Issue 9, 2021

https://doi.org/10.23939/sisn2021.09.122

UDK УДК 004.9:376.091.33-056.3](043.3)

INFORMATION TECHNOLOGY SUPPORT OF EDUCATION OF STUDENTS WITH AUTISM: ASPECTS OF VIRTUAL ASSISTANT MODELING

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People with autism find that interacting with a computer or tablet is less stressful and more attractive than interacting with people. The analysis of information technologies developed both abroad and in Ukraine reveals the lack of systematic support for the education processes of people with autism. In this context, the development of personalized information technology support for the learning processes of such students is an urgent scientific and practical task. To achieve this goal it is necessary to explore the theoretical and methodological foundations of teaching people with autism and state the role of IT support of such education. Experts agree that the main areas of development of information technology to support the training of students with autism are the improvement of communication skills, improvement of social communication, and academic training.

The method of personalization of virtual content of information technologies developed or adjusted to support education of students with autism should take into account the results psychological diagnostics of a student, his/her educational abilities and needs, and also such method might involve the participation of paraprofessionals and parents of a student. When developing such a method, it should be taken into account that some students might use non-verbal communication only, and an algorithm for evaluating the emotions of a student with autism should be developed.

The most promising technologies which can be with an appropriate level of ease be adapted into the education of students with autism are augmented and virtual reality technologies. According to the developed method of personalization of virtual content of information technologies, different modeling and visualization software should be used.

Key words: information technology; student with autism; semantic differential method; virtual assistant; augmented reality; virtual reality.

Introduction

Over the years, the number of people with autism spectrum disorder who can and should receive help in the process of socialization is growing. It is because of the improvement of methods for studying and diagnosing autism spectrum disorders. Learning is an effective tool of socialization, and a strong argument in favor of the use of information technology in teaching students with autism is their perception of the environment: the visual content of education information technology is becoming increasingly important because they allow reducing the difficulties of verbal communication of such students.

Researchers note that compared to traditional, computer-based teaching methods for students with autism are more effective. People with autism find that interacting with a computer or tablet is less stressful

and more attractive than interacting with people, and the interaction demonstrates greater accuracy and performance. Experts say that the main areas of development of information technology to support the training of such persons are communication skills, social communication, and academic training.

It is known that about 25 % of all people with autism communicate nonverbally only, and it causes communication difficulties, and significantly affects the quality of life, education, and inability to interact. Well-known means of overcoming these difficulties are PECS (Picture Exchange Communication System), a system of communication exchange of images, MAKATON – a simplified sign language; and VOCAs (Voice Output Communication Aids), the portable electronic speech synthesis devices.

Robots with support for artificial intelligence functions are used to overcome the problems of social interaction. The use of virtual reality and augmented reality technologies allows the controlled practice of social skills with a minimum of "dangerous" environments.

The use of information technologies, 3D holograms, as well as mixed, augmented, and virtual reality technologies are promising for the academic training of children with autism.

Information technologies in the modern system of inclusive education are becoming more widespread. Specialists from around the world work in this field, the most significant results are declared by scientists and practitioners from Great Britain, USA, France, Spain, as well as domestic researchers at Lviv Polytechnic National University, Taras Shevchenko National University of Kyiv, Khmelnytsky National University. However, it should be noted that the use of information technology in the learning process of students with autism is usually unsystematic, available information technology is poorly integrated into a holistic system. This emphasizes the need for an interdisciplinary approach to the development of information technology focused on solving the problems of teaching students with autism. The need to improve support for the learning processes of people with autism by developing information technology support for such learning determines the relevance of research.

State of the art

The education of a student with autism is, by all means, a complex process. It involves psychophysical, medical, pedagogical institutions, inclusive schools, afterschool education institutions [1–5]. Paraprofessionals, school administration, extracurricular activity specialist, and parents of a student with autism are also involved in the education of such a student. Applying different techniques and approaches, all the participants of the educational process are aimed to establish cooperation between a socium and a child with autism, to improve the co-existanc of different members of the socium.

