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Features of design of digital aids for training students with autistic disorders

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Abstract. In accordance with the aims of the paper, it is covered essential peculiarities of the design of digital aids for ASD-students. They are distinguished coming from the analysis of common learning and social difficulties inherent to the trainees with autistic disorders; needs for their speaking habits development; advantages of special digital support in terms of facilitating ASD-students' training. The distinguished features essential in the process of the digital aids design are demonstrated on the example of the development of an e-simulator for young ASD-students' speech encouragement. The main stages of its design and functionality are characterised. It is emphasised in conclusion that the developed digital simulator due to its functionality helps to overcome a number of problems faced by young ASD-students. The problems are specified.

Keywords: ASD-students' training, digital aids design, digital transformation of education, e-simulator for ASD-students' speech encouragement

1. Introduction

During the last decades digital transformation has referred all aspects of education including inclusive learning. Various surveys testify that one of the global problems of contemporary education in its digital age becomes finding the ways to facilitate the learning process for students with special needs based on technology support. Special focus of experts, however, has been obtained recently by the students with autistic spectrum disorders (ASD), as the number of the cases and variety of the disorder's modifications has been growing for last few years [5, 7, 8, 10, 14]. In particular, it is pointed out that in the USA, for instance, every 54th child now appears to have autistic disorders what is 10% greater than in 2018.

Thus, we deal with the global problem, and it is clear that software and learning aids market tries to respond to the said challenges of ASD-students' social adaptation and academic training at different levels. There are a number of special centers all over the world which offer evidence-based educational programs that focus on educating peer groups of ASD-students, and at the same time, teaching prosocial communication strategies to enhance social inclusion and to reduce these students' isolation and bullying. However, it is pointed out [2, 7, 8, 17] that the

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developed software is mostly of general educational purpose and do not cover specific cognitive needs of ASD-students, one of which is poor speech and communication skills what complicates the students' social adaptation. Thus, it is necessary to develop approaches to special digital aids design based on the psychological peculiarities of these students' training.

One more problem in this aspect is connected directly with Ukrainian localization of such digital aids and their development due to exact needs of national situation in the lines of provision ASD-students' education and social adaptation.

Coming from the said evidence, the purpose of the article is to cover core features of the design of digital aids for ASD-students and demonstrate them on the example of the development of an e-simulator for the students' speech encouragement.

2. Theoretical framework

Theoretical background of the work is made by the analysis of the challenges of ASD students' educational practices and learning of potential benefits which might be given by the digital aids support for the training process of these students.

Analysis of psychological and pedagogical sources [11, 13, 16] allowed us to identify a number of major learning difficulties that are inherent in students with autistic disorders. According to studies, the learning difficulties are caused by the students' problems in three core spheres: social interaction, communication and imagination. The most essential of them include generalized insufficient ability to learn, poor concentration, unawareness of dangerous situations, insufficient or excessive reactivity, increased anxiety, low level of adaptation to new social and educational situations, problems in establishing and maintaining relationships with others etc.

In addition, experts highlight the special disorders of autistic students in the formation and development of their reading and speaking skills in both native and foreign languages [3, 11, 13, 15, 20]. In particular, the students face the problems of insufficient vocabulary and its limited use in their speech; misunderstanding of the general sense of the read content; fragmentary perception of oral speech; lack of motivation to communicate with others, etc. On the other hand, the psychologists emphasize that speaking habits make the most essential basis for the students' socialization. Hence, these habits' developing has to be in focus of all kinds of educational practices for ASD students of all ages.

It is also important to point out some ASD students' strengths which are underlined by the researchers and might be helpful in their teaching: their very well-developed visual memory, considerable attention to details, a large amount of mechanical memory. In this regard, experts recommend involving in the learning process of such students visual aids and visualization tools, but it is emphasized the need for maximum organization and concentration of the student's visual field [3, 4, 6, 15, 20].

