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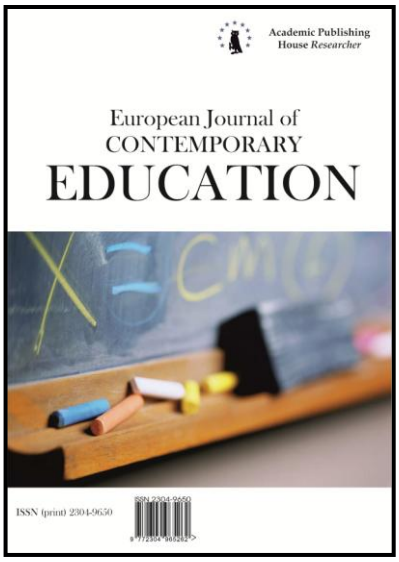

Improvement of Methodology of Teaching Natural Science for Students with Intellectual Disabilities by Means of 3D-Graphics

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Abstract

At the present stage of the development of education of persons with disabilities ways of enhancing the effectiveness of training students with intellectual disabilities undergo active research. One means of improving the efficiency and further upgrading of teaching methods is information technology. The article gives an example of improvement of methodology of teaching natural science through such information technologies as 3D-graphics. The authors assume that including animated 3D graphics in the computer educational technology, increases the level of assimilation of material by students with intellectual disabilities. The authors have developed lecture notes using the designed computer program and test tasks for the Biology course, examples of which are presented in the article. Statistical analysis of the results of testing students after the lesson and of deferred testing in 9 topics of the Biology course allowed to establish that the learning material is assimilated more intensely by students with intellectual disabilities when using 3D graphics in the learning process rather than without using it.

Keywords: methods of teaching science, information technology, 3D-graphics, control of knowledge, students with intellectual disabilities, biology lesson.

1. Introduction

Nowadays, a wide variety of information technologies are used in educational institutions to facilitate more effective learning (Bobrova & Likhacheva, 2013; Bouck et al, 2009; Garkusha, 2004; Hasselbring & Glaser, 2000; Kremer, 2004; Korolevskaya, 1996; Kukishkina 1996; Kwon, 2012; Melnikova, 2012). Teachers of correctional educational institutions actively implement existing

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computer technologies in the education of children with disabilities (Gorina & Makhotina, 2013; Glumova, 2011; Kol'tsova, 2011).

Researchers have developed and continue to develop computer programs and educational computer games for children with intellectual disabilities, that contribute to the improvement of learning motivation, help to acquire and retain new knowledge in various subject areas (Borblik & Shabalina, 2015; Renzhiglo & Voynov, 2010; Lifanova & Podvalnaya, 2010; Greshnikova, 2013; Lanyi et al, 2012; Kwon, 2012). Scientists in the sphere of Special Education note the need for the use of information technology in teaching students with intellectual disabilities due to the fact that these technologies are most adaptable to the individual needs of children of this category, help solve correctional and educational tasks in various subject areas of Special Education (Lifanova & Podvalnaya, 2010; Klyputenko, 2009; Kwon, 2012; Bouck et al, 2009; Kovalenko & Privalova, 2015; Mekie et al., 2015; Perera et al., 2014).

J. Kwon's studies (2012) found out that computer games have a common strategy with the traditional educational technologies which are used by teachers in Special Education: the presence of feedback, the practice of repeating material to attract students' attention through visual signs and auditory signals, motivation by sustaining success and individual approach. Analyzing the research of the use of computer programs in correctional education, J. Mekie and her colleagues (2015) noted that the use of information technology is rather effective in teaching students with intellectual disabilities. However, the authors' analysis of computer programs for children with developmental disabilities such as intellectual disabilities, autism spectrum disorders, leads to a conclusion that a more careful analysis of the deviations in the specifics of the development and taking into account individual characteristics of each child are required. The authors also discuss the question of what should be the degree of incorporation of information technology in the educational process of students with special needs, and to what extent they are compatible with the traditional forms of training, what should be the degree of intervention of the teacher in the learning process based on information technology. Testing a computer program developed by the authors, and its use in teaching pupils with intellectual disabilities and autism spectrum disorders showed that the audio-visual educational material helps to make learning easier for children and increases its effectiveness. However, J. Mekie (2015), E.C. Bouck and their colleagues (2009) note the lack of investigation of the influence of various computer technologies on the effectiveness of training pupils with disabilities in different school subjects. Some researchers also point out that the same computer technologies have different effects on different groups of children depending on the form of developmental disorders, so the effectiveness of the impact will also be different (Bouck et al., 2009; Main et al., 2016). We believe that the uncertainty in the responses to questions about the effectiveness of computer technology in teaching children with disabilities in general, and the nature of the impact of computer technology on the efficiency of teaching children with different variants of impaired development, in particular, is due to the intensive development of computer technology and the advent of a large number of software development, on the one hand, and the paucity of studies aimed at identifying the effects of these programs on learning processes, on the other hand. The teachers' attempt to introduce computer technology to the educational process without experimental verification is an intuitive search for effective methods of teaching, which is not always justified.