The basic approach of the process of education of a student with autism is presented in Fig. 1 [6].

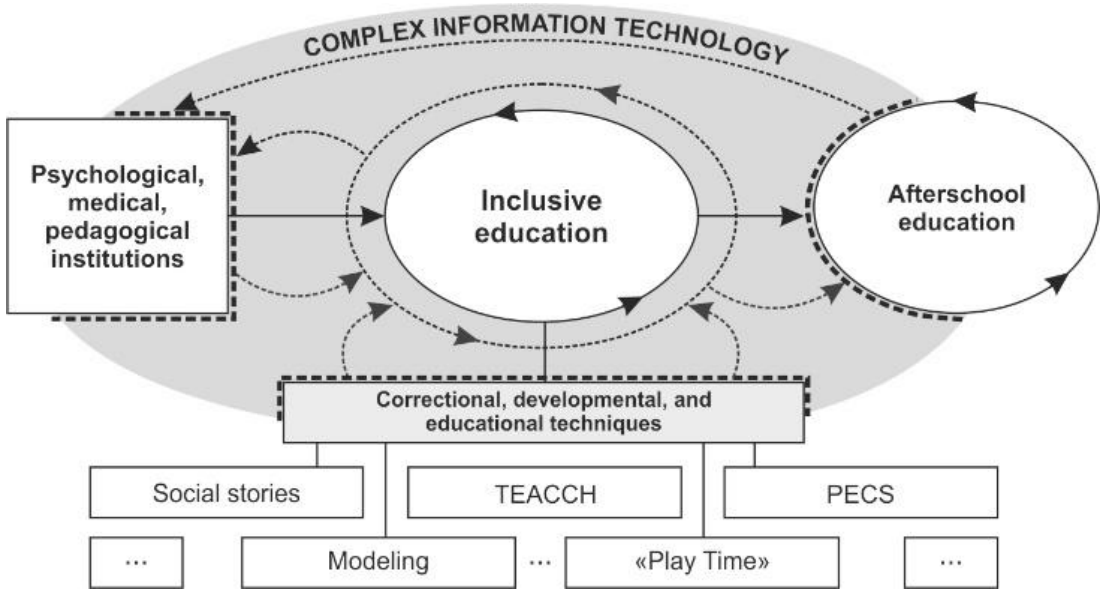

Fig. 1. The concept of complex IT support of the education of students with autism

An information technology that would take into account a special features of the system of education of a student with autism should be based on the understanding of what IT features are most appropriate for such students. It was proven practically that visual motivation is well accepted by a child with autism [7, 8]. Augmented, virtual, mixed reality technologies are powerful means of communication and cooperation with a child with autism [9–18].

The more formal model of the complex information technology of support of the education of students with autism is presented as a Petri Net (Fig. 2, Table 1, Table 2). Petri Nets are widely used in the modeling processes, where both simultaneous and sequential tasks should be performed, and an educational process is one of them [6, 19, 20].

The goal of the research

The research aims to develop models and algorithms on the basis of which to develop information technology to support student learning with autism. This technology should take into account the importance of visual support for students with autism, as well as the features of evaluation procedures, where experts are students with autism, who may have difficulty communicating.