In this context, the special attention must be paid to the digital support of ASD students' education. There is a number of research which claim the advantages of technology-supported learning of the students. The results of several studies suggest that autistic students learn faster with the help of a computer than with the help of verbal instructions [3, 16, 19]. Researchers consider the reason for this not only in the fact that the digital devices are able to hold students'

attention longer, but also in the fact that it uses the principle of content visualization and encourages students to focus on specific areas of the screen. Besides, computers provide students with multimedia content that enables to combine audio and graphical images, to enrich and facilitate in such a way students' perception of text information developing their reading and speech habits.

In some research papers [17, 19] it is pointed out that digital aids support while learning is very promising for these students as they have significant kinship toward technology and interaction with e-devices, digital means etc. It is explained by the essential advantages which are provided by technology for people with ASD. In fact, a technology functions as an interface between ASD person and other people, providing necessary social and emotional distancing that helps decreasing their anxiety. Another educational technology's benefit is its facility to provide tailored and individually driven digital support for ASD students who usually have their own preferences for sensory outputs (colors, sounds, graphical details etc.) produced by software as well as for the way of learning due to individual peculiarities [17, 19, 20] of their disorder. As a result, due to the technology's advantages, the students obtain personalized, friendly and one-to-one digital aid to master both social and academic skills.

Thus, the said benefits of digital aids for ASD students and their social and learning difficulties determine the variety of the aids as for their main purposes for the students' training as well as the core features of their design.

As we said above, speaking habits, vocabulary boosting, and speech stimulation must be in focus of ASD students' learning on all the levels. In this connection, it is relevant to concentrate on the advantages of e-simulators as a special type of digital support in general and look precisely at the potential of e-simulators focused exactly on ASD students' speech and language boosting.

A simulator in a common sense is a modeling complex (system) created in order to prepare a person to make high-quality and quick decisions. According to studies, with regard to the learning process, a simulator is defined as a device for training which due to psychological and didactic requirements should have constructive, modeling and didactic components as its core parts. It is also mentioned that simulators are promising as for their application to learning practice since they allow students to form the skills of motor-reflex and cognitive actions in difficult situations, to understand the essence of the ongoing processes and their mutual dependence.

A special role in education is played by e-simulators which are defined in the studies [1, 9, 12, 17, 18] as a learning tool that provides a trainee with step-by-step work-out of the learning content, and allows them to obtain sustainable skills of proper actions along with the parallel detection of the trainee's errors. The experience of using e-simulators in the learning process testifies their benefits for trainees. In particular, e-simulators take into account the individual pace of student's work and enable his own managing and controlling the learning process. They also reduce the time of developing necessary skills and do this process more efficient due to the great number and variety of training tasks, which raises the motivation of educational activity.

In the [1, 17] it is pointed out that the general purpose e-simulator must meet the set of requirements. In particular, it is underlined that tools for the simulator design should be simple and flexible. E-simulator should give the student the opportunity to repeatedly perform the same tasks on a particular topic in order to work out certain skills. At the same time the simulator

should provide the student with clear instructions and/or a sample solution at his request. In addition, the simulator should analyze the student's actions with a qualitative assessment of the results and giving recommendations as for the achievement of better results. There are also some special recommendations for the e-simulator interface that should be friendly and clear to encourage students to practice routine skills and to create an atmosphere of success and interest.

The analysis of the challenges of ASD students' educational practices, peculiarities of their learning, and importance of the facilitating the students' speech stimulation and language boosting depicted above, testify the urgency of the development of e-simulators with Ukrainian localization for the young students' speech encouragement.

Based on the analyzed needs of speech development of young students with autism and the general requirements for e-simulators, it is possible to formulate the following specific requirements for the said e-simulators for language boosting which are to be used as a basis for their design. Formulating them we bear in mind two core speculations which come from the above analysis of the psychological and pedagogical characteristics of the said students. On the one hand, the software for ASD-students must be helpful for them in terms of their common and individual learning challenges, has to decrease the level of the students' difficulties, and hence, to make smoother the process of their learning and social adaptation. On the other hand, any kind of digital aids for ASD-students including the said e-simulators for speech encouragement must be cooperative in terms of the students' strong points (their well-developed visual memory, attention to details, a large amount of mechanical memory) which are considered by the psychologists to be helpful in their teaching.