Traditionally in Russian correctional schools teaching children with intellectual disabilities, biology lessons are held with the active inclusion of visual material. Used as visual aids are 3-D objects (natural objects, models), and two-dimensional ones (figures, tables, and other schemes). In recent years, in order to explain the teaching material teachers of correctional schools apply computer technology as well, by which two-dimensional objects are demonstrated, as a rule. The use of such a demonstration is due to both the reduction in resource costs of their production and use, and the fact that the visibility of the objects displayed via computer means, are more attractive for students with intellectual disabilities than traditional ones. The use of computer tools in teaching children of this category is also justified by the fact that their educational and cognitive activity is characterized by the lack of development of higher forms of perception, visual thinking, resulting in incomplete, fragmentary notions of objects and environmental phenomena of reality, inability to operate with these notions (Vorobyov, 2014; Lifanova & Podvalnaya, 2010; Meleshkina, 2016; Melnikova, 2012; Kukishkina, 1996; Klyputenko, 2009; Lanyi & Brown, 2012; Hasselbring &

Glaser, 2000). In addition, the material of some subjects, such as biology, requires mandatory visualization of information.

3D-technology in education

We are interested in the use of 3D-technology in education. The analysis of scientific literature has shown that the set of such technologies is limited. 3D-technology is often used to study human anatomy in medical schools (Azer, Azer, 2016; Nikonorova, 2013; Ratova et al., 2012). S.A. Azer and S. Azer noted that the spatial visualization of the anatomical structure of the human with the use of 3D-technology is required for teaching of the discipline and allows students to understand the dynamic aspects of the functioning of organs and systems. Rotating and manipulating studied objects in different positions further contributes to their proper identification regardless of the angle both in a two-dimensional or three-dimensional space. In addition, this presentation of educational material allows students to see the relationship between different anatomical structures in space, as a three-dimensional computer modeling simulates the real world, and calls for increased spatial visual thinking ability.

Taking into account the educational and developmental opportunities of 3D-technology, researchers began to test them to teach people with intellectual disabilities. One example of this is a study aimed at studying the influence of 3D-graphics on social adaptation, but it relates to adults with intellectual disabilities (Lanyi et al., 2012). There are few investigations that reflect the study of the impact of 3D-graphics on the efficiency of the training of pupils of correctional schools. There may be mentioned a study conducted in Singapore by K.H. Ang and Q. Wang (2006), aimed at identifying the efficiency of 3D-graphics application in the study of astronomy (theme “Solar System”), which showed that the use of such computer technology enhances students' interest in the studied material. This result, from the scholars’ point of view, is achieved due to the fact that the children find themselves inside the three-dimensional space (thanks to the possibilities of 3D-graphics) their attention is drawn to animation, sound effects used in the program. The researchers note that the previously boisterous, unrestrained children have become more patient, ceased to miss lessons and be late for them, and actively discuss the content of the material after school.

So, today attempts are made to develop computerized programs for the education and socialization of children and adults with intellectual disabilities, including 3D-graphics, which help to more productively solve the problems of their training and forming their skills. However, the sphere of subject teaching of this category of students, their acquisition and consolidation of knowledge in certain school subjects, is still inadequately developed, which inevitably raises the question of improving or supplementing the methodology of teaching school subjects with the help of new work tools. In this case, such a tool of computer technologies, as 3D-graphics can be taken into account.

