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E-learning resources for successful math teaching to pupils of primary school

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Abstract. Ukrainian primary schools are undergoing significant changes as for Reform 'New Ukrainian School', it reflects rapid updating information technology and high level of children' informational activity. Primary schools are basically focused on development subject knowledge and general study skills. One of the ways of their developing is to use tools and apps. There are the examples of using interactive tools and apps for teaching Math for young learners by teachers-to-be in the article. The article presents as well the experimental data about training teachers-to-be to use tools and apps. Interactive tools and apps provide real task variability, uniqueness of exercises, operative assessment of correction, adjustment of task difficulty, a shade of competitiveness and gaming to the exercises. To create their own apps teachers-to be use the tools that are the part of the integrated Microsoft Office package using designing environments, and other simple and convenient programs. The article presents experimental data about the results of training teachers-to-be to create apps. A set of criteria for creation apps was made and checked at the experimental research such as ability to develop apps, knowledge and understanding the functional capabilities of apps, knowledge of tools for creating apps and their functional capabilities, ability to select and formulate tasks for young learners, ability to assess adequately the quality of the developed apps.

Keywords: tools and apps, teaching Math, young learners, primary school, experimental research.

1 Introduction

As for ongoing Reform 'New Ukrainian School' in Ukrainian primary schools and education changes occurring in the society, the particular attention should be paid to the primary level of education. Primary schools are the foundation for creating intellectual and general study children' skills, development their cognitive activity, and

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independence. It is the elementary school that affects all subsequent nature of the relationship of young learners with the educational environment and society.

There are some reasons for changes. The present stage of education system development in primary school is undergoing the significant changes. These changes are associated with a wide penetration of information and communication technologies in all areas of human activity, rapid updating of information technology and high level of children' informational activity. The evidence to this is as follows:

- reduction of the age of a child's first encounter with a computer. As a rule, a child who comes to primary school, already has the first experience of using a computer. This is facilitated by the presence of household digital devices in the family such as photo and video cameras, mobile phones, smart phones that are compatible with a computer and assume data processing by a computer. In addition, current software market is filled with entertaining and educational multimedia programs for children aged 3-4 years. However, the lack of purposeful use of information technologies in educational activities that meet child's needs, is mainly compensated by gaming activities on the computer;
- the emergence of mobile devices connected to the Internet. The capacities of such mobile devices are not used in training process. However, young learners tend to be well acquainted with such devices and use them solely for entertainment. In addition, other technical devices of algorithms automation could be used in the learning process: household and office equipment, robotic machines, automated construction sets, etc.;
- presence of specific skills to use information technology for personal use with young learners of primary school age. Currently, young learners get familiar with the computer components and software tools for themselves as a need arises for writing and editing papers or reports (text processors, program browsers, image editors), for communication (social networks, communication software), for finding new applications for mobile phones and so on. However, existing skills can be used to develop the necessary substantive and general study skills;
- approaches of presentation new information to children in the classroom need to change. Young learners expect beautiful, bright illustrations, presentations, videos to be used, game situations to be created and so on. This is due to the changes in the media – modern TV programs are bright, emotive, dynamic, in order to maintain the audience's attention; stories in publications for children are accompanied by high-quality illustrations, videos, etc.; modern books expect the reader's action to color, to find the path of the character, find differences, etc.;
- presence of a large number of applications and devices that can always help a young learner such as calculators and translation tools in mobile devices and computers; electronic reference books; spelling dictionaries, built into text editors. Prohibition to use such applications can be changed for the selection of such tasks, which provide for educational research and give young learners an opportunity to use various means to test their own suggestions;
- willingness of teachers, especially in primary schools, to use the new information technologies in education. In primary school a teacher and a textbook remain the

primary source of information, and that is the teacher who determines the level of acquired knowledge, the level of general study skills.

The named reasons condition the need for new approaches to implementation of information and communications technologies in teaching young learners. Primary school is focused on the development subject knowledge and general study skills such as skills of writing, reading, doing sums, spelling and others, assured command of which is a prerequisite for further successful studying in school.

Achieving success in building subject and general study skills is a natural need of every young learner. Each child comes to school with an aspiration to be successful and to gain recognition of personal achievements. For a young learner the expectations of success are connected with the efforts to gain recognition on the part of people important for him/her – parents, teachers, principal, classmates and getting approval from them. Experiencing success by young learners affects the quality of education, the development of the inner child's world, the formation of self-confidence.