Thus, in the process of development of an e-simulator for language boosting for ASD-students the set of recommendations have to be taken into consideration.

Firstly, it must have a concise, intuitively clear interface that must be the same for work in all modes of the simulator. It is recommended to use the same template to support unique basic design of the application which has to be downloaded quite quickly. The application window should not contain too much information in one spot, and must focus the student's attention on certain areas of the screen.

Secondly, the said e-simulator has to provide visual reinforcement of verbal content (as the ASD-students have well-developed visual memory which might compensate their verbal difficulties). It makes topical to include appropriate visual (multimedia) support for text information representation in the application and hence, puts up the problem of rational storing of graphical and text data within the application.

In addition, it is essential to provide opportunities for multiple repetitions of the proper exercises which must be generated by the simulator due to the didactic purposes. At the same time, the application must have facilities for gradual complication of the tasks and a moderate variety of exercises that would provide not only the vocabulary boosting, but also the speech stimulation. In this context, it is important to provide various modes of the application work which include different learning activities with a simulator. Besides simple words-training facilities, a developer should also create options for phrases building and work with digital narratives that provide combination of the verbal content and visual images. According to recent studies, creating of digital narratives by ASD-students, followed by work upon their combined content, provoke the students' needs for expressing ideas and potentially stimulate

their speech habits. In order to guarantee such a functionality, the developer has to work in tight collaboration with educators who are experts in ASD students' training.

Finally, the e-simulator on the said purpose should guarantee high level of interaction with friendly feedback in learning situations of success and failure to increase motivation for speech encouragement. Besides, the software should provide significant level of adaptivity due to the student's needs, so the student (together with his tutor) could progress in his own pace, according to his individual preferences, and was able to handle the process of learning.

The formulated specific recommendations for the said e-simulators might be considered as features which are necessary to be regarded in the process of the simulators elaboration and determine their functionality in terms of the ASD students' didactic needs. We would like to cover them in details on the example of the design of an e-simulator for young students' speech boosting in Ukrainian and in English.

3. Development of e-simulator for young students' speech boosting

Coming from the formulated recommendations, the main phases of the application design were outlined which can be characterized as follows.

3.1. Main stages of the application design

At the first stage the didactic functions of the application were specified due to the recommendations, the modes of its work were determined, use cases diagram was built which allowed to specify a potential user's behavior.

In particular, it was determined that the user is expected to initiate such use cases as:

(1) to run the application;
(2) to get familiar with it introducing himself;
(3) to choose the language (Ukrainian or English) to be trained;
(4) to choose the mode of training (boosting vocabulary via learning new words, building phrases, work upon social stories);
(5) to work in any of the modes doing various exercises and repeating them with various content;
(6) to obtain immediate feedback;
(7) to change the content of words training and fill it with user's set of words.

All the use cases are connected with each other, which was also shown at the diagram that is not included into the article for the sake of conciseness.

At the next stage, the conceptual model of the subject area "ASD-students' language encouragement with the help of e-simulator" was created. On the stage of object-oriented design the obtained conceptual model was used to determine application classes, objects, and proper links between them.

Next phase was devoted to the application interface design coming from the requirements to the e-simulator, the use case diagram and obtained conceptual model. In particular, design of all

application windows was developed in accordance with all use cases and links between them. It was also followed the necessity to apply the same template to support unique basic design of the application in all its modes. The application windows in all the modes of work contain only proper information which is concentrated in certain spots, and focuses the student's attention on these areas of the screen. Proper concise prompts are put in certain areas of each window. Due to ASD-students' needs for visual reinforcement of verbal content there was solved the problem of vocabulary boosting with the elements of words visualization. All of the elements of the interface were tested as for their usability to make sure that the design solutions are ergonomical ones and enable a user to interact with the simulator efficiently in various learning situations obtaining immediate and relevant feedback.

Then the program realization of the e-simulator was undertaken in Java within Netbeans environment: class diagram was built, and the class and methods description was done along with their program implementations.