2. Method

We hypothesized that an effective way to improve the methodology for such a subject area as natural science, which makes it possible to increase the level of acquisition of knowledge by students with intellectual disabilities, will be including in the computer educational technology animated 3D-graphics, aimed at demonstrating the structure and functioning of the organs and systems of the human body. We decided to check this assumption in biology class (“Man” section) in the study unit “Musculoskeletal system. Skeleton”. Checking the effectiveness of this technology will also make it appropriate to develop 3D-products for the acquisition of other sections of biology, as well as raise the question of the application of this technology in the study of other school subjects in the special school, such as geography and technology.

In order to establish the differences in the results of students’ immediate and delayed testing of the studied material, we used the Mann-Whitney test.

Features of the developed computer technology

Computer technology that we have developed using Adobe Flash and tools like “3D-modeling”, “3D-animation”, “rigging”, allows students with intellectual disabilities to perceive three-dimensional objects (skeleton and its parts) in 3D-format and differs from the traditional perception of a three-dimensional object (skeleton) in the following ways:

1) in accordance with the algorithm of learning of the educational material the developed computer technology breaks the object of perception into larger (the skeleton of the head, torso, limbs skeleton) and smaller (parts of the skull, vertebrae and their parts, parts of the chest, and others.) parts, which enables the students to systemically and meaningfully acquire educational material;

2) it takes into account the dynamics of the learning process of the pupils by regulating the movement speed of the image and its elements on the screen, repeated demonstration of the object, its movement in the same sequence;

3) it helps compensate for lack of educational and cognitive activity of pupils due to the fact that the objects exhibited by a computer are more attractive to them.

The program is designed for the use in biology classes in a correctional school with the demonstration of 3D-objects on the interactive whiteboard. In accordance with the program content the computer technology includes such topics for study as: "The structure of bones", "Bone connection", "The structure of the skull", "Torso skeleton", "Limbs skeleton". The computer program includes both static and dynamic objects. Thus, the program provides for the possibility of the axial rotation of the skeleton and its parts – the skull, spine, limbs and their parts. All the elements of the objects depicted have inscriptions and are sounded when the cursor points to them. In addition, to attract the students' attention to one or another part of the object under study, this part is displayed when you point the cursor to it. During the study of the theme "The skeleton of the head": when you hover over parts of a three-dimensional image of the skull, they become brighter, there is an inscription in the form of strips, which is announced ("nose", "cheek-bone", "part of the temporal lobe", etc.). At any axial rotation of the object the selection of the desired portion of the object under study is maintained.

The program provides not only the possibility of introducing the material to the students, but also ways to consolidate and control the acquisition of knowledge. Thus, at the stage of the teacher's control of the mastery of knowledge inscriptions and sounding can be deactivated by pressing a special button on the interactive menu screen.

Sample lessons using computer technology. Here is a fragment of the lesson of biology using the developed computer program on the theme: "The skeleton of the head" the purpose of which is the formation of the notion of the structure of the skeleton of the head and the connection of its bones.

The teacher switches on an interactive whiteboard, enters the computer program menu "Musculoskeletal System», and then the submenu "skeleton" and then – the submenu "The structure of the skull". On the interactive whiteboard appears a three-dimensional image of the skull. The teacher begins the explanation of the new theme, accompanying his speech with questions aimed at consolidating the basic concepts and knowledge on the topic by the students.

"Under the skin and muscles of the head is the skeleton of the head, which is called" skull "(the teacher clicks on the arrows on the screen to the left and right of the image of the skull, showing the skull from all aspects). What is the name of the skeleton of the head? The bones of the skull are arranged very close to each other. Remember the name of such a bone connection (fixed connection). The skull distinguishes 2 divisions - the brain and face divisions. Which divisions are discriminated in the skull structure? Let's name the bones of the brain skull division (the teacher hovers over a particular part of the three-dimensional skull image, it becomes brighter, there is an inscription in the form of strips, which is sounded, and the students repeat these names: the frontal bone, the parietal bone, the occipital bone, the temporal bone). Please note that there are paired bones in the brain skull division: two parietal and two temporal bones (the teacher again turns the three-dimensional image of the skull with the cursor, indicating the paired bones). What are the names of the paired bones of the brain skull division? Why do you think this division of the skull is called the brain? That's right, the bones of the brain skull division protect the brain from damage. So, the bones of the brain skull division have fixed connection. What danger do you think it would be for a human being if the bones of the skull had a mobile connection? Why? "

