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Visualization of the content of information technologies: supporting the education of students with autism

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Abstract. Psychologists, teachers of inclusive education (for example, a teacher's assistant), parents, and IT specialists are involved in the process of teaching students with autism. Modern information technologies of education support can help paraprofessionals to perform their functions. Virtualization of educational content, namely avatars in the mode of augmented (virtual) reality, will allow taking into account the personal learning opportunities and needs of students with autism. The semantic differential method should be used to understand how the proposed virtual assistant satisfies the individual characteristics of such a student.

Keywords: autism, autistic spectrum disorder, semantic differential, avatar, information technologies of education support, content visualization

INTRODUCTION

Having strains in communication, children with an autistic spectrum disorder might experience difficulties in socialization. One of the effective methods of socializing students with autism is education. However, the realities of today`s Ukraine are such that people with special educational needs often have difficulty obtaining a full school and vocational education. The implementation of the basic principles of inclusive education, which is based on racial equality, equal treatment of each student, regardless of his or her nosology, an adaptation of educational institutions to individual needs, and ensuring equal access to quality educational services, will help to overcome such educational problems. Among the main conditions for the successful implementation of inclusive education is to provide students with modern information and communication and multimedia technologies to support inclusive education [1].

Augmented and virtual reality (AR, VR) technologies were among the most promising technologies for supporting the education of children with autism. Such technologies make it possible to create environments where students with autism can learn and re-perform various tasks. For a student with autism spectrum disorders in augmented reality, it is important to interact with virtual assistants – avatars.

In this paper, it is proposed to use the semantic differential method, also known as the method of Charles Osgood, to diagnose (study) the interaction of avatar and student with autism. It is a method of psycholinguistics in which measured objects, such as images, are evaluated on a set of bipolar graduated scales whose poles form verbal antonyms. Such studies are the latest in Ukraine and have not been conducted for students with autism.

STATE OF THE ART

The model in [2] implements an approach to the education of people with special needs as a complex iterative process. It takes into account a large number of specific parameters and prerequisites, and consists of four successive stages: determining the characteristics of psychophysical development; personalization of the purpose of training; formation of a personal learning trajectory; analysis of the implementation of the educational trajectory. The implementation of each stage is the consistent implementation of certain tasks related to the organization and support of training of people with special needs. The model of the process of IT support of such training reflects the methods and means of information technology, the use of which allows to improve the learning process of a person with personal needs, taking into account the consistent and parallel educational tasks that arise in such a process. The use of modern methods and tools to support the learning of students with autism makes it possible to improve such a model. The concept of a comprehensive process of IT support for teaching students with autism is presented in Fig. 1.

Complex IT support for students with autism involves the involvement of Psychological, medical, pedagogical institutions on a regular basis as a subject of psychophysical diagnosis. The concept supports the changing role of such institutions in supporting the education of a student with autism – from a one-time procedure to determine the characteristics of psychophysical development to a permanent participant in the process of supporting the education of a student with autism. Appropriate information technologies will ensure the continuity of participation in

such a process [3-5]. Such technologies should also provide a constant connection and transfer of data on the peculiarities of psychophysical development and changes in it between the participants in the learning process of a child with autism – during training in an inclusive classroom and in after-school education.

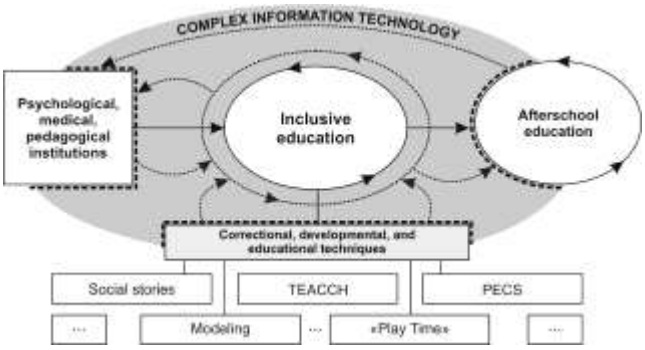

Fig. 1. The concept of complex IT support of the education of students with autism

The model of complex information technology support for children with autism is conveniently presented as a Diagram of States (Fig. 2), where each vertex corresponds to the actions performed with IT support, the set of which, in fact, forms a complex IT support for students with autism.