Then necessary didactic content for all modes of the e-simulator was created in collaboration with psychologists, ASD experts and primary school teachers. In particular, the variety of word sets with visual support was picked up for their mastering in accordance with Ukrainian and English languages curriculum. Phrases builder of the e-simulator was filled in with proper content. The social stories for work with digital narratives were composed. As a result, all the proper components of the application were filled in with the elaborated learning content.

At the final stage the application was tested, according to the didactic and technical requirements formulated above.

Finally, the application was introduced into practice of ASD-students' classroom and independent learning activities.

Below we are covering the functionality of the developed simulator highlighting the features of their implementation.

3.2. Functionality of the developed e-simulator in terms of ASD-students' speech encouragement

As a result of development, speech e-simulator "Speak-up!" ("Розмовляй-ка!") for young students with autism spectrum disorders has a concise but intuitively clear interface that enables both educators and students to interact with it efficiently from the very beginning.

In addition, the interface of the e-simulator offers to get familiar with a user (ASD-student) introducing his name, which immediately makes training personalized (figure 1).

After getting familiar and choosing the language (Ukrainian of English) of training by the user, the application encourages the trainee to work in three main modes which determine basic didactic functions of the application.

The first core mode focuses the trainee on boosting his vocabulary via learning new words of native (of foreign) language along with their meanings. There are two main activities provided by the e-simulator. First, the student is enabled to look through the vocabulary of the lesson (in accordance with the curriculum theme) along with the words meaning and proper associative images (figure 2). The activity encourages the student to learn the sets of words with visual support in his own pace returning to the same sets as many time as the trainee needs.

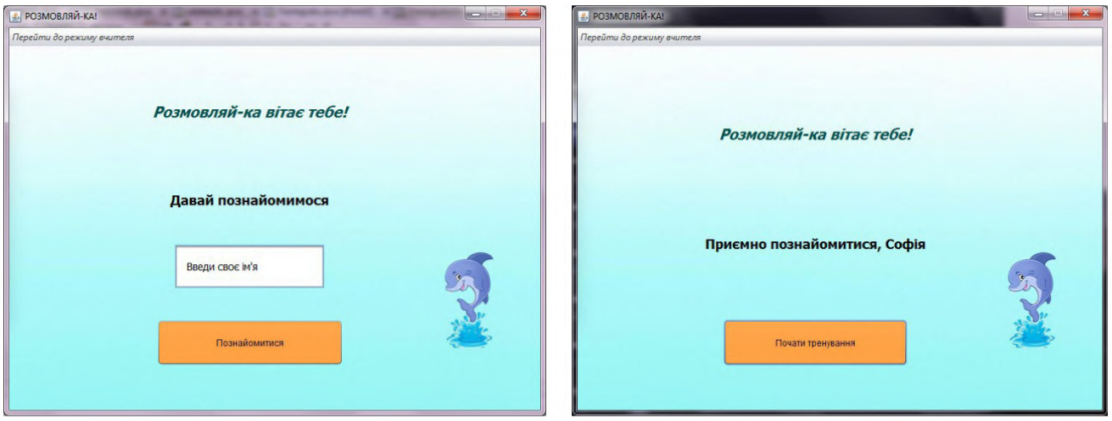

Figure 1: The episode of work with the simulator at the moment of getting familiar with a user.