Study Participants

In order to test the effectiveness of the developed computer educational technology and the expediency of introducing 3D-graphics in methods of biology teaching, we conducted pedagogical testing, which was organized with students with intellectual disabilities in a correctional school that

had a special education program approved by the Ministry of Education and Science of the Russian Federation (Voronkova, 2011). The study involved 10 15-16-year-old students with the conclusion "F 70 mild mental retardation", 9th graders of correctional school № 59 in Ufa, Russian Federation. According to the International Classification of Diseases, children with the conclusion "F 70 Light mental retardation" are characterized by low cognitive abilities (IQ ranging from 50 to 69) and reduced social functioning (International statistical, 2008). This group of students worked on the program with the use of 3D-graphics. Testing was conducted at the end of each lesson (Quality Control of Learning immediately after its acquisition) and at the beginning of the next lesson (delayed check of the material learned).

Examples of tests

Each test version included 5 assignments. We used the following test assignments of closed type:
1) alternative choice (valued at 1 point)
2) multiple-choice (2 points);
3) classification (3 points);
4) correspondence (3 points).
The maximum possible number of points for each test was 8 points.
Here are some examples of each of the test assignments (Figure 1-4).

Select 2 parts of the musculoskeletal system (circle one correct option of the answer):
a) skull and limbs;
b) clavicle and scapula;
c) skeleton and muscles;
d) no correct answer.

Fig. 1. Alternative choice assignment

Select the bones related to the facial division of the skull (circle the corresponding numbers in the picture):
a) frontal;
b) nasal;
c) lower jaw;
g) occipital;
d) malar.

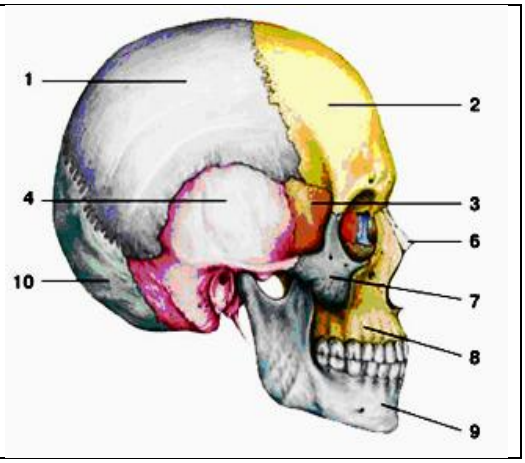

Fig. 2. Multiple choice assignment

Group limb skeletal parts into those relating to the skeleton of the upper limbs, and those relating to the skeleton of the lower limbs. Enter their names in the blank squares:
Hip bone, collarbone, foot bones, the ulna, humerus, femur.

The skeleton of the upper limbs	*The skeleton of the lower limbs*

Fig. 3. Classification Assignment

Use arrows to connect the names of the skeleton divisions and the parts that apply to them:

Skeleton head	
Torso skeleton	
Limb skeleton	

Fig. 4. Correspondence assignment

The results of the test items were analyzed by means of:

1) comparing the data obtained from the control of knowledge on the same theme at different stages – immediately after the learning and delayed;

2) comparing the results of the acquisition of knowledge of the topics that were studied with 3D-graphics and without.

Figure 5-6 are graphs of the dynamics of students with intellectual disabilities' acquisition of educational material on nine themes:

1) "Cell structure";
2) "Chemical composition of cells";
3) "Tissues. Organs";
4) "System of organs. The body";
5) "Bearing and motion. The value of the musculoskeletal system";
6) "Composition and structure of bones";
7) "Skeleton of the head";
8) "Torso skeleton";
9) "Skeleton of the limbs".

Lessons №№ 1-4 were conducted without 3D-graphics and lessons №№ 5-9 with the use of this means.

3. Results

Figure 5 and Figure 6 show the results of comparative analysis (median, minimum and maximum scores) of testing students after the lesson and through delayed testing on 9 topics of the course of biology.