In this work, attention is focused on the process of selecting a virtual learning assistant – an avatar. An appropriate method has been developed, and that takes into account the capabilities and characteristics of students with autism while choosing a personalized avatar, as well as involving all relevant participants of the educational process.

THE METHOD OF VIRTUALIZATION OF THE CONTENT OF EDUCATIONAL IT FOR STUDENTS WITH AUTISM

Augmented reality is an effective learning technology that reproduces (complements) 3D models on a real stage in real-time. To implement AR, a smartphone, laptop, or PC with a camera and the appropriate software are enough. Full operation is possible with the use of special markers or on the basis of GPS data and recognition of real-world objects, such as your own face. As an example, we can cite augmented reality in the IKEA Catalog application, which allows users to select virtual items from the catalog and place them in their room.

Augmented reality technology seems to be specifically designed for students with autism because teaching methods using modern computer and multimedia technologies for such people have proven to be more effective than traditional teaching methods. Some existing studies have found that people with autism find interacting with a computer or tablet less stressful and more attractive than interacting with people, which contributes to in-depth learning [6].

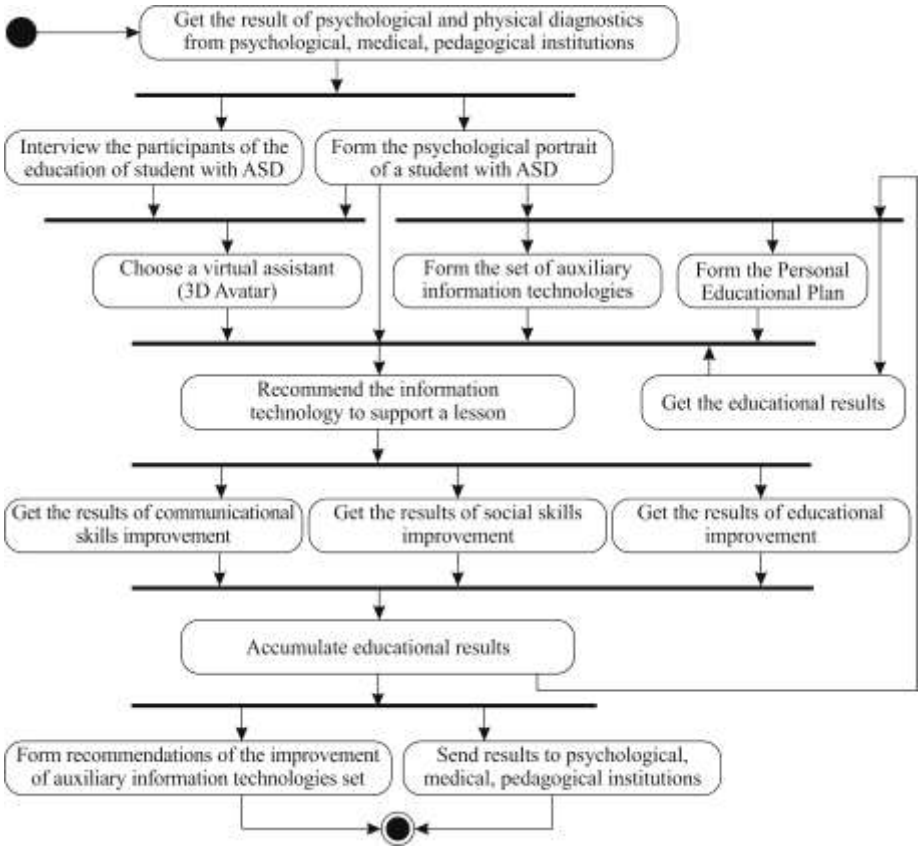

Fig. 2. Model of complex IT support education of the student with autism

AR technology was described by the authors M.F. Syahputra, O. Sheta, and others [7] and based on the Likert scale with an average percentage of 71.18%, respondents agree that the system can support the visualization of social behavior for children with autism with the correct interpretation and understanding of the surrounding social situations. In turn, authors Jorge Brandão, Pedro Cunha and others suggested the everyday use of augmented reality technology to motivate and engage children with autism in interactive learning activities. The authors proposed to design and develop an innovative gamebook that will help such people to recognize emotions, attracting their attention and motivation, to improve learning skills. A child with autism will have to interact with different scenarios, interact with a 3D avatar, a boy Tobias [8]. Communication with the avatar makes the learning process simple and interesting, as demonstrated by the software application TellaGammi for creating and sharing fast animated videos using the Gami avatar [9]. Persefoni Karamanoli, Avgoustos Tsinakov, and Charalampos Karagiannidis [10] described augmented reality studies for people with autism with prior assessment and follow-up suggestions for improving appropriate software applications.

