applicants of two groups (the Student's criteria for independent groups equals 0,71 at p=0,48, the distribution of students' estimates correspond to the normal distribution). Boys demonstrated better results than girls (the students' criteria equals 4,36 at p=0,01).

After the challenge applicants had to answer a 5-question survey (https://is.gd/icpwQY) that would help to reveal their motivation to choose the IT department, and also their attitude to the championship we arranged.

Table 2. Statistics on gender and evaluation format.

		Average	**Standard measurement error**	**Minimum score**	**Maximum score**
Format	Real equipment	13,9	0,4	6	19
	Application	14,3	0,4	8	20
Gender	Girls	12	0,6	6	17
	Boys	14,7	0,3	7	20

Thus, 74,8% of the applicants answered they liked the challenges they got during the championship, 14 applicants (that is 12,2%) didn't enjoy the tasks, and 15 of them (13%) found it complicated to answer, as the tasks appeared to be challenging for them. The student who didn't like the tasks had worse scores and significantly lower digital competence levels (scored 2 points less, $p<0{,}05$).

Answering what type of tasks, they prefer 43,5% of respondents said they like computer quests, puzzles, etc., 27,8% of respondents claimed they would prefer a real quest or puzzle, 9,65% chose online testing, 11,3% of respondents make no difference, and 7,8% of applicants preferred testing on paper.

The average on this challenge does not vary significantly, though the applicants who preferred paper tests scored 2 points less on average ($p<0{,}05$). Considering the time given to complete those challenges 87% of applicants said it was enough, and they also scored for better average comparing to the applicants who were out of time.

The answers distribution for "Do you plan applying for our department?" was the following. 52,2% answered "Yes, for I will gain practical skills here (I saw the faculty keeps up to date, and I saw what the students are capable of), 27,8% would like to enter though there were not sure their knowledge is enough, 20% were not going to apply or planned to enter another department.

4 Conclusion

Out of the aim of this research and the particular tasks we faced developing a 3D quest game, as well as the results of assessing the application efficiency in career guidance we came up with the following conclusions.

The game application development technology we suggest can be utilized by 3D models and game developers, in particular for training the future IT specialists.

We utilized various technologies to implement the application idea. Leveraging Unity 3D and Source Engine as the main engines allowed for creating a 3D model of a game and its main objects. We edited objects via Hammer Editor and created a realistic department's classroom model with the Agisoft PhotoScan Pro tool and the photogrammetry. Searching the right way was implemented via navigation grids, which allow through the geometrically complicate 3D objects.

The game scenario provides for a virtual tour around a department of the 3D university. As far as the game replicates the real-life objects, applicants can see the department's equipment and classrooms.

The quest includes several different challenges meant to evaluate the applicants' digital competence connected to the main components such as Computer and Information Literacy and Computational thinking. The tasks also allow for understanding the applicants' ability to work efficiently and to use computers in real life.

The experiment results prove the 3D quest to be effective. Yet the results of digital competence evaluation do not depend on the testing format, applicants mostly preferred to take a 3D quest, as more up-to-date and attractive engagement. Also, they claimed this up-to-date approach would influence their choice of a university.

Thus, our 3D quest application can grow the audience for career guidance activities and improve the public image of the university. Besides, applicants can use this 3D quest to decide on their future occupation.

In addition to campaigning and career guidance, this application can help to teach and test students. The prospective research aims to utilize the application to evaluate the digital competence of the future IT specialists for adjusting the educational plan for the university's first-year students.

References

1. Anuar, A.: Digital Photogrammetry: An Experience Of Processing Aerial Photograph Of UTM Acquired Using Digital Camera. Paper presented at the AsiaGIS 2006, Johor, Malaysia. https://www.researchgate.net/publication/228739845_Digital_Photogrammetry_An_Experience_Of_Processing_Aerial_Photograph_Of_UTM_Acquired_Using_Digital_Camera (2006)
2. Barab, S., Thomas, M., Dodge, T., Carteaux, R., Tuzun, H.: Making learning fun: Quest Atlantis, a game without guns. Educational Technology Research and Development **53**, 86–107(2005). doi: 10.1007/BF02504859
3. Barab, S.A., Hay, K.E., Barnett, M.G., Squire, K.: Constructing virtual worlds: Tracing the historical development of learner practices/understandings. Cognition and Instruction **19**(1), 47–94 (2001)
4. Buzko, V.L., Bonk, A.V., Tron, V.V.: Implementation of Gamification and Elements of Augmented Reality During the Binary Lessons in a Secondary School. CEUR Workshop Proceedings **2257**, 53–60 (2018)
5. Demirbilek, M., Koç, D.: Using Computer Simulations and Games in Engineering Education: Views from the Field. CEUR Workshop Proceedings **2393**, 944–951 (2019)
6. Finnegan, T.: Learning Unity Android Game Development. Packt Publishing, Birmingham (2015)
7. Frontoni E., Paolanti M., Puggioni M., Pierdicca R., Sasso M.: Measuring and Assessing Augmented Reality Potential for Educational Purposes: SmartMarca Project. In: De Paolis, L., Bourdot, P. (eds.) Augmented Reality, Virtual Reality, and Computer Graphics. AVR 2019. Lecture Notes in Computer Science, vol. 11614, pp. 319–334. Springer, Cham (2019). doi:10.1007/978-3-030-25999-0_28
8. Gravetter, F.J., Wallnau, L.B.: Statistics for The Behavioral Sciences, 10th edn. Cengage Learning, Boston (2017)
9. Haranin, O.M., Moiseienko, N.V.: Adaptive artificial intelligence in RPG-game on the Unity game engine. CEUR Workshop Proceedings **2292**, 143–150 (2018)

