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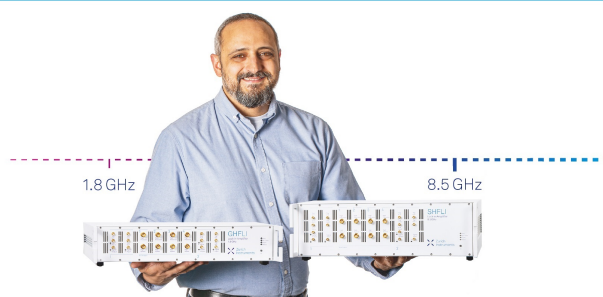
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Conditions for the Successful Mastering of Virtual Reality Technology by Schoolchildren

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Abstract. This article describes the results of the work of the “School of Virtual Reality and Neurotechnology”, which functioned within the framework of the Talant22 school. During this training course, schoolchildren used VR headsets (Oculus Rift S and Class VR) to learn the basics of interacting with virtual (VR) and augmented realities (AR), and also used the free Google Street View mobile application to create their own VR content (photosphere). We have obtained evidence that video games as a hobby leads to more successful mastering of virtual reality technology by children. AAA games and a deeper knowledge of physics (within the school curriculum or wider) can make this mastering even more successful. We have also established the fact that developed skills in various game mechanics, controller operation skill and the perception of 3D space and experience in the following genres of video games are also key: simulation, shooter, action and adventure. It has been found that the best way to quickly adapt to a virtual environment and learn how to interact with virtual objects is obtained with the experience of playing on video game consoles. In addition, it turns out that playing video games as a hobby contributes to a deeper knowledge of the English and is a kind of additional practice. The use of VR in the educational process is accompanied by multiple positive effects, while the manifestation of different negative side effects turned out to be low, and the proposed tasks were rated by schoolchildren as simple and exciting. In this regard, we see that the further development of gamification should be closely associated with the process of introducing video games into the education. The main principles we promote — motivation through entertainment and game as the most important process, in our opinion, can stimulate students to master new areas of knowledge and create their own VR content. Thus, a deep revision of gamification approaches and further research in this area is required.

INTRODUCTION

The world around us is undergoing continuous changes and as we move into the future, the speed of these transformation processes is steadily increasing. Only in the last 70 years we have been able to observe the change of several generations, which sociologists have given conventional designations and described the distinctive features for each of them. Children, accordingly, also change and the education system is forced to adapt to all these changes.

At the same time, education remains a somewhat conservative and inert environment. This is its strengths and weaknesses. On the one hand, adherence to traditions and adherence to old, well-functioning and well-proven principles and techniques certainly in most cases has a positive effect (not all modern trends have only good consequences). On the other hand, this conservatism and inertia turns the education system into a clumsy and bureaucratic machine that sometimes openly accepts everything new with hostility. We can observe approximately this process in the framework of the expansion of gamification.

Despite all its successes, gamification as a field of scientific research is still in its early stages of development. Most of the articles concern the application of game methods and elements of game design in the learning process. We see that this area desperately needs a complete revision of methods and approaches. Most importantly, it is necessary to introduce “professional” games (especially AAA projects) in teaching if they correspond to the topic of the lesson. Moreover, such examples (still extremely rare) of using “serious” video games in teaching are already known [1].

Correct use of created gamified learning environment can provide us with an extremely powerful tool for acquiring new knowledge and strengthening important skills such as problem solving, collaboration and interaction (communication). One of the existing definitions of gamification describes it as the use of game design elements (motivation of students through these features which are rather characteristic of games) in a non-game situation [2, 3]. Our proposed vision of the gamification process (see above) requires extensive study and publication of a number of works, some of which should be conceptual rather than research in its nature.

Nevertheless, it is important to remember that the ever-accelerating introduction of digital technologies into the educational environment (sometimes we are talking about a complete transition to them) can lead to the development of the process of digital marginalization, which is fatal for many countries [4].

Obviously, the plots of many video games allow simulating situations (many of them are based on real historical events) that could not happen in reality or that we cannot observe due to extreme environmental conditions or colossal remoteness from us in space or time. Modeling such situations allows you to teach children to consciously interact with the surrounding reality and learn new things. The introduction of video games into education also allows us to solve the long-term problems of the traditional educational environment associated with the already mentioned failure of the modern education system. The solution to this problem is quite simple and is carried out by transforming learning into an interesting and exciting process. The self-evident interactivity and immersiveness of games enhances the degree of student involvement in the educational process, thereby supporting active learning, problem-based learning and experiential learning [2].