The need to take into account the personal needs and capabilities of the student to improve his interaction with educational content complicates the process of modeling a virtual assistant (hereinafter – the avatar). Conceptually (Fig. 3) the process of selecting an avatar can be represented by three blocks:

- input data obtained from psychological, medical, and pedagogical institutions, as well as expert evaluation of test avatars [11];
- data processing, where expert evaluations, obtained from process participants, are processed by different methods (semantic differential method [12, 13], machine learning methods [14], etc.);
- virtualization of content, where based on the dependencies obtained as a result of data processing, taking into account the personal characteristics of the student [15] and the objective requirements of IT development standards [16-18] for people with special needs, an avatar is modeled.

In general, the method of method of content virtualization of educational IT for students with autism is convenient to perform with the following steps.

Step 0. Create a library of avatar prototypes.

Step 1. Select prototype avatars based on the analysis of the psychophysical portrait of a student, created on the basis of the results of psychological and physical diagnosis of the student and the quantitative characteristics of his learning.

Step 2. Conduct expert evaluation of avatar prototypes. Consolidate the results of subjective assessment of avatar prototypes by parents and students with autism.

Step 3. Model a personal avatar to assist a student with autism.

Step 4. Evaluate the features of the student's learning and update the library of avatar prototypes.

As mentioned earlier, the study focuses on the step of expert assessment of avatar prototypes, taking into account the assessments of paraprofessionals and subjective assessments of avatar prototypes made by parents and students with autism. Conceptually, this step can be presented as in Fig. 4.

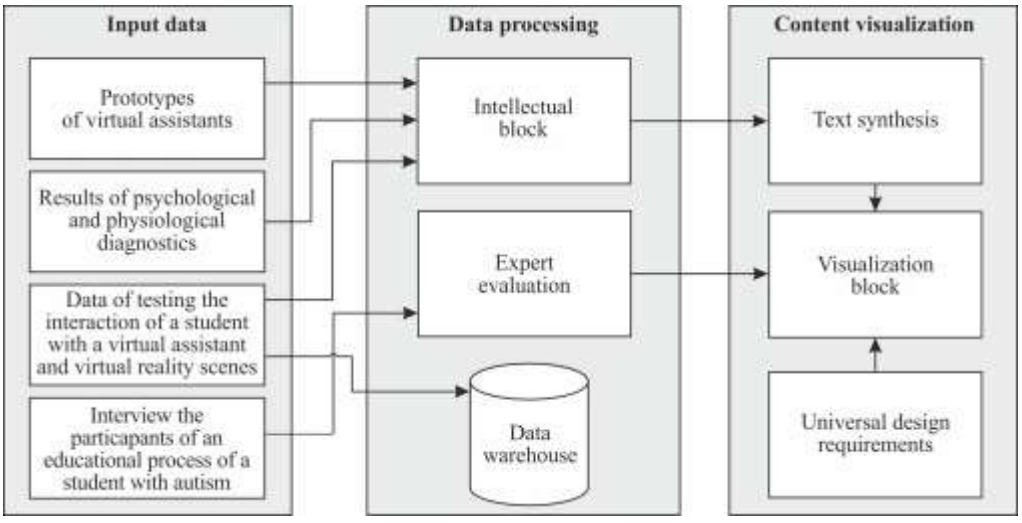

Fig. 3. The concept of the method of virtualization of the content of educational IT for students with autism