10. Katsko, O.O., Moiseienko, N.V.: Development computer games on the Unity game engine for research of elements of the cognitive thinking in the playing process. CEUR Workshop Proceedings **2292**, 151–155 (2018)
11. Kompaniets, A., Chemerys, H., Krasheninnik, I.: Using 3D modelling in design training simulator with augmented reality. CEUR Workshop Proceedings **2546**, 213–223 (2019)
12. Kuzminska, O., Mazorchuk, M., Morze, N., Pavlenko, V., Prokhorov, A.: Digital competency of the students and teachers in Ukraine: measurement, analysis, development prospects. CEUR Workshop Proceedings **2104**, 366–379 (2018)
13. Lavrentieva, O.O., Arkhypov, I.O., Kuchma, O.I., Uchitel, A.D.: Use of simulators together with virtual and augmented reality in the system of welders' vocational training: past, present, and future. CEUR Workshop Proceedings **2547**, 201–216 (2020)
14. Levesque, R.: Programming and Data Management for IBM SPSS Statistics 24: A Guide for IBM SPSS Statistics and SAS Users. IBM. https://developer.ibm.com/predictiveanalytics/wp-content/uploads/sites/48/2016/03/Programming-and-Data-Management-for-IBM-SPSS-Statistics-24.zip (2016)
15. Lvov, M.S., Popova, H.V.: Simulation technologies of virtual reality usage in the training of future ship navigators. CEUR Workshop Proceedings **2547**, 50–65 (2020)
16. Ma, M., Bale, K., Rea, P.: Constructionist Learning in Anatomy Education. In: Ma, M., Oliveira, M.F., Hauge, J.B., Duin, H., Thoben K.D. (eds.) Serious Games Development and Applications. SGDA 2012. Lecture Notes in Computer Science, vol. 7528, pp. 43–58. Springer, Berlin, Heidelberg (2012)
17. OECD: Learning for Jobs: Synthesis Report of the OECD Reviews of Vocational Education and Training. OECD Publishing, Paris. http://www.oecd.org/education/skills-beyond-school/Learning%20for%20Jobs%20book.pdf (2010). Accessed 21 Mar 2017
18. Patiar, A., Kensbock, S., Ma, E., Cox, R.: Information and Communication Technology–Enabled Innovation: Application of the Virtual Field Trip in Hospitality Education. Journal of Hospitality & Tourism Education **29**(3), 129–140 (2017). doi:10.1080/10963758.2017.1336096
19. Pazdrii, V., Banschykov, P., Kosyk, V., Tropina, I., Hryshchenko, O.: Simulation System in Educational and Career Guidance State Policy of Ukraine. CEUR Workshop Proceedings **2393**, 935–943 (2019)
20. Rankin, Y.A., Gold, R., Gooch, B.: 3D Role-Playing Games as Language Learning Tools. In: Brown, J., Hansmann, W. (eds.) Eurographics'06 Education Papers, Vienna, Austria. The Eurographics Association (2006). doi:10.2312/eged.20061005.033-038
21. Shepiliev, D.S., Semerikov, S.O., Yechkalo, Yu.V., Tkachuk, V.V., Markova, O.M., Modlo, Ye.O., Mintii, I.S., Mintii, M.M., Selivanova, T.V., Maksyshko, N.K., Vakaliuk, T.A., Osadchyi, V.V., Tarasenko, R.O., Amelina, S.M., Kiv, A.E.: Development of career guidance quests using WebAR. Journal of Physics: Conference Series (2020, in press)
22. Striuk, A.M., Rassovytska, M.V., Shokaliuk, S.V.: Using Blippar Augmented Reality Browser in the Practical Training of Mechanical Engineers. CEUR Workshop Proceedings **2104**, 412–419 (2018)
23. Thürkow, D., Gläßer, C., Kratsch, S.: Virtual landscapes and excursions-innovative tools as a means of training in geography. In: Proceedings of ISPRS VI/1 & VI/2 Workshop on Tools and Techniques for E-Learning, pp. 61–64. https://www.isprs.org/proceedings/xxxvi/6-w30/paper/elearnws_potsdam2005_thuerkow.unlocked.pdf (2005). Accessed 21 Mar 2017
24. Tokarieva, A.V., Volkova, N.P., Harkusha, I.V., Soloviev, V.N.: Educational digital games: models and implementation. CEUR Workshop Proceedings **2433**, 74–89 (2019)

25. Vakaliuk, T.A., Kontsedailo, V.V., Antoniuk, D.S., Korotun, O.V., Mintii, I.S., Pikilnyak, A.V.: Using game simulator Software Inc in the Software Engineering education. CEUR Workshop Proceedings **2547**, 66–80 (2020)
26. Villagrasa, S., Duran, J.: Gamification for learning 3D computer graphics arts. In: TEEM '13: Proceedings of the First International Conference on technological ecosystem for enhancing multiculturality, November 2013, pp. 429–433. ACM (2013). doi:10.1145/2536536.2536602
27. Vlachopoulos, D., Makri, A.: The effect of games and simulations on higher education: a systematic literature review. International Journal of Educational Technology in Higher Education **14**, 22 (2017). doi:10.1186/s41239-017-0062-1