Modern children (the so-called “Generation Z” (Gen Z)) almost stop reading and increasingly use fragmentary knowledge (clip thinking). The motto of this generation is “the result is here and now”. Therefore, it all starts when it becomes boring to read books. Books are replaced by videos at first (cartoons, TV series). Then videos are replaced by short video plots (TikTok, YouTube). Updating content in a constantly changing environment causes rapid satiety and loss of interest. Today, interactivity, interaction with objects still remains a trend. In these conditions, education has to react to the challenges of society. Forms and methods that make it possible to retain the attention of schoolchildren and immerse them in the learning environment are becoming in demand. If only yesterday, visualization was able to stimulate the mental activity in learning, today it has been replaced by clear bright entertainment, while the teacher (lecturer) is increasingly looking and acting as a presenter.

The visualized information is easily assimilated by human consciousness. Interaction with it contributes to the development of visual memory and the ability to make decisions intuitively. Among the negative factors are the deterioration of the ability for prolonged concentration, identification of cause-and-effect relationships, critical perception of information and reflection.

The rapid informatization of society led to the widespread use of various gadgets, which began to play the role of the main means of accessing information. All these changes contributed to the fact that the visual communication channel became dominant. Nevertheless, man as a species was formed and evolved under conditions when the auditory channel was of great importance. The more developed speech, the better developed verbal thinking and all cognitive processes in general.

The ever-increasing proliferation of smart devices, social media, online services and gaming leaves us no choice but to include all these relatively new elements for education in the learning process. The key visualization problem (since the old visualization methods no longer work as efficiently as before) can be solved by using virtual reality technologies. VR technologies represent a qualitatively new step in the field of visual presentation of information.

There are many articles devoted to the positive effects of using VR in teaching: on improving the perception of information and increasing class attendance [5], making it easier for the teacher to convey complex and abstract material and stimulating motivation [6], on expanding opportunities in laboratory classes (complex experiments) [7]. At the same time, there is still a need for teachers and lecturers to pass additional educational programs, since they do not have enough knowledge and skills to fully implement VR tools [8].

The conjunction of video games (including VR) with other educational technologies can enhance the support of attention and immersion of schoolchildren (students) in the educational process [9]. In addition, as practice shows, working with augmented (AR) and virtual (VR) realities at the user (amateur) level turns out to be quite simple, but no less exciting.

The main principles we promote — motivation through entertainment and game as the most important process, in our opinion, can stimulate students to master new areas of knowledge and create their own VR content.

METHODS

The characteristic features of modern education are the principles of involving students in the filling and repeated use of educational content and in the mash-up of technologies and digital resources. All these components in the process of integration enrich each other.

In March-April and June 2021 at the Shukshin Altai State Humanities Pedagogical University, with the assistance of the Regional Centre for the Identification and Support of Gifted Children in Altai Krai “Talant22”, an additional program for schoolchildren “School of Virtual Reality and Neurotechnologies” was carried out. The goal of this program is to involve talented schoolchildren of the city of Biysk and the Biysky District in research and applied activities in the field of virtual reality.

The mastering of the program (development of digital competencies) was carried out in groups. Each group included ten schoolchildren (from 9 to 15 years old) and was led by the students (third-year bachelors — future teachers of Mathematics and Computer Science). For this purpose we organized a co-working area equipped with computers (desktops and laptops), large LED TV, Oculus Rift S headsets with controllers as well as Class VR headsets (without controllers).

The training took place in three weeks. In the first week, we used face-to-face classes. After that, the schoolchildren chose the topic of the collective project and worked on it remotely using digital communication tools (Trello, Discord).

The tasks included mastering ready-made VR developments (game study of control systems, virtual travel around the world) and development of our own VR product using geographic information systems (GIS), a tool for creating virtual 3D panoramas (360° photos, photospheres).

The first task involved interactive training using the First Contact app — Oculus VR Interactive Experience. The task was completed individually using virtual reality headsets and game content from Oculus. In the course of completing this task, the participants got acquainted with the virtual environment, mastered the skills of working with controllers: the children could interact with objects (pick up firecrackers and launch them, print toys on a 3D printer and play with them). Interactivity enhances the immersive effect (high-resolution graphics, most objects can be lifted and twisted in the hands and obey the physical laws of the material world).