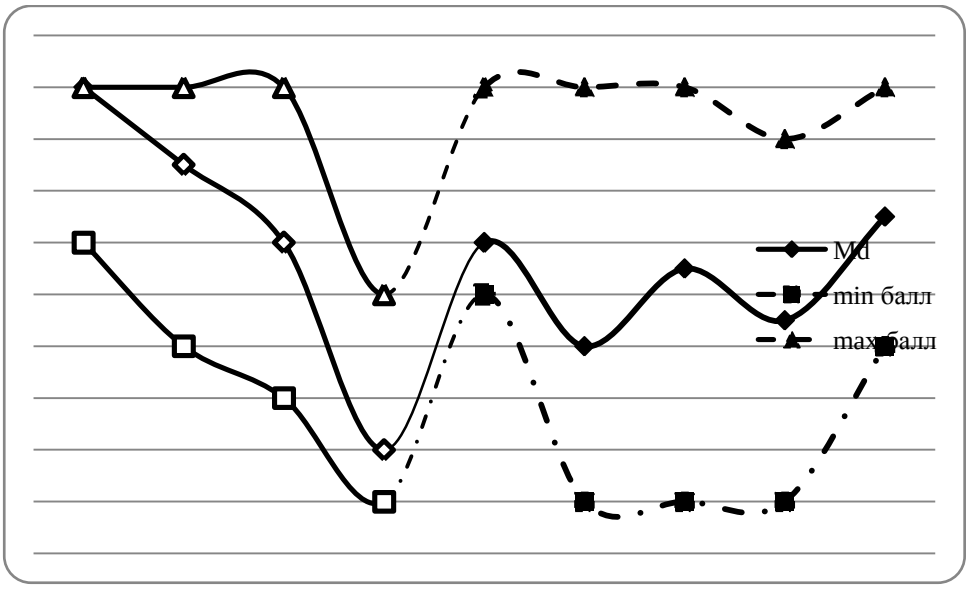

Fig. 5. Dynamics of test results of the acquisition by students with intellectual disabilities of educational material under the heading "Biology" immediately after the digestion (after the lesson)
Note. Md – median, min score – minimum result of testing, max score – the best result for the test; numbers of the lesson themes: 1 – "Cell structure", 2 – "Chemical composition of the cell", 3 – "Tissues. Organs", 4 – "System of organs. The body", 5 – "Bearing and motion. The value of the musculoskeletal system", 6 – "Composition and structure of bones", 7 – "Skeleton of the head", 8 – "Torso skeleton", 9 – "Skeleton of the limbs".

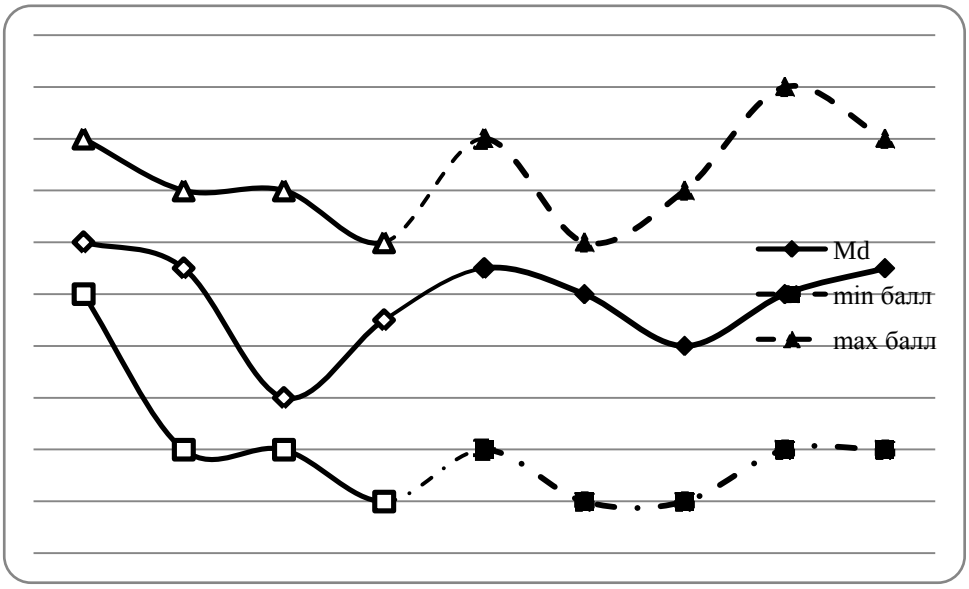

Fig. 6. Dynamics of the delayed test results of the acquisition by students with educational disabilities of educational material under the heading "Biology" (at the next lesson)
Note. See the note on Figure 5.