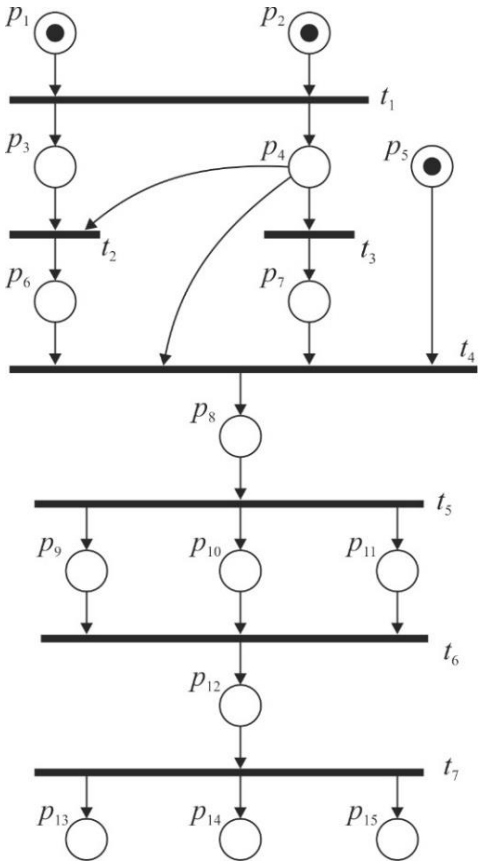

Fig. 2. Model of complex information technology of support of education of students with autism

Table 1

The transitions of Petri net

Transition	Explanation
t_1	Proceed the results of the psychophysical diagnostics
t_2	Choose the most appropriate virtual assistant
t_3	Update the individual education plan
t_4	Form the information technology of the lesson support
t_5	Accumulate education results
t_6	Consolidate education results
t_7	Form recommendations

Table 2

The positions of Petri net

Position	Explanation
p_1	Psychophysical diagnostics results
p_2	Library of the virtual assistants
p_3	Selected virtual assistant prototypes
p_4	Psychophysical portrait of a student
p_5	Library of the assistive information technologies
p_6	Personified virtual assistant
p_7	Individual education plan
p_8	Information technology of the lesson support
p_9	Communication skills improvement indicators
p_{10}	Social skills improvement indicators
p_{11}	Academic knowledge improvement indicators
p_{12}	Consolidated education results
p_{13}	Recommendations for the library of assistive ITs improvement
p_{14}	Recommendations for the library of virtual assistants improvement
p_{15}	Data for the psychological, medical, and pedagogical commission

The method of visual assistant personalization

One of the important components of the process of supporting a student with autism is the choice of a personal virtual assistant that would meet the individual characteristics and capabilities of each student. To improve the student's perception of educational material using visual aids, a method of personalizing a virtual assistant was developed. The main steps of the method of selection of a virtual assistant can be presented as in Fig. 3. The formation of a library of virtual assistants comes from open access sources (for example, the resource *Turbosquid*) as well as the efforts of 3D artists. Based on the results of the psychophysical diagnosis of the student, from the library of prototypes of virtual assistants are selected the most relevant. A student with autism and his parents interact with several prototypes of virtual assistants, and an algorithm for evaluating such prototypes has been developed, provided that the student has difficulty in verbal communication (see below). Based on the results of data analysis methods, a personalized virtual assistant is formed.