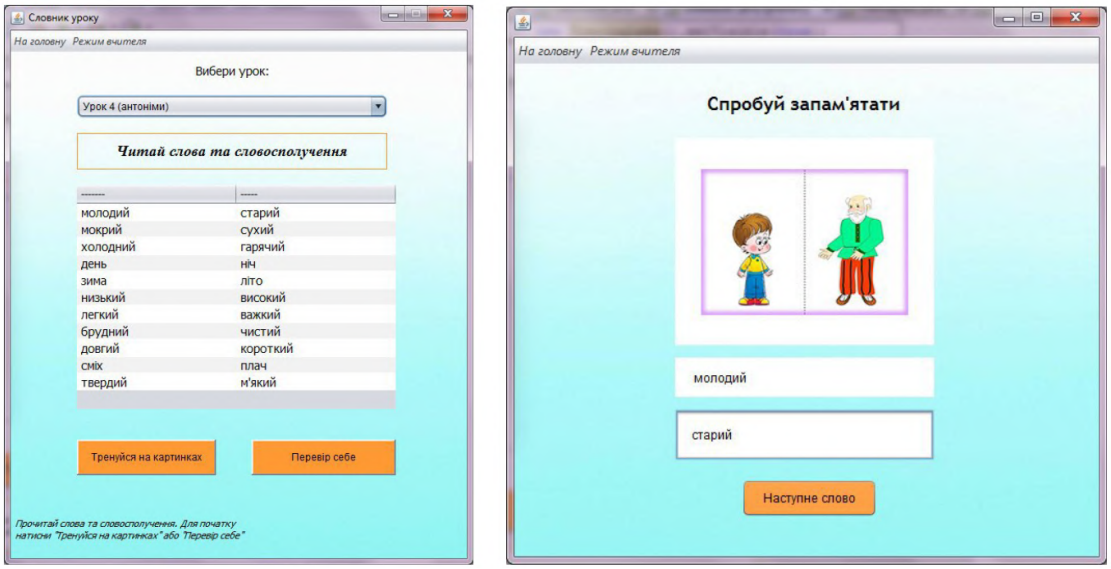

Figure 2: Fragments of work in the simulator in the mode of vocabulary boosting.

The other activity in the vocabulary mode is devoted to the words simulation with estimating of the students' attempts. In particular, in this mode the e-simulator encourages students to recollect the learnt vocabulary with immediate feedback and with friendly processing of the situations of success and failure (figure 3).

Thus, the realized mode of the e-simulator helps ASD-students to get used to the situation of training with estimation, allows to decrease their anxiety, which is essential for the students, and motivates them for vocabulary boosting.

An important function realized in the simulator is the opportunity for the trainee (with the help of his tutor) to edit existing vocabularies, to fill them with their own sets of words, and save their own vocabulary in files (along with proper associative images) within the simulator to use

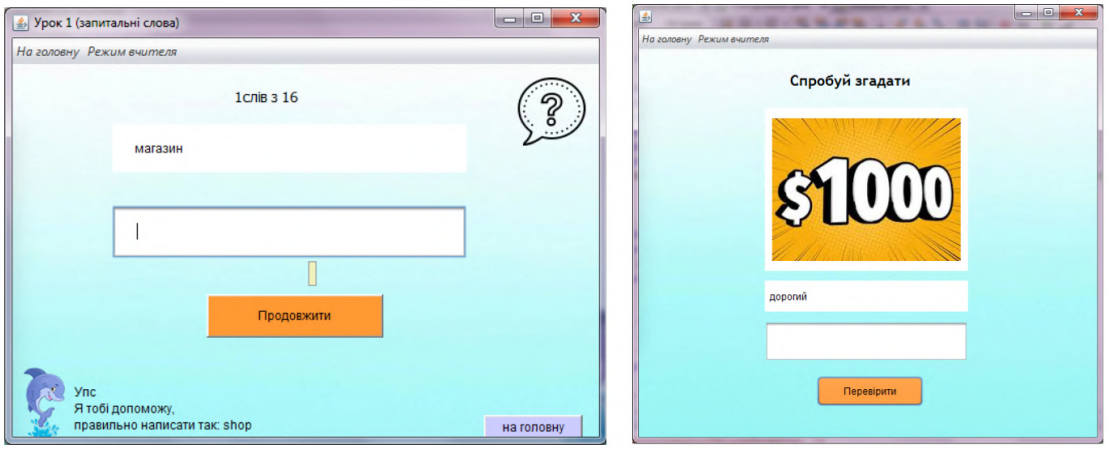

Figure 3: Working out the words in the mode of vocabulary boosting with estimation.

them for work out (figure 4). This ensures the adaptability of the simulator to the needs and requests of the trainee. As he can work out the words which seem for exactly him to be useful and important, it is possible to predict the growth of the student's motivation to remember and use them. In this way, the student can make their learning the most comfortable and individual, as well as avoid the fear of testing their knowledge. The situation of learning, training and control becomes familiar, safe and psychologically comfortable for him.