The next step was to divide the schoolchildren into groups and they were offered a game quiz with questions from different fields of knowledge. The answers were encrypted in QR codes in order to show how augmented reality (AR) technologies can be used in real life. This task contributed to the formation of the ability to work in a team, listen to the interlocutor, see the common goal, the willingness to help others and to seek a compromise, the ability to convince, generalize and take responsibility for the decision. This task caused a strong reaction also because it was of an adversarial nature: it was required to answer as quickly as possible a large number of questions.

After getting acquainted with VR and AR technologies, the last task was to create panoramic photos using smartphones with the installed free Google Street View application and post this image on the Google Maps.

Working with the application is intuitive for schoolchildren: just select the “Create”, choose “Photo Sphere” and follow the yellow point on the screen. The application will do all the work by itself — it will take a series of shots covering the entire space around you. After that, the application starts processing the received data. A green mark will signal that all photos have been processed. The panoramic image saved in the smartphone’s gallery has an unusual look. This is due to the fact that the three-dimensional sphere was placed in a two-dimensional plane. You can view a spherical panorama using a smartphone, VR headset or posting on social networks, geographic information systems etc.

Students told the schoolchildren about the rules for successful creating photospheres:

1. The smartphone must be equipped with a gyroscope. You can find modern models of smartphones where gyroscope is not included. In this situation you will not be able to use the device’s camera for shooting in the Google Street View;
2. It is recommended to shoot in sunny weather (no wind or precipitation) at noon;
3. Indoor photography requires uniform lighting of the room;
4. When choosing a location for shooting (if possible), it is necessary to avoid straight (including parallel) lines and geometric patterns (power lines, paving slabs, horizontal stripes in the decor, parquet on the floor etc.). Compliance with this rule will allow you to get a more realistic photo from the glued fragments when moving from a two-dimensional plane to a three-dimensional space;
5. When shooting, it is necessary to move the smartphone camera slowly and sequentially to cover all areas around to fill the panorama space. In this case, different variants of camera movement are possible. One of

the recommended methods is horizontal shooting alternately in rows in a clockwise direction, then a frame is taken at the top point (zenith) and a frame at the bottom point — nadir (the place where the tripod with the camera and the photographer himself were located). Sometimes it is advisable to shoot the nadir in the first place in order to avoid the appearance of footprints in the sand or snow in the photo.

As part of the study of the influence of the experience of playing activity on the development of virtual reality technology at the first stage, schoolchildren were offered a questionnaire with the following questions (Table 1).

TABLE 1. Survey form before training course.

Questions	Suggested answer options
1. How old are you?	none
2. Enter your gender	none
3. How well do you speak English?	a) I can speak, I translate; b) I translate with a dictionary; c) I know English badly; d) I don't know or didn't study.
4. Have you ever used virtual reality?	a) yes; b) no.
5. How often do you play video games?	a) less than once a week; b) once a week; c) almost every day; d) every day for 1 hour; e) every day for 2 hours; f) every day for 3 hours; g) every day for 4 hours; h) every day for 5 hours; i) every day for 6 hours or more; j) I don't play video games.
6. What video game system do you prefer?	a) PC (personal computer); b) smartphone (Android); c) smartphone (iOS); d) Xbox; e) PlayStation; f) Nintendo; g) emulators of old consoles; h) I do not play video games.
7. What genre of video games do you prefer?	a) action; b) adventure; c) shooter; d) fighting; e) simulation; f) puzzle; g) strategy; h) survival; i) platform; j) RPG; k) MMORPG; l) racing; m) action-adventure; n) sports.
8. Write the names of your favourite video games.	none
9. What, in your opinion, is the benefit of video games?	none
10. What do you think is the harm of video games?	none
11. What is your favourite discipline (s) at school?	none

After getting acquainted with the rules for creating spherical panoramas (photospheres), the students demonstrated to schoolchildren the process of its creation (using smartphones) and showed the result. Then schoolchildren began to complete the task in groups. The group method turned out to be justified: the schoolchildren jointly chose the location

for the shooting, suggested the rules to each other, and mastered the shooting techniques. The schoolchildren were able to immediately see the result in virtual reality using Oculus Rift S headsets.