The results shown in the graphs make it possible to see the differences in the dynamics of the students' acquisition of the lesson material immediately after the lesson and in a delayed mode (at the beginning of the next lesson as testing the mastery of the material studied at the previous lesson). In order to establish the effectiveness of learning, we presented the results of pupils'

testing in both cases on the topics in which computer technology with 3D-graphics was not used (1 to 4 lessons) and in which it was applied (5 to 9 lessons). Graphic data enable us to see a gradual decline in test results in the traditional classroom, while beginning with the very first lesson (lesson 5) based on the computer technology we have developed there is an increase of all indicators – median, minimum and maximum scores of the test results. It should be noted that the effectiveness of the tests, conducted immediately after the lesson, is higher than that of those done at the next lesson, which corresponds to the specifics of the cognitive development of students with intellectual disabilities, that is, they are characterized by low capacity for long-term memorization. The average trend of the test results is characterized by significant jumps from higher to lower, and vice versa, at each subsequent lesson. Besides the test results shown in Figure 8, indicate a considerable variation of the minimum (from 0 to 5 points), and the maximum score (4 points with a predominance of 8 points).

Delayed test results (Figure 6) of students with intellectual disabilities have lower median values, the range of the minimum (the dominant point 1) and the maximum scores (dominated by 6 points and 7) becomes more stable. The mean values of the test results are characterized by a slight tendency to increase. The above suggests that the use of computer technology in the classroom, including 3D-graphics (under the heading "Musculoskeletal System. Skeleton") enhances the effectiveness of the acquisition by students with intellectual disabilities of the educational material, its better memorization in terms of learning stability.

We supposed that the differences in the results of immediate and delayed testing are an indicator of lower efficiency of students' assimilation of the material, because it means a rapid loss of learned knowledge, short-term memorization of the material given in class. The absence of significant differences will, on the contrary, make it evident that computer technology contributes to a better, in our case, more durable learning (Table 1).

Table 1. Statistical data of the differences of the results of immediate and delayed testing of students with intellectual disabilities (Mann-Whitney U criterion)

Lesson topics	Rank Sum (testing immediately after the lesson)	Rank Sum (delayed testing)	U	p-level
1. Cell structure	**147,50**	**62,50**	**7,50**	**0,01**
2. Chemical composition of cells	**135,00**	**75,00**	**20,00**	**0,05**
3. Tissues. Organs	**137,00**	**73,00**	**18,00**	**0,01**
4. System of organs. The body	**70,50**	**139,50**	**15,50**	**0,01**
5. Bearing and motion. The value of the musculoskeletal system	121,50	88,50	33,50	insignificant
6. Composition and structure of bones	110,00	100,00	45,00	insignificant
7. Skeleton of the head	119,50	90,50	35,50	insignificant
8. Torso skeleton	96,00	114,00	41,00	insignificant
9. Skeleton of the limbs	127,00	83,00	28,00	insignificant

The data presented in the table helped reveal the differences in the test results of students with intellectual disabilities on the topics of lessons, which were carried out without the use of such means of computer technology as 3D-graphics: "Cell structure" ($U = 7,5$; $p<0,01$), "Chemical composition of cells" ($U = 20,0$; $p<0,05$), "Tissues. Organs" ($U = 18,0$; $p<0,01$), "System of organs. The body" ($U= 15,5$; $p<0,01$).

4. Discussion

Thus, our assumption is confirmed in respect of all the themes studied. The presence of differences in the parameters “Cell structure”, “Chemical composition of cells”, “Fabrics. Bodies”, “Body System. The body” indicates that the knowledge acquired by students in biology class without 3D-graphics is not sufficiently sustainable and lost by the next lesson. On the other hand, the absence of differences in the parameters such as “Bearing and motion. The value of the musculoskeletal system”, “Composition and structure of bones”, “Skeleton of the head”, “Torso skeleton”, “Skeleton of the limbs”, testifies that the study material, which was given to the students through 3D-graphics, is quite firmly mastered by them.

The teacher’s observations of the students with intellectual disabilities’ behavior in the classroom and outside also show positive effects from the use of computer technology developed. Thus, the students’ interest in the subject under study has increased, the evidence to which is the reduction of non-attendance of biology classes, pupils’ reprobation of those classmates who are late for biology classes. Improvement of the students’ cognitive activity is evidenced by the fact that they are more likely to ask the teacher questions about the lesson, express surprise at the facts reported in biology classes, ask the teacher to carry out all subsequent lessons using this computer technology. Increased comprehension of the academic material is demonstrated through students’ judgments, which they started making in connection with viewing animations and teacher’s explanations.