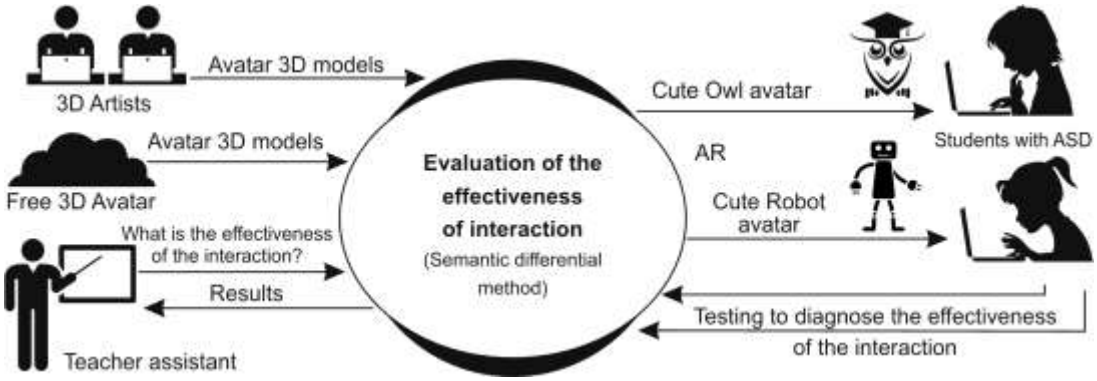

Fig. 4. The concept of the step of expert evaluation of avatar prototypes

This step involves various participants in the process of teaching students with autism, i.e. paraprofessionals, parents and students with autism, and their participation in the process should be organized in parallel. Paraprofessionals evaluate prototypes of avatar using the semantic differential method, which uses questionnaires, and the obtained data are processed by statistical methods [12]. Children with autism and their parents evaluate the same avatars, and to collect the results of the evaluation it is advisable to use a combination of machine learning methods that allow *reading* the emotions of the child and thus establish his attachment to a particular avatar.

This step of the method of virtualization of the content of educational IT for students with autism will be presented by the Petri net, a convenient tool for modeling processes that illustrates sequential and parallel tasks performing (Fig. 5, Table 1, Table 2).

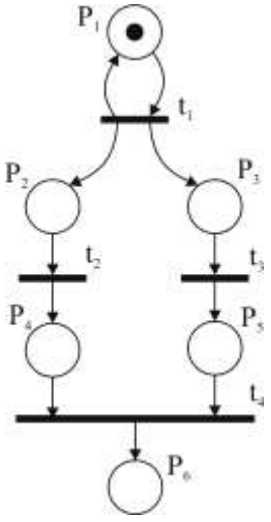

Fig. 5. Model of the process of expert evaluation of avatar prototypes

EXPERT EVALUATION OF AVATAR PROTOTYPES BY PARAPROFESSIONALS

In the process, modeled in Fig. 5, is a survey on the perception of the test avatar. To conduct such an assessment, it is advisable to use the semantic differential method.

TABLE 1. THE TRANSITIONS OF PETRI NET

Transiton	Explanation
t_1	Activation of the set of avatars prototypes selected on the basis of the results of psychological and physical diagnosis of a student with autism
t_2	Expert evaluation of avatar prototypes by paraprofessionals
t_3	Consolidation of the results of subjective evaluation of avatar prototypes by parents and students with autism
t_4	Formation of a comprehensive assessment of the avatar

TABLE 2. THE POSITIONS OF PETRI NET

Position	Explanation
p_1	The set of prototype avatars, selected based on the results of psychological and physical diagnosis of a student with autism
p_2	Expert evaluation of avatar prototypes
p_3	Multidimensional data on the results of student interaction with avatar prototypes
p_4	Estimates of avatar prototypes obtained from paraprofessionals
p_5	Subjective assessment of avatar prototypes by a student with autism
p_6	Personalized avatar characteristics

The Semantic differential method

The semantic differential method was proposed by Charles Osgood in 1952 for quantitative and qualitative measurement of word meanings, using bipolar scales given by pairs of antonymous adjectives [19]. The respondent is presented with an appropriate list (usually written on a separate card) and asked to rate a particular object (in this case, the interaction between a student and an avatar) on a 7-point scale.

In [19], Osgood's method is used to describe the behavior and emotions of students. Between the statements of each pair, for example, *boring-interesting*, *soft-hard*, it should be left seven underlined fields. The field in each pair, which most closely corresponds to the idea of students' emotionality, is marked with a cross. These scales are suitable, first of all, for comparison of objects among themselves. In [20], the semantic differential method was used to diagnose the evaluation of the properties of the

interlocutor. The psychoacoustic properties of the voice, ways of organizing a long speech, other components, and the actual content characteristics of the message were taken into account. The semantic differential makes it possible to integrally describe the psychoacoustic on the complex of his vocal and linguistic features.

By implementing the semantic differential method to the problem of personally fitted avatar for a student with autism, parafacists - teachers of inclusive education and their assistants, school psychologists, psychological, medical, pedagogical institutions specialists, can evaluate the proposed avatars, for example, using a questionnaire implemented as a Google form, sent by e-mail (Fig. 6).

