

Mobile Applications as a Means for the Diagnostics and Speech Development in Children with Speech Disturbances and as a Resource for Alternative Communication

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Keywords: Mobile Applications, Speech Diagnostics, Speech Development, Specific Language Impairment, Alternative Communication.

Abstract: This paper presents three mobile application systems which have been designed and developed at the Department of Fundamental and Applied Linguistics of Novosibirsk State University, Russian Federation. These mobile applications are “Logoball”, “Developing Speech”, and “PictInteraction”. The diagnostic system “Logoball” aims at detecting speech defects in children having different language problems. The programme “Developing Speech” is intended to be used for the development of impressive speech in children with the specific language impairment. The mobile application “PictInteraction” deals with the development of coherent speech in children with speech disturbances. It also serves as a means of alternative communication for such children. The mobile applications are described in some detail. The paper briefly discusses the strengths and weaknesses of the applications as well as the opportunities they provide to the children with language problems, to their parents, and to the speech and language therapists who work with the children having language problems.

1 INTRODUCTION

The paper studies the experience of creating comprehensive software systems for the diagnostics, development and rehabilitation of the linguistic competence in children with various kinds of speech disturbances. The electronic means of alternative communication for such children are also presented.

The kinds of speech disturbances vary from the specific language impairment to the autism spectrum disorders. The former include language problems at different speech levels:

- 1) when the produced speech is not coherent;
- 2) when the lexical-grammatical composition of speech is not consecutive;
- 3) when there is no phonetic or phonemic understanding;
- 4) when the verbalization of ideas in general does not happen.

The latter comprises the cases in which the communication with the external world is compromised and a complete refusal from the social interaction can take place.

The approach to the development of mobile applications that can help to both diagnose the language problems and cultivate the linguistic competence is highly important and challenging. There are only few mobile applications in Russian similar to the ones described in this paper. None of such mobile applications have been recorded so far on the Records of the Federal Institute for Industrial Property, on the Records of the Fund of Algorithms and Programs of the Siberian Branch of the Russian Academy of Sciences, on the *FREEPATENT* website, or in the Registry of the Intellectual Property *FindPatent.ru*.

Nowadays speech and language therapists or teacher-logopedists do not often use both electronic technologies and mobile learning technologies in their practice. They usually employ old-fashioned paper-based systems that are bulky, take a good deal of space in the therapist’s office and require a lot of time-consuming work to be prepared. The difficulties of using the paper-based stimulus materials are especially noticeable in the diagnostics of speech development.

In the course of diagnostics the diagnostic materials are selected in manual way using a variety of textbooks with logopedic tests and illustrations. The results of the diagnostics and the speech errors are entered in the form. Then they are carried over to the electronic spread sheets for the further construction of charts and for the comparison of results. All this takes plenty of time that the speech and language therapists could spend much more productively working with children.

Meanwhile, a mobile application system will allow rapid and easy access to the well-organized and structured information. It will also carry out automatic processing of the results of the diagnostics or of the results of a particular therapeutic session.

Several years ago a new idea started up at the Department of Fundamental and Applied Linguistics of Novosibirsk State University. The idea was about creating a multi-subject educational project that would bring together fundamental and applied research in the fields of applied linguistics, computer linguistics, psycholinguistics, speech and language therapy, and cognitive psychology. The project has resulted in the creation of real electronic systems for the diagnostics of speech development and for the development of speech in children with specific health capabilities, particularly in children with various kinds of speech disturbances.

Three mobile application systems (= programmes) in Russian have been elaborated and tried out thus far. They are the diagnostic programme “Logoball”, the mobile application “Developing Speech”, and the mobile application “PictInteraction”. These programmes are being put into the speech and language therapy practice currently.

2 MOBILE APPLICATIONS FOR THE SPEECH DIAGNOSTICS, SPEECH DEVELOPMENT, AND ALTERNATIVE COMMUNICATION

The three mobile applications in question have been created since 2014. The diagnostic programme “Logoball” appeared in 2017. It is intended for the speech diagnostics in children having different language problems. It helps to detect speech defects in children faster and more effectively in comparison with the traditional methods.