The impact on the educational and cognitive activity of students with intellectual disabilities by means of computer animation with the use of 3D-graphics was undertaken eventually to increase the effectiveness of teaching methodology aimed at the assimilation of such a complex area of knowledge, as natural science.

5. Conclusion

Methods of teaching any school discipline require constant improvement. Today, one of the means of such improvement is the inclusion in the educational process of various computer technologies, including those with the use of 3D-graphics.

Being included in the educational process of the correctional school, the computer program developed by the authors will help to optimize the process of assimilation of scientific knowledge by students with intellectual disabilities. It takes into account the peculiarities of perception and learning of children with intellectual disabilities and complement (not replace) traditional means of explaining educational material in the classroom. The developed computer technology is correlated with the program content for the academic subject “Biology” (see “The Man”) and completely controlled by the teacher.

The computer program makes it possible to repeatedly return to the studied material. The teacher can use it not only to explain the new material, but also to consolidate it, which is an important argument in favor of its use for teaching students with intellectual disabilities, whose memory is characterized by fragile and incomplete retention of material, rapid loss of what has been learned. In addition to the possibilities of explaining and consolidating educational material, the program can also be used as a tool for monitoring the assimilation of the material by using commands to mute and switch off popup labels.

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References

Ang, Wang, 2006 – *Ang, K.H., & Wang, Q.* (2006). A case study of engaging primary school students in learning science by using Active Worlds. *Proceedings of The First International LAMS Conference: Designing the Future of Learning*.

Azer, Azer, 2016 – *Azer, S.A., & Azer, S.* (2016). 3D anatomy models and impact on learning: a rewiew of the quality of the literature. *Health Professions Education,* 2, 80-98.

Bobrova, Likhacheva, 2013 – *Bobrova, V.V., & Likhacheva, E.N.* (2013). Innovational technologies of the development of visual perception of children with intellectual disabilities through computer technology. *Educational Technology & Society*, 16, 293-301.

Borblik, Shabalina, 2015 – *Borblik, J.V., & Shabalina, O.A.* (2015). The use of educational games in the teaching process at correctional schools of type VIII. *Educational Technology & Society*, 18 (1), 427-439.

Bouck et al., 2009 – *Bouck, E.C., Bassette, L., Taber-Doughty, T., Flanagan, S.V., & Szwed, K.* (2009). Pentop Computers as Tools for Teaching Multiplication to Students with Mild Intellectual Disabilities. *Education and Training in Developmental Disabilities,* 44(3), 367-380.

Garkusha, 2004 – *Garkusha, Y.F.* (2004). New informational technologies in speech therapy. *Logopedist*, 4, 22-28.

Glumova, 2011 – *Glumova, N.I.* (2011). The use of information and communication technology at lessons of Russian in type VIII correctional school as a means of enhancing students' learning capacity. *Vestnik of Mari State University*, 7, 149-151.

Gorina, Makhotina, 2013 – *Gorina, E.N., & Makhotina, A.N.* (2013). The use of computer technology in the instruction of different categories of students. *Correctional Pedagogy: theory and practice,* 2 (56), 58-61.

Greshnikova, 2013 – *Greshnikova, M.A.* (2013). Teaching math skills to students with intellectual disabilities through ICT. *Topical problems of human and natural sciences*, 9, 194-196.

Hasselbring, Glaser, 2000 – *Hasselbring, T.S., & Glaser, C.N.* (2000) Use of computer technology to help students with special needs. *The future of children*. 10 (2). 102-122.

Klyputenko, 2009 – *Klyputenko, V.V.* (2009). *Formation of mathematical notions of preschool children with intellectual disabilities through computer technology. Abstract of the candidate of pedagogic sciences thesis. Moscow.*

Kol'tsova, 2011 – *Kol'tsova, S.N.* (2011). Teaching elementary geometry to students of type VIII correctional schools through ICT. *Vestnik of Mari State University*, 7, 156-159.

Korolevskaya, 1996 – *Korolevskaya, T.K.* (1996). "Visual speech": new technology – new relationships. *Defectology,* 2, 51-57.