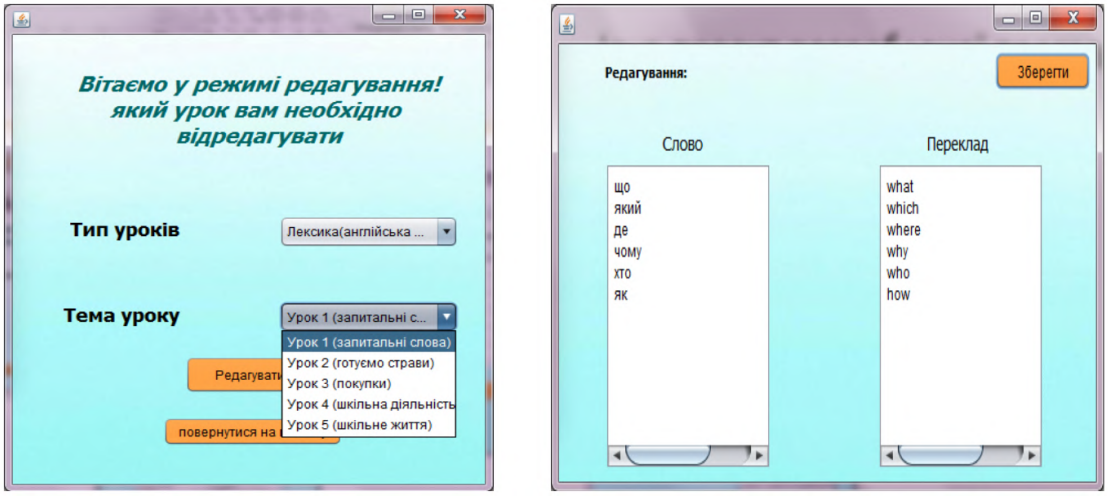

Figure 4: The process of editing existing lessons vocabularies.

The second mode which is realized in the simulator is aimed at progressing the ASD –students' skills of composing sentences of various types. On this purpose, the simulator implements a phrase builder which offers the student two main types of speech learning activities. The first type of activity encourages the student to build sentences according to the scheme and compare

their own sentence with the sample. The second type offers to choose from the suggested members of the sentence correct ones, as well as to build their own phrases and check their correctness (figure 5).

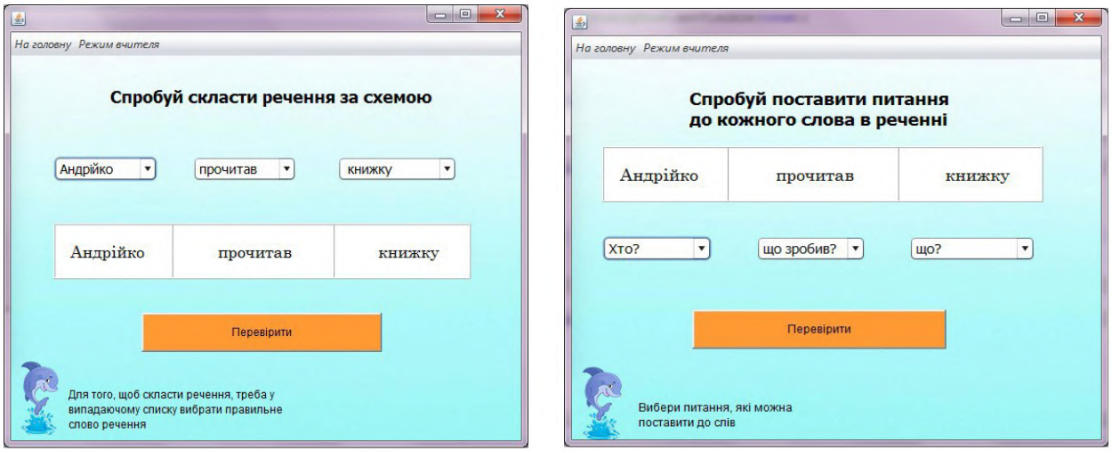

Figure 5: The episodes of work in the mode of phrases builder.