Unfortunately, the parents do not always have an opportunity to consult a speech and language

therapist. In such instance they can use textbooks with logopedic games and tasks as well as the developmental applications for the mobile devices. The mobile applications are more effective than paper-based textbooks due to their interactivity which encourages the involvement of a child in the gaming and logopedic experience.

The mobile application “*Developing Speech*” was made in 2017. It helps to develop the impressive speech in children with the specific language impairment. Children and their parents can use this programme independently, without any participation of specialists in the field of speech and language therapy.

The mobile application “*PictInteraction*” was created in 2015. It is supposed to develop the coherent speech in children with speech disturbances. And it can also be used as a means of alternative communication by such children.

2.1 Diagnostic Programme “Logoball”

This mobile application allows us to speed up the process of detecting the speech defects in children. It became possible as the diagnostic process was computerized. The following actions were automated:

- 1) posting the diagnostic results into the electronic spread sheets;
- 2) setting up the diagrams;
- 3) comparing the diagnostic results at various stages of the developmental teaching;
- 4) retaining the lists of errors made by the children during the process of diagnostics.

The “Logoball” application is structured after the diagnostics procedure created by N.V. Nishcheva (Chirkina, 2003). The given structure consists of nine series and of 33 groups of tasks. The diagnostic series are as follows:

- 1) the assignments for the perception of audio-syllabic word structure;
- 2) the assignments for the phonemic perception;
- 3) the assignments for the phonemic analysis and synthesis;
- 4) the assignments for the comprehension of speech in general;
- 5) the assignments for the comprehension of word combinations and simple sentences;
- 6) the assignments for the assessment of the lexical-grammatical formedness of the child’s speech as well as of the formedness of the child’s skills in the inflexion, word-building, and coherent speech.

The application is meant to be used on a notebook computer operating under *Windows 7, 8 or 10*. The written programming code is divided into two separate files in order to make the code more readable and user-friendly. Thus, not only the author but also anyone who wishes could read the programme.

The first file comprises the functions, classes and cycles of the programme. The second file includes the descriptions of widgets of the programme such as the buttons, images and labels.

There was a particular problem to be handled, the problem of preserving the results. It was solved with the help of one of the *Python* language modules, the *CSV* module. The given module allows both reading from a *CSV* format file and writing some values into a *CSV* format file. The values in such a file can be separated with a comma, a semi-colon, or tabulation.

The computer programming language *Python 3.4* has been utilized to develop the application. The application programming code includes some data structures such as *List, Tuple, Dictionary, and Set*.

Let us describe the interface of the programme as seen by the speech and language therapist and the child. The diagnostic stimulus materials used in the tasks are found in two types: 1) materials without illustrations; 2) materials with illustrations.

If there is a task of the first type on the screen, the light-yellow buttons appear with the words, word combinations, or sentences written on them. They are the words, word combinations, and sentences the child is going to use while fulfilling the task. In case a child makes an error responding to a particular word, the button topped with this word should be pressed in order to preserve this error in a special electronic spreadsheet containing errors. An electronic “piggy box” (“safe”) with the child’s errors is very important as it helps the speech and language therapist to set up an individual course of further developing work for each child.

If there is a task of the second type on the screen, the illustrations appear that are to be used by a child in the course of fulfilling the task. At the bottom of the screen the light-yellow buttons are located topped with the picture captions. Should a child mispress such a button, the error is also preserved in the list of errors made by a child in the course of fulfilling the task.

During the performance of all the tasks there is the name of the section and the name of the diagnostic task specified at the top of the screen. On the right-hand side of the screen there are the four buttons topped with the scores from 0 (zero) to 3

(three). They are used to grade the child’s work. Having pressed the button with the score the therapist automatically goes on to the next task. There is no possibility to undo anything. The task-performance time is not limited depending on the child’s productivity alone.

Below there are two pictures (Figures 1 and 2) describing the tasks as seen on the screen by both the child and the speech and language therapist.