Fig. 6. Questionnaire for the semantic differential method, organized in the format of Google-form

Evaluation of an Avatar is performed on a seven-point scale, where: "0" is when the respondent can not attribute the quality of the specified characteristics to this avatar; "-1"… "1" for the quality that is present in the 3D Avatar to a small extent; "-2"… "2" for quality that is present on average; "-3"… "3" is the highest degree of the specified characteristic.

The results of the survey are processed with a semantic differential method [12, 21], and the results are conveniently presented by the semantic space [22, 23] (Fig. 7).

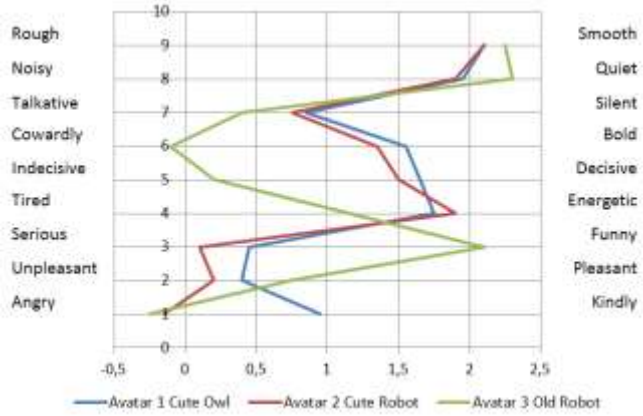

Fig. 7. The results of a semantic differential method

Aditinally, such resuts are the input data to factor analysis, performed with SPSS tool of statistical data analysis. As the factors were chosen Cute Owl Avatar (Component 1), Cute Robor Avatar (Component 2), and Old Robot Avatar (Component 3). According to the Kaiser-Meyer-Olkin Measure of Sampling Adequacy, the data that being analyzed have sufficient adequacy (0,7); Barlett' Test of Sphericity proves the data are suitable for factoring analysis, when level is less then 0,05 (and it is 0.04 for the data being analyzed), see Fig. 8.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,439
Bartlett's Test of Sphericity	Approx. Chi-Square	62,904
	df	36
	Sig.	,004

Fig. 8. The KMO and Bartlett's Test at SPSS factor analysis

By calculating the total Total Variance (Fig. 9), we come into conclusion that only first three factors are chosen for for the next analysis, as they explain totally the 70,104% of total dispersion.

According to rotated component matrix data (Table 3), the *Noisy-Talkative* pair correlates the most with Cute Owl Avatar (0,916), and pair *Unpleasant-Pleasant* is connected with Cute Robot Avatar (0,914).

Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,719	30,216	30,216	2,303	25,592	25,592
2	1,950	21,664	51,880	1,786	19,845	45,437
3	1,424	15,819	67,699	1,648	18,308	63,745
4	1,108	12,316	80,015	1,464	16,270	80,015
5	,766	8,510	88,525			
6	,464	5,154	93,679			
7	,277	3,078	96,758			
8	,192	2,131	98,888			
9	,100	1,112	100,000			

Extraction Method: Principal Component Analysis.

Fig. 9. The total variance explanation

TABLE 3. THE ROTATED COMPONENT MATRIX

Rotated Component Matrix			
	Component		
	1	2	3
Rough - Smooth	0,771	0,253	0,158
Noisy - Quiet	0,903	0,087	0,157
Talkative - Silent	0,916	-0,009	0,085
Cowardly - Bold	0,045	0,010	0,821
Indecisive - Decisive	0,384	0,499	0,381
Tired - Energetic	0,172	0,141	0,764
Serious - Funny	0,569	0,589	-0,064
Unpleasant - Pleasant	0,061	0,914	-0,044
Angry - Kind	0,049	0,719	0,213

SUBJECTIVE EVALUATION OF AVATAR PROTOTYPES BY PARENTS AND STUDENTS WITH AUTISM

Obtaining avatar grades from a student with autism is complicated by the peculiarities of her psychophysical condition (students with autistic spectrum find it difficult to communicate with other children or adults, such students are often non-verbal communicators). Therefore, we consider it appropriate to use machine learning methods that provide automatic recognition of the student's face with reactions to the relevant avatars. This approach is described in [14]. In parallel with the recording of facial expressions of a student with autism, assessments of avatars and parents of students accumulate. The results of comparing the child's response and the parent's response to this response will help to accumulate input for intelligent data processing methods, and over time reduce the need to involve parents in assessing the child's reactions. This improvement of the processes of recording the facial expressions of a student with autism will allow to dynamically, in the educational process, read the information and interpret it, thus taking into account the child's personal reactions to what is happening around.