Further work was carried out in a remote format during the development of the collective project “City Monuments”, the purpose of which was to create spherical panoramas of the city’s cultural heritage sites and place them in the Google Maps geographic information system. Here, schoolchildren could independently study historical and local history sources in order to choose the most significant object (monument) from their point of view. They also needed to coordinate their joint actions - the immediate task was to avoid repeating objects. That is, each monument of historical, cultural or scientific heritage had to be presented only once.

The task of gamification is to involve students in the process, to form skills and abilities unobtrusively in a playful way. The virtual environment expands the boundaries of the game transforming surrounding reality. Schoolchildren enthusiastically mastered new digital tools and game mechanics, participated in the discussion of exercises.

After completing the training courses (“School of Virtual Reality and Neurotechnologies”), schoolchildren were asked to answer the following questions (Table 2).

TABLE 2. Survey form after training course.

Questions	Suggested answer options
1. Rate your VR experience 1 to 5	<i>a)</i> how it was interesting for you (1 — not interesting; 5 — very interesting); <i>b)</i> how it was difficult for you (1 — it was not difficult; 5 — very difficult); <i>c)</i> how clearly and accessible the content was demonstrated (1 — not visual and not accessible; 5 — visual and accessible).
2. Have you experienced any side effects while using VR?	<i>a)</i> moderate to severe dizziness (motion sickness, VR sickness (VR seasickness)); <i>b)</i> tired eyes; <i>c)</i> disorientation (couldn’t figure out where you are); <i>d)</i> fear of what you saw; <i>e)</i> fear of stumbling and falling in reality.
3. What seemed more interesting to you — to use ready-made content or create your own?	<i>a)</i> use ready-made; <i>b)</i> create your own.
4. Was it difficult for you to create content for VR on your own (for example, photo spheres)?	<i>a)</i> yes; <i>b)</i> no.

RESULTS AND DISCUSSION

The age of the children who took part in the study ranged from 9 to 15 years (Fig. 1).

Among the pupils of the “School of Virtual Reality and Neurotechnologies”, 60.7% were boys and 39.3% were girls. Only 21.4% of the participants stated that they know English well (35.7% can translate only with a dictionary; 42.9% know English badly — all data are taken from the schoolchildren’s own assessment of their capabilities). Moreover, all schoolchildren study English at school.

Most of the participants had no experience with virtual reality technology before the project: among the participants, 43% noted that they had met this technology (as a rule, game content), the remaining 57% only know about the existence of VR. It turned out that many of the schoolchildren who took part in these training courses imagined VR technology as headsets, where an installed mobile phone (a smartphone with a touch screen) acts as a display. Few of the participants had an understanding of, or had experience with, serious virtual reality (computer or autonomous) systems (Oculus (Rift, Rift S, Go, Quest, Quest 2), HTC (Vive, Vive Pro, Vive Pro Eye, Vive Focus, Vive Cosmos), HP Reverb (HP Reverb G2), Valve Index, PlayStation VR, etc.).

None of the schoolchildren have previously participated in the use of virtual reality to create photospheres (360° image, spherical panorama).

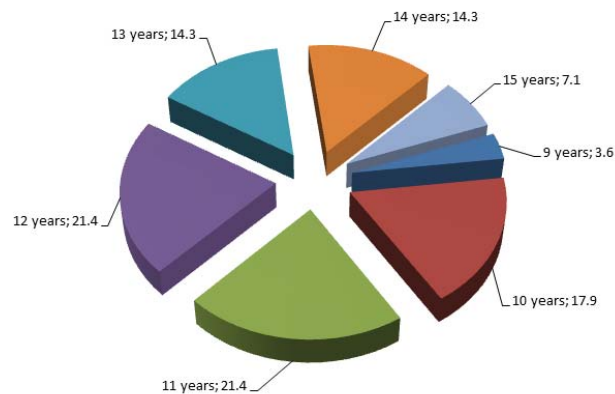


FIGURE 1. Shares of different age groups of schoolchildren who took part in the survey (%).

The analysis of the questionnaires showed a different amount of time that schoolchildren spend playing video games (Fig. 2). As we can see, a quarter of all schoolchildren do not play video games at all. Close to them is a small group that plays extremely rarely (only 3.6%). The vast majority of 71.4% play video games quite regularly. Among them, we can single out a group who plays a lot: 4 hours a day (14.3%), 5 hours a day (3.6%) and real gamers — 6 hours a day or more (7.1%).