Kovalenko, Privalova, 2015 – *Kovalenko, O.V., & Privalova, O.V.* (2015). Using computer technologies and developing equipment in mathematics lessons in teaching children with intellectual disabilities. *Kazakh and American Free University Bulletin. Scientific journal. Issue №5: Problems of psychology. Personality, education, society. Ust-Kamensk,* 101-107.

Kremer, 2004 – *Kremer, O.B.* (2004). Original computer games as a means of pedagogical communication to realize individualized teaching at type VIII correctional school. *E-journal of the Internet Education Federation of Moscow Internet Education Centre "Problems of internet education",* 2, 54-58.

Kukishkina, 1996 – *Kukishkina, O.I.* (1996). "World outside your window" program. Seasons of the year. *Defectology, 5, 65-72.*

Kwon, 2012 – *Kwon, J.* (2012). The Development of Educational and/or Training Computer Games for Students. With Disabilities. *Intervention in School and Clinic*, 48 (2), 87-98.

Lanyi et al., 2012 – *Lanyi, C.S., Brown, D.J, Standen, P., Lewis, J., & Butkute, V.* (2012). Results of user interface evaluation of serious games for students wits intellectual disability *Acta Polytechnica Hungarica*, 9 (1), 225-245.

Lifanova, Podvalnaya, 2010 – *Lifanova, T. M., & Podvalnaya, E.V.* (2010). Ways of making and using multimedia presentations at geography lessons in type VIII correctional schools. *Correctional Pedagogy: Theory and Practice*, 4 (40), 36-40.

Main et al., 2016 – *Main, S., O'Rourke, J., Morris, J., & Dunjey, H.* (2016). Focus on the journey, not the destination: Digital games and students with disability *Issues in Educational Research,* 26 (2), 316-331.

Mekie et al., 2015 – *Mekie, J., Mehta, D., & Sajja, P.A.* (2015, May, Special Issue). Survey on Effects of Computer Based Technology for Special Needs Learners. *International Journal of Advanced Networking Applications, pp.* 29-33.

Meleshkina, 2016 – *Meleshkina, M.S.* (2016). Multimedia technology as a means of developing natural science notions of teenagers with intellectual disability // *Scientific-methodological E-journal "Concept",* 5. URL: http://e-koncept.ru/2016/16111.htm.

Melnikova, 2012 – *Melnikova, O.A.* (2012). Senior preschool child with underdeveloped speech ability: Complex of didactic computer games to overcome it through training skills of mediated memorizing. *Bulletin of the University of the Russian Academy of Education*, 1, 65-67.

Nikonorova, 2013 – *Nikonorova, M.L.* (2013). Computer models medical imaging in practice of studying «Human anatomy». *St. Petersburg State Polytechnical University Journal. Humanities and Social Sciences*, 2, 121-125.

Perera et al., 2014 – *Perera, N.T., Wijerathne, I.S., Wijesooriya, M.M., Dharmarathne, A.T., & Weerasinghe, A.R.* (2014). A Game Based Learning Approach to Enrich Special Education in Sri Lanka. *International Journal on Advances in ICT for Emerging Regions,* 07 (2), 1-15.

Programs of special, 2011 – Programs of special (correctional) educational institutions of type VIII: 5-9 forms. In two books (2011). edited by V. V. Voronkova. – Moscow: Humanitarian publishing centre VLADOS, Book 1. 224 p.

Ratova et al., 2012 – *Ratova, M.R., Shilina, N.G., Kichigina, E.I., & Myagkova, E.G.* (2012). Analysis of usage 3D-graphics in education in medical high school. *Siberian Pedagogical Journal,* 5, 55-60.

Renzhiglo, Voynov, 2010 – *Renzhiglo, L.M., & Voynov, I.D.* (2010). New technologies in logopedics based on the methods of computer stabilography. *News of Southern Federal University. Pedagogical Sciences,* 110 (9), 217-219.

Vorobyov, 2014 – *Vorobyov, G.* (2014). Information technology in correctional-developing work with children with disabilities in the educational. *World of Science. Pedagogy and Psychology*. 3, 1-4.

International statistical, 2008 – International statistical classification of diseases and related health problems. – 10th revision, 2008 edition. URL: http://apps.who.int/classifications/ icd10/browse/ Content/statichtml/ICD10Volume2_en_2008.pdf (date of treatment: 11.01.2014).