The results of assessments obtained by the semantic differential method (from paraprofessionals) and using machine learning methods (from evaluations of students and their parents` assesments) are consolidated and are the input for the avatar virtualization step.

In the step of avatar virtualization, in addition to its basic characteristics determined during the evaluation of avatar prototypes, it is also necessary to take into account communication aspects, in particular, those text messages that broadcast avatars (Fig. 10). This should be done using a model of the processes of analysis and synthesis of the text [15, 26-29].

Fig. 10. Text communication of avatars

For example, to study texts, both oral or written, generated by teachers and parents, it is advisable using approaches of statistical text analysis [24, 25]. For example, such a characteristic of the studied texts as the frequency of words used in greetings or to motivate an action can be used to create a communication dictionary of the avatar. It is advisable to dynamically update this dictionary during the

learning process and use it to personalize the communication processes during the learning of a student with autism.

The implementation of universal design methods is a necessary condition when developing software for a student with an autism spectrum disorder. Relevant standards for the IT industry have been developed and implemented [17, 18], and to be guided by them during software development is no longer the rule of good manners, but becomes the default requirement.

CONCLUSIONS

Education as a means of socialization of children with autism definitely needs support by information technologies. In nowadays, when distance education became an obligation but not a choice, the appropriate information technologies are developed rapidly, which is very good for children, who have difficulties with communication. The visualization of education of children with autistic spectrum disorder is very well accepted by the children, and the development of the method of personalization of visual content of the educational technology is an actual task, both scientific and practical. Virtual assistants should look and act to support the navigation through the learning process, and making avatars personally fitted for the student will increase the efficiency of the studying process. references