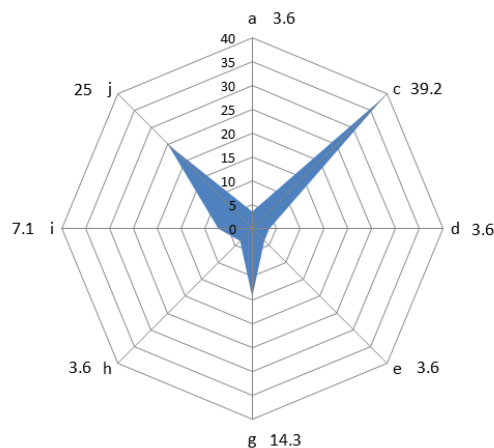


FIGURE 2. The time schoolchildren spend on video games (%).

Most of the surveyed schoolchildren answered that they prefer PC as their main video gaming system (60.7%). Such a large share was predicted by us and is easily explained by the general popularity of the PC as a gaming system in the post-Soviet space, largely associated with the ability to use pirated content, as well as with the presence of a computer as a working tool almost in every family. About a quarter of participants (24.9%) are more likely to play on mobile devices — smartphones (iPhones) or tablet computer (18.4% on Android and 6.5% on iOS devices). Only 14.4% play on video game consoles (7.2% — Xbox; 3.6% — PlayStation; 3.6% — Nintendo). The share of consoles in Russia is traditionally small, and reflects the financial dependence of participants, the presence of a console is mainly due to the level of family income.

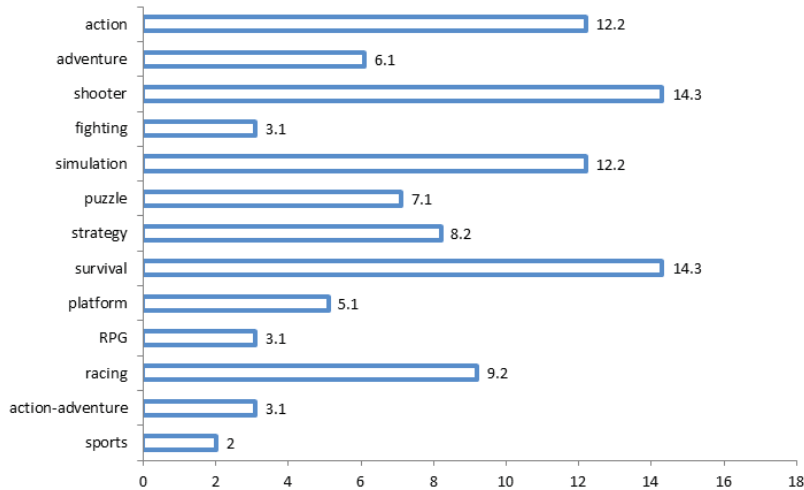


FIGURE 3. The popularity of various genres of video games among the surveyed schoolchildren (%).

According to the survey results, it turned out that the most popular game genres in this group of schoolchildren are shooter, survival, action and simulation (Fig. 3). The least popular genres are fighting, RPG, action-adventure and sports. The rest of the genres were in the group of average popularity (except for the MMORPG, which was never named).

Schoolchildren listed the names of 36 games, but the most common of them were Minecraft (16.4%), CS: GO (11%), Crossout (5.5%) and Roblox (5.5%). Every other game accounted for no more than 1–2%. It was not surprising that not a single major console project was named due to the low popularity of consoles among the masses (this is how a kind of elitism of console players is formed). It was unexpected that large serial AAA projects such as The Witcher, Need for Speed (NFS), Grand Theft Auto (GTA), Call of Duty, Assassin's Creed, Resident Evil, Tomb Raider, Halo, God of War Crysis, Heavy Rain, Uncharted, Final Fantasy, Killzone, Battlefield, S.T.A.L.K.E.R., Quake, Half-Life, etc. were named very few times (most of these titles were not named at all). The explanation for this phenomenon can be either explicit (the hardware component of the participants' gaming systems is weak and unable to support the latest versions of these games), or more complex (for various reasons, the survey participants simply do not know about the existence of these games). In any case, a separate study is needed to clarify this situation.

Answers to the question "What, in your opinion, is the benefit of video games?" is presented in Fig. 4. Most of the schoolchildren noted that games stimulate personal development (development of logic, cognitive abilities, erudition, reaction, etc.). At the same time, only 3.2% of schoolchildren noted that during the games it is possible to practice well in English.