Figure 1: The screenshot of a task without illustrations.

Figure 1 shows a task without illustrations. This is Task 2.3. “Differentiating by ear the sounds which are confused during pronunciation.” It is one of the tasks from Section 2 “Phonemic awareness (audiolingual differentiation of sounds).”

At the top of the screenshot the following captions in Russian are written: 2. “Phonemic awareness (audiolingual differentiation of sounds). 2.3. Differentiating by ear the sounds which are confused during pronunciation.” On the screen the following word pairs in Russian are written: *Mouse-Bowl, Rat-Roof, River-Radish, Fringe-Slot, Wind-Evening, Goats-Plaits*.

Task 2.3 is meant to teach children how to distinguish between the sounds which are confused in the process of pronunciation. The task is performed in the following way: the speech therapist pronounces the pairs of words with confusing sounds, and the child repeats them after the therapist.

The words in pairs are similar in sounding, but they are different in meaning. The word pairs are displayed in the yellow boxes on the screen. If the child does not differentiate the phonemes and repeats the word pairs improperly, the speech therapist asks clarification questions. These questions help to clear up whether the child distinguishes the meanings and the disturbance is only about pronunciation. Or the meanings of the words are confused and the disturbance is about comprehension. It is crucial for establishing the logopedic diagnosis.

The speech therapist marks by mouse clicks all the word pairs which the child pronounced improperly. They are automatically recorded in a special electronic database (“piggy box” or “safe”). This database can be used during the process of training when the speech therapist would work with the words which were pronounced incorrectly during the process of diagnostics.



Figure 2: The screenshot of a task with illustrations.

Figure 2 shows a task with illustrations. This is Task 7.3. “Noun Adjective Agreement in the singular.” It is meant to check the child’s skill to make agree the adjectives and nouns in the singular (e.g., green bucket, red flag, blue pencil, etc).

At the top of the screenshot the following captions in Russian are written: “7. *Inflexion*. 7.3. *Noun Adjective Agreement in the singular*.” At the bottom there are the following words in Russian: *Flower, Flag, Bucket, Pencil, Saucepan, Leaf*.

The speech therapist screens the picture and asks questions like “What colour is the bucket?”, “In what bucket shall we pour water?” etc. The child should demonstrate the skill of Noun Adjective Agreement.

After the child has fulfilled the task, the speech therapist gives him/her a grade by pressing one of the blue buttons on the right side of the screen.

We recommend the following method of allocation of grades. Grade “0” means that the child has not coped with the task. Grade “1” means that the child has fulfilled about 30% of the task. Grade “2” means that the child has fulfilled from 31% to 70% of the task. Grade “3” means that the child has fulfilled the task completely or almost completely.

For further development we are going to do the following things:

- the improvement of illustrations (so that the children could perceive the interface better);
- the selection of tasks with various levels of complexity (so that it would be possible to differentiate between the children having diverse levels of development and grade the tasks for them accordingly);

- the addition of gaming blocks to the script (this can help to enhance the child’s motivation when tested);
- the introduction of such operations as “Step backward” and “Pause” (so that it would be more convenient for the speech and language therapist to arrange the test procedure);
- the attachment of a work manual to every diagnostics task (so that the programme could be used by anyone who feels like it and not only by the specialists).

A group of 22 experts – speech and language therapists – were recruited in order to get a feedback concerning the assessment of the developed application. The questionnaire was made up. It was meant to identify the good and bad points of the programme.

The results of the questionnaire survey indicated that the good points are the stability and the operating speed of the application as well as the congruency of the diagnostic content to the original, i.e. the diagnostic procedure created by N.V. Nishcheva mentioned above. The criterion “*Quality of Visualization*” got the lowest mark. The work is now being undertaken to improve this part of the *Logoball* diagnostic application.

2.2 Mobile Application “*Developing Speech*”

The mobile application “*Developing Speech*” has been designed to be used for the development of impressive speech in children with the specific language impairment of the 1-st, 2-nd, and 3-rd levels of speech development.