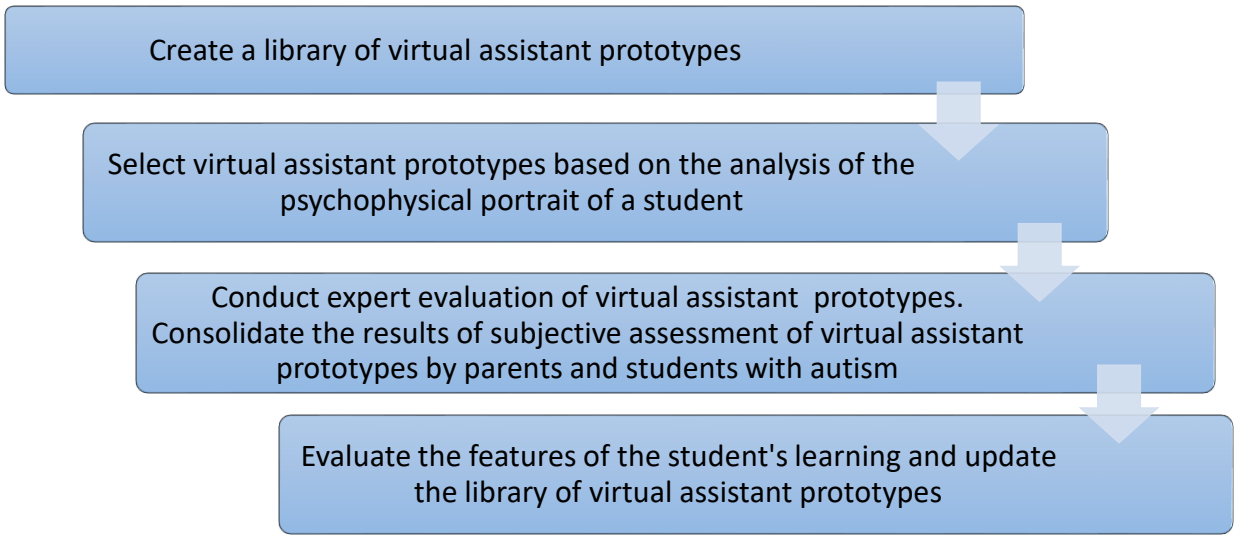

Fig. 3. The concept of the process of choosing a virtual assistant

Algorithm of formation of virtual assistants prototypes library

When working with a child with autism, in the case of complicated interaction or lack of verbal skills, an algorithm based on intellectual recognition of emotions has been developed to evaluate the prototypes of a virtual assistant.

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Step 1. Set up emotion recognition criteria.
Step 2. Apply data mining technologies to study the facial expressions
of a student with autism during the interaction with the prototype of the
virtual assistant (information carrier is a video stream).
Step 3. Interpret the results of recognizing the emotions of a student
with autism
Step 4. Interpret the results of the study of facial expressions of a
student with autism, choose a personal virtual assistant.
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The grades of the virtual assistant received from a student with autism should be consolidated with the grades from paraprofessionals and parents. You can obtain virtual assistant estimates from experts, for example, using the analytic hierarchy process. At the same time, the use of another method, the *semantic differential*, seems more appropriate, because it allows taking into account the peculiarities of the process of evaluating a visual object.

Semantic differential method for evaluation of a virtual assistant prototype

Expert assessment of virtual assistants by paraprofessionals was conducted by the method of semantic differential (Osgood method), which allows to quantitatively and qualitatively assess the interaction of virtual assistant and student with autism using bipolar scales. The virtual assistant was rated by 9 antonymous pairs (*Rough – Smooth, Noisy – Quiet, Talkative – Silent, Cowardly – Bold, Indecisive – Decisive, Tired – Energetic, Serious – Funny, Unpleasant – Pleasant, Angry – Kind*), formed by three main characteristics: activity, strength, and attitude [6].

The results of the expert assessment of virtual assistants carried out by paraprofessinals and the results of assessments obtained from students with autism are consolidated to make a decision on the choice of a personal virtual assistant.

The personalized virtual 3D assistant, as well as the psychophysical portrait of the student, and the results of previous training, and individual curriculum of the student are the basis for the formation of information technology for lesson support. Based on the above components, as well as on the available in the inclusive school auxiliary ITs, for each lesson is formed the appropriate information technology that meets the personal needs and capabilities of a particular student. If the set of auxiliary ITs does not have the necessary software components, a request is made to develop such an application in compliance with the requirements of accessibility (ISO / IEC 40500: 2012) and universal design.

Software realization of the virtual assistant prototype

To develop prototypes of personalized virtual assistants, a character concept was created, step-by-step 3D modeling was performed, materials and textures for the prototype were adjusted, lighting was selected, and animation was created (Fig. 4). Developed prototypes of 3D virtual assistants complement the library of virtual assistants to support learning. The developed models, algorithms, and method were used in the development of individual software applications for the discipline *Social and domestic orientation* in the Training and Rehabilitation Center of I-II degrees *Trust* (Lviv, Ukraine) and in the Center for Child Development *Yangolyatko* (Mukachevo, Ukraine).