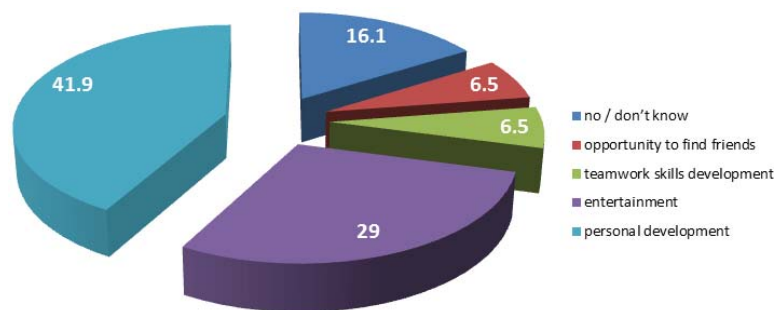


FIGURE 4. The benefits of video games according to the opinion of the surveyed schoolchildren (%).

Approximately half of the survey participants indicated that playing games can lead to vision problems (Fig. 5). 14.4% of schoolchildren believe that games can provoke the development of a kind of addiction. A relatively small proportion of children responded that games harm the nervous system (they did not elaborate on how exactly it harms) and are a waste of time.

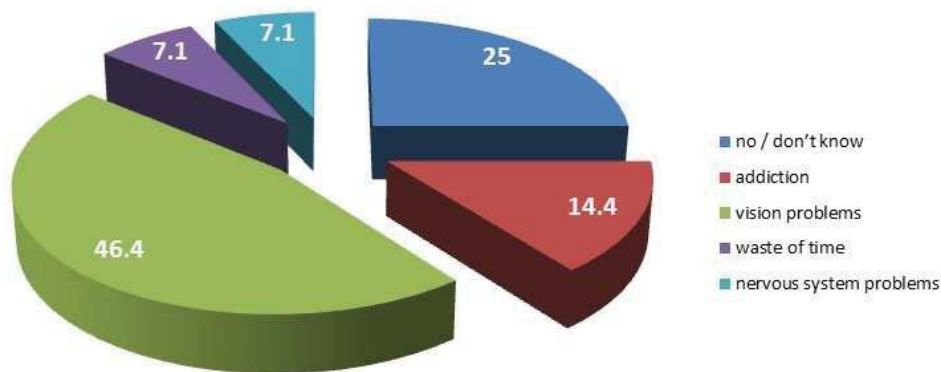


FIGURE 5. The harm of video games according to the opinion of the surveyed schoolchildren (%).

The last question in the questionnaire that was offered to schoolchildren before completing the first part of these preparatory courses was “What is your favorite discipline (s) at school?”. Among the 13 named subjects, mathematics was the leader (16.7%). Physical culture, Russian, computer science, fine arts and literature got 9.5% of the votes each. Design and technology (D&T), history, chemistry, biology and physics each scored only 4.8% (this block can be designated as natural sciences, with the exception of history and technology). Music and geography turned out to be the least popular — each of these subjects had only 2.4% of the vote. 7% of pupils have no favorite subjects at all.

The next phase was the direct conduct of the school Talant22. The schoolchildren got acquainted with the basics of virtual (VR) and augmented (AR) reality, studied various equipment (3D printer, 3D scanner, robots, etc.) and computer science. A direct analysis of the interaction of schoolchildren with VR headsets was carried out (how much time they spent on completing tasks, how many attempts did they need to successfully complete a particular task, how relaxed and free the children felt when interacting with the virtual environment, whether they improvised, etc.). Then, the schoolchildren, divided into several groups, proceeded to do their homework related to the creation of photospheres.

The survey of participants helped to reveal how various gaming systems and different genres of video games shape the certain personality traits and gaming skills that are in demand for the successful mastering of virtual reality technology.

Among the three gaming systems, video game consoles turned out to be the most effective (72.7% of the maximum assessment of the usefulness of gaming skills for mastering VR technology). PC is slightly behind them (62.6%). The least useful experience in this regard is the experience of interacting with mobile devices — Android / iOS (44.9%).