REFERENCES

1. **Gheta A., et.al. 2018.** Modern ICT technologies to support inclusive education, Poltava (in Ukrainian).
2. **Shestakevytch T. 2017.** The method of education format ascertaining in program system of inclusive education support, Proceedings of the 12th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2017, 1, art. no. 8098786, pp. 279-283.
3. **Andrunyk V., Shestakevych T., Pasichnyk V. 2018**. The technology of augmented and virtual reality in teaching children with ASD. Econtechmod: scientific journal, Lublin. Vol. 7, No 4, pp. 59-64.
4. **Vasyliuk V., Shyika Y., Shestakevych T. 2020**. Information system of psycholinguistic text analysis (2020) CEUR Workshop Proceedings, 2604, pp. 178-188.
5. **Andrunyk V., Pasichnyk V., Kunanets N., Shestakevych T. 2019.** Multimedia educational technologies for teaching students with autism. 2019. CEUR Workshop Proceedings. Vol. 2533: Proceedings of the 1st International workshop on digital content & smart multimedia (DCSMart 2019), Lviv, Ukraine, December 23–25, 2019. Vol., pp. 237–248.
6. **Andrunyk V., Shestakevych T., Pasichnyk V., Kunanets N. 2018.** Information technologies for teaching student with autism, Lviv Polytechnic National University bulletin, , Lviv, vol. 901, pp. 76–88.
7. **Syahputra M. F., Arisandi D., Lumbanbatu A. F., Kemit L. F., Nababan E. B., Sheta O. 2018.** Augmented reality social story for autism spectrum disorder. 2nd International Conference on Computing and Applied Informatics. 2017 IOP Publishing IOP Conf. Series: Journal of Physics: Conf. Series 978, 012040 doi :10.1088/1742-6596/978/1/0120
8. **Jorge Brandão, Pedro Cunha, José Vasconcelos, Vítor Carvalho and Filomena Soares. 2015**. An Augmented Reality GameBook for Children with Autism Spectrum Disorders, ICELW 2015 June 10th-12th, New York, NY, USA
9. Tellagami labs, URL: https://tellagami.com
10. **Persefoni Karamanoli, Avgoustos Tsinakov, Charalampos Karagiannidis. 2017.** The Application of Augmented Reality for Intervention to People with Autism Spectrum Disorder / IOSR Journal of Mobile Computing & Application (IOSR-JMCA), e-ISSN: 2394-0042. Volume 4, Issue 2 (Mar.-Apr. 2017), pp. 42-51.
11. **Andrunyk V., Shestakevytch T., Pasichnyk V. 2018**. The technology of augmented and virtual reality in teaching children with ASD, ECONTECHMOD 2018, Vol. 07, No. 4, pp. 59 – 64.
12. **Trofimov A., Miliutina K., Drobot O., Lyuta L., Otych D., Pustovyi S., Karamushka T. 2019**. A study on psychological capital by a method of semantic differential, Humanities and Social Sciences Reviews, 7 (5), pp. 387-392.
13. **Jylhä H., Hamari J. 2019.** An icon that everyone wants to click: How perceived aesthetic qualities predict app icon successfulness, International Journal of Human Computer Studies, 130, pp. 73-85.
14. **Andrunyk V., Yaloveha O. 2020**. Information System for Monitoring the Emotional State of a Student with Special Needs Using AI, 2020 IEEE 15th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2020 - Proceedings, 1, art. no. 9321933, pp. 66-69.
15. **Andrunyk, V., Bekesh V., Chyrun L. 2014**. Structural modeling of technical text synthesis and analysis, Lviv Polytechnic National University Bulletin, vol. 805, pp. 237–257.
16. **Farinazzo Martins, V., Amato, C.A.H., Eliseo, M.A., Silva, C., Herscovici, M.C., Oyelere, S.S., Silveira, I.F. 2019**. Accessibility recommendations for creating digital learning material for elderly, Proceedings - 14th Latin American Conference on Learning Technologies, LACLO 2019, art. no. 8995129, pp. 81-86.
17. **Radianti J., Gjøsæter T., Chen W. 2019**. Universal design of information sharing tools for disaster risk reduction, IFIP Advances in Information and Communication Technology, 516, pp. 81-95.
18. **Pasichnyk V., Shestakevych T., Kunanets N., Andrunyk V. 2018.** Analysis of completeness, diversity and ergonomics of information online resources of diagnostic and correction facilities in Ukraine, CEUR Workshop Proceedings, pp. 193-208.
19. **Manheim R., Reech R. 2003.** Polytology: Methods of analysis, Moscow.
20. **Balin V., Ghayda V., Gerbachevskyy V. 2003**. Practicum on basic, experimental and applied psychology, StPetersburg, 2003 (in Russian).
21. **Eger L., Egerová D., Pisoňová M. 2018.** Assessment of school image [Ocena šolske podobe], Center for Educational Policy Studies Journal, 8 (2), pp. 97- 122.
22. **Kyshtymova I.M., Rozhkova N.A. 2019**. Public standing of a teacher and its adjustment, European Journal of Contemporary Education, 8 (2), pp. 294-302.

23. **Freeman V. 2018.** Speech intelligibility and personality Peer-ratings of young adults with cochlear implants, Journal of Deaf Studies and Deaf Education, 23 (1), pp. 41-49.

24. **Leavy S., Keane M.T., Pine E. 2019.** Patterns in language: Text analysis of government reports on the Irish industrial school system with word embedding, Digital Scholarship in the Humanities, 34, pp. I110-I122.

25. **Tolston M.T., Riley M.A., Mancuso V., Finomore V., Funke G.J. 2019.** Beyond frequency counts: Novel conceptual recurrence analysis metrics to index semantic coordination in team communications, Behavior Research Methods, 51 (1), pp. 342-360.

26. **Zavushchak I., Burov Y., Pasichnyk V. 2018**. Context Modelling In Process of Developing Employment Solutions ECONTECHMOD, Vol. 07, No. 3, pp. 47 – 52.

27. **Rybchak Z., Basystiuk O. 2017.** Analysis of methods and means of text mining ECONTECHMOD. Vol. 6, No. 2, pp. 73–78.

28. **Duduciuc Alina. 2015.** Advertising Brands By Means Of Sounds Symbolism: The Influence Of Vowels On Perceived Brand Characteristics, Studies and Scientific Researches. Economics Edition, Vasile Alecsandri University of Bacau, Faculty of Economic Sciences, issue 21, pp. 112-119.

29. **Zavuschak I. 2017.** The context analysis and the process of its formation ECONTECHMOD, Vol. 6, No. 2, pp. 67–72.