Fig. 4. Stages of creating a prototype of a virtual assistant

Autodesk 3ds MAX 3D modeling and visualization software, as well as *MagicaVoxel* software for voxel 3D modeling, were used to model the virtual assistant (*Cute Owl*). Avatar textures are prepared and edited using *Adobe Photoshop* software. The animation of virtual assistants is performed by *Autodesk Maya* simulation and animation tools. The development of additional augmented reality information technology was performed in the *Unity* 3D development environment (C # language), using the software platform *Vuforia Engine* 9.0.12.

During the development of information technologies to support the educational processes of students with autism, the requirements of universal design were met. All developed information technologies are designed for the Android operating system. The performance of virtual reality scenes demands a personal computer with the basic requirements: processor: Intel® Core ™ i3-6100 3.7 GHz; 4 Gb RAM and above, video adapter NVIDIA GTX 960 or AMD Radeon R9 290; to ensure interoperability between the operating system and the video adapter driver – DirectX v.11 and above. Augmented reality interaction is recommended for smartphones with 2 Gb RAM and higher, quad-core processor with a frequency of 2 GHz and higher.

Conclusions

The analysis of the features of information technology support for students with autism allowed to development a model of integrated information technology for the learning processes of such students. This model was presented using Petri nets, it demonstrates sequential and parallel tasks that arise in the process of teaching a student with autism.

A method of content personalization was also developed, which allows taking into account individual features of psychophysical development of a student with autism. To recognize and evaluate the emotions of a student with autism during the interaction with a virtual assistant, an algorithm for evaluating a virtual assistant has been developed. To develop prototypes of personalized virtual assistants, a character concept was created, step-by-step 3D modeling was performed, materials and textures for the prototype were adjusted, lighting was selected, and animation was created. Expert assessment of virtual assistants was conducted using the method of semantic differential, which allows to quantitatively and qualitatively assess the interaction of virtual assistants and student with autism using bipolar scales.

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ІНФОРМАЦІЙНА ТЕХНОЛОГІЯ СУПРОВОДУ НАВЧАННЯ СТУДЕНТІВ З АУТИЗМОМ: АСПЕКТИ МОДЕЛЮВАННЯ ВІРТУАЛЬНОГО АСИСТЕНТА

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Вважають, що взаємодія із комп'ютером або планшетом для особи з аутизмом є менш стресовою та привабливішою, ніж взаємодія із людьми. Аналіз інформаційних технологій, розроблених як за кордоном, так і в Україні, виявив відсутність систематичної підтримки процесів навчання учнів з аутизмом. У цьому контексті розроблення персоналізованого інформаційно-технологічного супроводу навчальних процесів таких учнів є актуальним науково-прикладним завданням. Для досягнення цієї мети необхідно дослідити теоретичні та методологічні основи навчання осіб з аутизмом та визначити роль ІТ-підтримки такої освіти. Експерти сходяться на думці, що основними напрямами розвитку інформаційних технологій для підтримки навчання учнів з аутизмом є удосконалення їхніх комунікативних навичок, соціальної взаємодії та академічної підготовки.

Метод персоналізації віртуального контенту інформаційних технологій, розроблений або адаптований для підтримки навчання учнів з аутизмом, повинен враховувати результати психологічної діагностики учня, його чи її освітні здібності та потреби, а також передбачати залучення парафахівців та батьків учня. Під час розроблення такого методу потрібно враховувати, що деякі студенти можуть використовувати лише невербальне спілкування, тому слід розробити алгоритм оцінювання емоцій учня з аутизмом.

Найперспективнішими технологіями, які можна належно і легко адаптувати до навчання учнів з аутизмом, є технології доповненої та віртуальної реальності. Відповідно до розробленого методу персоналізації віртуального контенту інформаційних технологій, необхідно використовувати різне програмне забезпечення для моделювання та візуалізації.

Ключові слова: інформаційні технології; студент з аутизмом; семантичний диференціальний метод; віртуальний асистент; доповнена реальність; віртуальна реальність.