Table 3 reflects the relationship between certain skills and the success of mastering virtual reality technologies, depending on the use of various video gaming systems. As our research has shown, among all the skills, those that most effectively allow new users (who had no experience) to efficiently master virtual reality include game mechanics, controller operation skills, and the perception of 3D space. The game content of different video game systems shapes these skills to varying degrees. For the development of the perception of 3D space, PC and video game consoles are approximately equally suitable (however, consoles may have some advantage, since they are used, as a rule, in tandem with TVs of large screen diagonals, which are in any case larger than the diagonal of a computer monitor — and the size of the visible image greatly affects the perception of what is happening in the game). Games on mobile devices in this case are noticeably less effective for developing this skill. Game mechanics are much better mastered when using a controller (gamepad), and here again the consoles are in a more advantageous position (PC is in second place, Android / iOS is again in last place). When analyzing the development of skills in using a controller, consoles are the undisputed leader, in second place are mobile devices (there are no hardware (physical) buttons, so some analogue of the controller is used on the touch screen, but such control is also inconvenient for obvious reasons). The PC is the least effective here. For the sake of fairness, it should be noted that the controller can also be connected to a computer, but do not forget that the control of computer games is optimized specifically for a PC, so the keyboard and mouse are more convenient to use here in any case.

TABLE 3. The relationship between the development of certain skills and the use of a various video game systems (%).

Personality traits and gaming skills	Video game system		
	Android / iOS	PC	Console
Attentiveness	54.3	80	80
Readiness for the development of events within the location	48.6	77.1	77.1
Game mechanics	41.4	57.1	67.1
Purposefulness	62.9	82.9	82.9
Reaction	61.4	82.9	82.9
Memory development	31.4	51.4	52.9
Lateral thinking	45.7	58.6	58.6
Algorithmic thinking	48.6	58.6	58.6
Perception of 3D space	37.1	67.1	67.1
Controller operation skill	17.1	10	100

Table 4 shows the relationship between the preferred genre of video games and successful mastering of VR technology. Here we also see that the use of video game consoles contributes to the most rapid adaptation to control in the VR space. Next, in terms of usefulness, comes the PC and the least useful, as in the first case, mobile devices. Simulation, shooter, action and adventure are the leaders in terms of the combined contribution to the development of useful (for VR) gaming skills. To an average extent, these skills are developed through playing fighting, strategy, survival, racing and action-adventure. The least useful in this regard are RPG, MMORPG, platform, sports and puzzle.

TABLE 4. The relationship between the usefulness (for development of necessary skills for VR) of different video game genres and various video game systems (%).

Video game genres	Video game system		
	Android / iOS	PC	Console
Action	48	68	80
Adventure	44	68	80
Shooter	50	70	80
Fighting	38	62	80
Simulator (Sim)	48	78	84
Puzzle	50	54	64
Strategy	52	62	68
Survival	46	64	74
Platform	36	60	70
RPG	46	52	62
MMORPG	46	52	62
Racing	38	66	70
Action-adventure	44	64	76
Sports	42	56	68

Thus, the analysis of the results showed that among all the game systems and game genres considered, the greatest influence on the preparation of schoolchildren for the subsequent mastering of virtual reality technology is exerted by gaming skills acquired while playing on video game consoles. This is what allows you to quickly adapt and learn how to operate the controllers in a short time.

By completing tasks, schoolchildren who had gaming skills on Xbox and PlayStation, without having experience in a virtual environment, quickly coped with tasks that involved the active use of Oculus controllers to interact with virtual objects. Other schoolchildren experienced difficulties using Oculus controllers (they were confusing buttons, unable to hold objects etc.), as a result of which they completed tasks for longer. Participants with experience of playing on consoles did not face such difficulties.

Passion for computer games leads to another positive effect, which was revealed by the survey. It turned out that 75% of schoolchildren who do not play computer games speak English at a rather low level (children note that they learn this language at school, but know it poorly or translate only with a dictionary). Meanwhile, the vast majority of available VR projects are not translated into Russian and there is a serious risk of encountering a language barrier.

The questionnaire survey, which the schoolchildren passed after the school Talant22, provided us with additional useful and curious information. Thus, the course participants found their experience of interacting with virtual reality interesting (average score 4.7 out of 5 possible points). According to their own assessment, they did not face any serious difficulties (1.4 points out of 5 possible (where 1 is not difficult, 5 is very difficult)). The displayed content was found to be visual and accessible (4.6 points out of 5).

Side effects manifested themselves in 42.9% of schoolchildren: VR motion sickness (VR seasickness) (3.6% of schoolchildren); tired eyes (17.9%); disorientation (10.7%); fear of stumbling and falling in reality (25%). Moreover, only 3.6% of all participants experienced all four side effects. Another 7.1% had two side effects at once. All other schoolchildren (32.2%) faced only one negative symptom of interaction with virtual reality.