It is important to emphasize that the program realization of this mode addresses to the main peculiarities of ASD-students' learning, such as focusing on details, necessity to concentrate their attention on the proper areas of the screen and certain activities, determination on the repeated habitual tasks with their gradual extension etc.

In the third mode of training the simulator provides an opportunity for students to work with so-called social stories that have social and educative content, and contribute to the effective adaptation of ASD-students to society. The student is offered two main stages of processing the stories: (1) reading the story followed by its analysis via answering suggested questions (figure 6); (2) reading the same text with pictures instead of some words that the student must recollect and enter (or choose from the suggested ones).

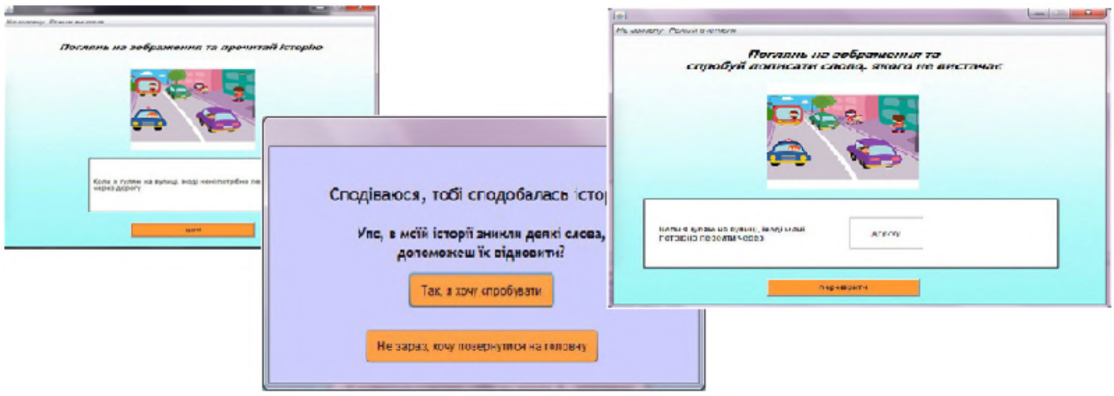

Figure 6: The episodes of work in the mode of social stories.

At all of the simulator's modes it is realized the facility of monitoring the correct answers with immediate feedback in the form of scored points displaying the results of training. The aid also efficiently handles situations of success and failure, which provides a favorable emotional background, creates a friendly atmosphere of training, and helps to increase motivation to practice language and speech skills.

Thus, the depicted above functionality of the developed digital simulator for ASD-students' language encouragement meets the core features of such aids design which were grounded and formulated in the section 2 of the paper.

4. Conclusions

In accordance with the aims of the paper, it is covered essential peculiarities of the design of digital aids for ASD-students. They are distinguished coming from the analysis of common learning and social difficulties inherent to the trainees with autistic disorders; needs for their speaking habits development; advantages of special digital support in terms of facilitating ASD-students' training.

The distinguished features essential in the process of the digital aids disign are demonstrated on the example of the development of an e-simulator for young ASD-students' speech encouragement. The main stages of its design and functionality are characterised. In conclusion, we would like to emphasise that the developed digital simulator due to its functionality helps to overcome a number of problems faced by young ASD-students.

In particular, the simulator promotes concentration of their attention and relies on increased visual memory of such students; allows to boost significantly the vocabulary of both native and foreign (English) language via multiple repetition and involvement of both verbal and nonverbal learning; provides opportunities for gradual complication of tasks and a moderate variety of exercises, which allows not only the expansion of vocabulary by memorizing words, but also the speech stimulation by constructing their own sentences, processing social stories with visual support etc.

In addition, provided communication within e-simulator, the realized option to repeat different, but similar learning situations, studying at their own comfortable pace help to reduce the student's anxiety, simplify their adaptation to unfamiliar tasks and situations, which is really essential for autistic students due to their psychological peculiarities.

Finally, the essential function of editing by the student offered vocabularies for training ensures the adaptability of the simulator to the needs and requests of the trainee and enables the student to handle his own process of training. In fact, this function represents the developed e-simulator as a computer shell for design of individual simulators for ASD-students' speech training.

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