The children can use the application in order to fulfill various logopedic tasks independently. There are 10 tasks at every level which are to be performed by a child-user. The task performance time is not limited. The texts of tasks and the actions of the user are accompanied by sound. After having fulfilled the tasks the child-user has the possibility to get to know the results.

The computer programming language *Python* with the *Kivy* library was utilized to develop the application. The application was made for the tablet computers (*Android* operational system).

When the mobile application “*Developing speech*” is started, the user gets oneself to the *Menu* of the programme. There are three buttons for the selection of task level and the “*Exit*” button on the screen. Having selected one of the levels the user is requested to perform 10 tasks in succession.

Every task is located in a new application window. In the centre of each screen there is a text containing the task. Above the text there is the play button used for reproducing the text of the task. That is the application provides a voice for the task. The play button can be pressed an unlimited number of times. So the child can listen to the task as many times as he/she needs.

A typical task screen displays from one to four variants of response which can be selected. Each response button can be selected and pressed just once. Pressing the response button is accompanied by an acoustic signal. The picture proposed for the task changes simultaneously. At the bottom of the screen there is a task changeover key.

For example, there is a task that examines whether a child understands and differentiates prepositions. The child can see several resembling pictures on the screen. They are: “The kitten is on the chair”, “The kitten is behind the chair”, “The kitten is under the chair”, etc. The child is offered to press the button with the task. Then the female voice delivers the question: “Show the picture where the kitten is on the chair, please.” The child is supposed to choose the right picture and press the relevant button. If the task has been fulfilled correctly, he/she hears “Correct, good for you!” If a mistake has been made, then he/she hears “Try again, please.”

Some of the tasks can be skipped. The user can pass on to one of the next tasks of the same level. The results of the missing exercises are not taken into account.

After having fulfilled 10 tasks the user presses the button situated at the bottom of the screen and gets into the screen containing the final result. In order to see the result it is necessary to press the button “*Refresh display*” situated at the top of the screen. At the bottom of the screen the button appears that can be pushed to get to the *Menu*.

After the fulfillment of any level it is possible to select this level again. It allows the user to review the performed tasks once more and to complete the fulfillment of the skipped tasks. The “*Exit*” button in the *Menu* ends the work of the programme.

The mobile application “*Developing Speech*” has been assessed by 20 teacher-logopedists from the child care centres located in different districts of Novosibirsk. The assessment has been made using the following criteria: 1) quality; 2) functionality; 3) stability; 4) reliability; and 5) accessibility. Five-point scale has been used. The teachers have provided the feedback together with their impressions and suggestions.

On the whole, the new mobile application “*Developing Speech*” has obtained the positive feedback from the professional teacher-logopedists. They have suggested that some parts of the programme are to be improved. First, the sound tracks are to be refined. Second, the sizes of some images are to be changed. Third, the tasks are to be made more varied. Fourth, the system of rewards should be significantly ameliorated.

At the same time, the teachers have specified that the interface of the programme and the tasks are adequately elaborated. The respondents are equally of the opinion that the usage of such mobile applications together with the speech and language therapy sessions will allow the children to develop their speech more effectively.

The experts have estimated positively such criteria as the functionality, stability, and the operation speed of the programme. But the application has also got some weaknesses:

- 1) there is no such an option as “turning the screen angle”;
- 2) the application flies out of control after the automatic switch-off of the screen;
- 3) at the start of the programme the files are loaded rather long – for about 30 seconds.

These weaknesses are to be taken care of as they can influence the concentration of the child during the performance of the task and his/her involvement into the gaming experience.

The mobile application “*Developing Speech*” has great potential as it can be used for various kinds of speech disturbances. In view of this we intend to select several levels of complexity of tasks and to specificate the tasks designed for different speech disturbances.

2.3 Mobile Application “*PictInteraction*”

This mobile application system is intended to develop the coherent speech in children with speech disturbances. It also allows them to communicate with the help of the language of pictograms and their colour layout. One and the same pictogram can specify an action (if it is red), an object (if it is blue), or an attribute (if it is green). For example, *to smile*, *a smile*, *cheerful*. The black colour is used to specify the function words.