Due to the fact that the ready content was the result of well-coordinated work of entire teams, 82.1% of participants preferred to use ready-made developments, while only 17.9% of schoolchildren attracted to create their own. The content that they created on their own was a photosphere and was naturally less spectacular and exciting. The creation of full-fledged 3D spaces requires much more effort and a high level of training.

Moreover, the process of creating photospheres was accompanied by the help of bachelor students, so 100% of the school participants stated that they had no difficulty in creating their own content.

Also, our investigation showed that age was not of fundamental importance for the degree of success in mastering this educational program. More important was the fact discovered during the survey — more than half of the girls (54.5%) do not play video games at all, while the share of boys who gave the same answer was only 11.8%. The girls explained their attitude to video games by the fact that they perceive this activity not as useful, but as stupid fun and a waste of time. The reason for this point of view is the inability of most girls to see the benefits that many video games bring (this problem can be partially solved if children, for example, at school, are introduced to AAA games and their capabilities, although in the absence of interest in learning new things in the child this task becomes truly intractable). And the consequence of this attitude was that most girls found it more difficult to master VR technology (they spent more time completing tasks, etc.).

Thus, following the principle of Occam's razor, the most intractable (hard to solve) problems arise for the most simple and obvious reasons. As a result, one of the main goals of school education should be the massive involvement of video games in the learning process.

CONCLUSION

Our research within the framework of the Talant22 School clearly showed the importance of video games in modern education and outlined the prospects for their future use (gamification). At the same time, when we talk about gamification here, we are talking about video games and not about the introduction of individual elements of game design into the learning process. We have obtained evidence that video games as a hobby leads to more successful (high-quality and effective) mastering of virtual reality technology by children. As expected, it turned out that the vast majority of schoolchildren use a PC as their main gaming system. They use it, but not always prefer it, since there is reason to assume that many would like to have a video game console, but the financial capabilities of the family do not allow making this purchase (however, additional research is needed here). But in the process of conducting research work, it turned out that it is the use of consoles that leads to the development of skills that contribute to quick adaptation to the VR environment (the control system through a controller, similar to VR systems, plays a decisive role here; a large diagonal of the TV used during the game improves and expands the perception, as well as a fairly long history of consoles using their own VR headsets and additional controllers).

Also, unfortunately, it turned out that at the moment most schoolchildren rarely play large game projects (AAA games), which actively develop cognitive abilities (algorithmic, logical and lateral thinking, or thinking outside the box), erudition (broadening one's horizons is carried out by learning new facts, combined with visual images (thus the immersion effect is achieved)). Together, all these effects motivate children to learn new additional information on their own.

We cannot ignore the fact that the surveyed schoolchildren lack a strong desire to study physics. When mastering virtual worlds, three school subjects are of particular importance: mathematics (according to the survey results, it turned out to be a leader) — develops logical thinking; informatics (necessary for successful interaction with various computing equipment (hardware) and software) — was in the group of leaders. Physics, on the other hand, describes the surrounding material world around us and how various objects in it interact with each other (what laws describe this interaction). Knowledge of these laws is extremely important when interacting with virtual objects, and even more so when creating virtual worlds.

The most significant for the successful mastering of VR technologies and adaptation in virtual space are the following game skills: game mechanics, controller operation skills and the perception of 3D space and following game genres: simulation, shooter, action and adventure. Such conclusions were easily confirmed when comparing the time during the tasks were completed by different schoolchildren, how uninhibited and unconstrained they behaved while interacting with the VR environment, etc. (a group stood out that easily adapted and quickly began to improvise, trying new ways of interacting with virtual objects, deliberately increasing their playing time). However, according to their own assessment, all schoolchildren characterized their experience of getting to know VR as interesting and not difficult and the content shown to them as accessible and visual. At the same time, the incidence of serious and multiple side effects was low (3.6%). All this together confirms that VR technology can be implemented in many different ways in the educational process, as well as tools for creating VR content, especially the basic level of complexity (Google Street View).

The analysis of the questionnaires showed that the degree of passion for games correlates with a higher level of English proficiency, since many games and VR projects have not been translated into Russian and in order to successfully fulfill the goals and objectives there, it is necessary to read and understand English well.

In other words, in this case, games and VR content act as a useful additional language practice. The article has already noted that English is necessary for the successful mastering of VR technology and the language barrier can become a serious problem here.

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