The colour-coded indication helps to turn correct phrases. A child is able to make up both simple and compound sentences by arranging the pictograms in a certain order. This is one of the most important stages in teaching the cohesion.

The “*PictInteraction*” application can be used by children with any autistic disorders and speech disturbances. It is recommended that the application is exploited independently for alternative communication. As a means of developing the coherent speech it can only be used at a particular therapeutic session.

The application was made for the tablet computers (the *Android* operational system). It is intended to be used in communication on the basis of the pictograms. It is an interactive option of learning activities organized with the help of logopedic activity books by L.B. Baryayeva (Baryayeva et al., 2007).

We consider the usage of pictograms to be an effective method that allows satisfying the needs of children with speech disturbances (and/or nonspeaking children) for communication.

The programme development comprises three stages.

1. *Stage 1* includes the construction of ontology required for the description of the object domain. This is the supplementary stage for the whole application.

The *Protégé 4.3* ontology editor is used as it allows graphical ontology matching. The *Ontology Web Language* is used. In *Protégé 4.3* the subclass *Things* is created. Then more particular thematic subclasses, topics, are made up inside the *Things* subclass. The topics are: *House, Animals, Toys, Family, Plants, Nature, School, and “I am a child”*. The topics are related to the activity books mentioned above.

Every topic is divided into several subtypes: *Preposition, Conjunction, Object, Attribute, Activity*. After that the names of the pictograms are specified inside the topics themselves.

If a pictogram is employed in several topics, all the necessary topics are linked to it. The pictogram is automatically displayed in the added topics. In the right upper rectangle we can see the pictogram file name (the picture name).

When the graphical ontology scan is made and the arrow is pointed at the requested object (pictogram), the file name is shown as well as the names of all the other topics in which this pictogram is used. The ontology in question is employed to put together the user interaction windows in the integrated software development environment IntelliJ IDEA.

2. *Stage 2* includes the “*Teaching*” module development. The module aims to introduce a child to the “character-symbol” pair which is the symbolic notation of a real thing represented in the pictogram.

It also aims to help acquire a better understanding of the pair.

The module trains the children’s skills to link the pictures of objects with their functions. It also teaches them the principles of logical construction of phrases by selecting the necessary symbols independently.

3. *Stage 3* deals with the “*Communicator*” module development. The “*Communicator*” module is used for communication per se. It is the leading module of the programme. It comprises the following three sections: “*Alert report*”, “*I want ...*”, and “*Phrases*”.

- 1) Section “*Alert report*”. This section is meant to be used by a child in case of emergency. By simply pressing a button a child is able to report of a situation that needs to be settled promptly. For example, when he/she comes down with a headache or needs the lavatory.
- 2) Section “*I want ...*”. This section is intended to be used by a child in case he/she wants to ask for an object. He/she is able just to press the pictogram of the object. The section includes a limited number of the most necessary pictograms.
- 3) Section “*Phrases*”. With the help of this section the phrases can be composed using the pictograms. In fact, it is the equivalent of typing the literal text. The section is to be used for the pictogram communication exclusively.

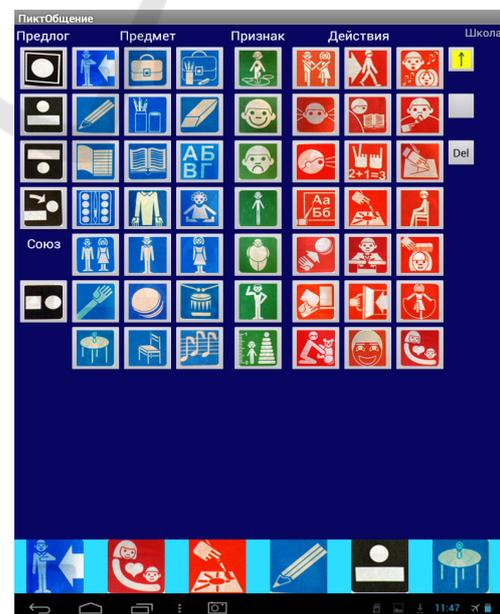


Figure 3: The screenshot of the “Communicator” module.

Figure 3 shows a sentence composed of the pictograms (the line at the bottom of the screen). The sentence reads “I like to draw pictures with a pencil while seated at the table.”

At the top of the screen a child can see a set of pictograms with varying semantics – *Object, Attribute, Activity, and Function Words*. If the child is in the learning stage, the therapist asks him/her probing questions about the following things: 1) at which part of the screen the needed pictogram is located; 2) what it means; 3) in what sequence the child should place the pictograms in order to communicate his/her idea. The child touches the needed pictogram with his/her finger, then the pictogram appears as a part of a sentence at the bottom of the screen.

This activity allows the child to become aware of the fact that every word has a real idea behind it. It also teaches to convey the thoughts successfully and meaningfully.

The assessment of the developed mobile application “PictInteraction” was conducted. The assessment was made of how the users perceive the application. The development designer account was registered on Google Play where the application was put.

After that a test group of 50 people was recruited those people being the parents of children with the oral speech disturbances. A feedback form was composed. It was supposed to evaluate the following three things:

- 1) how well the children acquire the language of pictograms;
- 2) how effective the mobile application is as a means of communication;
- 3) how the application influences the development of coherent speech.

The results from the questionnaire survey demonstrated that the mobile application in question is interesting and demanding. But there are some shortcomings as well. For example, the quality of pictures is not quite good.

We conducted both the entry testing and the exit testing of children who had used the “Teaching” module of the “PictInteraction” application. The entry testing was done before using the application. The exit testing was done when the parents decided that their children had already learnt how to use the application and could employ it for alternative communication.

The results of testing have shown that it is possible to learn the language of pictograms and that the “Teaching” module is an extremely efficient tool. There is an obvious improvement of the results

in all types of questions. However, it appears that there are some complicated questions which have been answered improperly by many children. We believe that they should be restated in order to become more understandable.

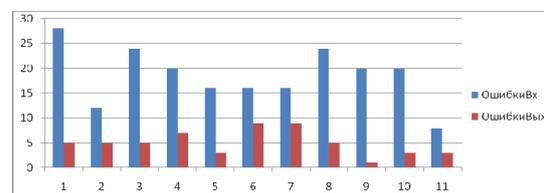


Figure 4: The diagram representing the incorrect answers in the tests.

Figure 4 shows the diagram representing the number of incorrect answers to the test questions before using the “Teaching” module and after that. There are 11 questions in the test. Forty children took part in the test. The horizontal axis contains the numbers of questions. The vertical axis contains the amount of children under test who answered the questions incorrectly.

The errors made during the entry testing are denoted with the blue colour. The errors made during the exit testing are denoted with the red colour. It can be seen very easily that the children have made much less errors when answering the test questions after they have used the given application.

The “PictInteraction” application raises the possibilities of the speech development in general and of the coherent speech development in particular. At present we are engaged in the following promising activities:

- 1) improving the quality of the pictogram graphics;
- 2) creating the animated pictograms;
- 3) expanding the “Communicator” module by adding the tasks which are intended to develop the coherence of speech as a crucial parameter of the speech development;
- 4) testing the application not only for the children with the autistic spectrum disorders but also for the children with different manifestations of the specific language impairment.

3 CONCLUSIONS

Our work experience in the field of speech and language therapy with children and our close co-operation with the teacher-logopedists lead us to believe that the usage of mobile applications

promotes the children's interest in the speech and language therapy sessions. Thus, these sessions become more successful.

Today, children spend a lot of time with their smart-phones and tablet computers. The use of mobile applications for the correction of speech disturbances (together with the performance of various logopedic tasks) will encourage the children to work on their own speech in the course of a computer game. It will also prevent them from the "light-headed" pastime with their mobile devices.

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