As we know, success is a feeling of joy, satisfaction from the fact that the result, which the personality was striving for in his work, either matches his expectations, hopes, or exceeds them. Success is always connected with actions, it is not an end in itself. This is the result of achieving the desired goal, accepted, recognized and meaningful to a child, experience of feelings of joy after overcoming difficulties. Achievement provides for getting a specific result, and recognition can be public, local or individual [12]. The success supports a child's interest in learning, encourages him/her to overcome the difficulties, urges to achieve new goals.

One of the modern ways of forming a general study and subject skills by primary school children are tools and apps. Tools and apps are educational software that designed to shape and consolidate practical skills after preliminary mastering of theoretical data by young learners.

2 Literature review

The literature also holds many studies related to the positive effects of educational use of information and communication technology (ICT) in general [13] and cloud technology in particular [9]; instructional design principles, their interrelationships, overall process of designing effective teaching with ICT [4]; engineering design thinking, teaching and learning with ICT [5]. Some issues about primary learning were discussed such as developing technological pedagogical content knowledge in pre-service science teachers [1]; using ICT in primary school curriculum [8]; e-learning for primary teachers [7]; using ICT in primary Mathematics [11].

We wrote some articles concerning such a significant investment in the theory as didactic potential of digital educational resources for young learners [2]; on cloud-based complex of computer dynamic models and their transdisciplinary facilities [3]; and in practice as use of GeoGebra in primary pupils training [10].

3 Methods

In this research theoretical, empirical and statistical methods are used. Theoretical methods (analysis and synthesis) serve to analyze opportunities, advantages and disadvantages of tools and apps as new means to teach Math for young learners in primary school.

Empirical methods (observation, testing, pedagogical experiment) provide conducting the experiment itself, detailed and achievement tests in order to collect data for examining the efficiency of use systematic tools and apps to teach Math for young learners in primary school.

Statistical methods helped make statistical analysis of the pedagogical experiment data; the experiment was conducted at H. S. Skovoroda Kharkiv National Pedagogical University (Ukraine) at Computer Science lessons during 2016-2018 with 82 teachers-to-be for primary school.

4 Results

4.1 Interactive teaching tools in ensuring the success of young learners in Mathematics study

As mentioned above, using tools and apps to teach Math for young learners in primary school is relatively new teaching means for Ukrainian educationalists. Definitely, tools and apps can provide successful learning.

To educate young learners there are many tools and apps developed that facilitate the acquisition of skills in Math, in native language, in foreign languages, etc. However, a tool is only relevant if it allows you to work out exactly what caused the difficulty in a particular lesson, when the specifics of teaching material is taken into account, especially the perception of young learners.

Tools and apps unlike traditional manuals provide real variability of interactive tasks, uniqueness of exercises designed to form appropriate skills. In particular, for training young learners in performing calculations and doing sums, tools and apps are able to generate an unlimited number of numeric values to each task type, which allows diversifying the learning objectives, avoiding memorizing answers.

Tools and apps feature operative assessment of correctness of each task. Immediately after each task a child can get a reaction, indicating a correct solution. This immediate response is important in the early stages of training young learners when they expect approval for successful tasks or reassurance if making errors. Immediate reaction of the software will improve learners' confidence in their abilities, willingness to effort to improve their results. However, with getting experience in work with the software, instant control must be reduced in order to maintain and encourage learners' initiative.

An important feature is the adjustment of task difficulty. The difficulty level can be preset designated by a teacher or selected by a learner. Of particular interest there are tools and apps that implement adaptive algorithms and basing on learners' performance

of first proposed tasks adjust automatically the level of subsequent tasks. Such adaptive interactive tools and apps are useful especially in primary school, because the difference in learners' background, in level of their habits and skills is the most notable among children in a class there are those who perform calculations easily, read quickly, etc., and those who are only acquainted with basic rules, learn to form syllables.

Automatic control of the difficulty level of tasks enables a teacher to identify quickly gaps in learners' knowledge and eliminate them. To learners whose skills, which are being trained, are already formed at a high level, tools and apps provide an opportunity to test their skills in doing exercises of increased difficulty. Thus, tasks for each learner are in the zone of their proximal development.

Tools and apps feature the ability to provide a shade of competitiveness and gaming to the exercises. It is worthy of note that game is not the main activity for primary school children, but it takes a significant place in child's life along with educational activities. Playful learning requires substantial intellectualization of primary school child's activities such as prompt realization of task, analysis of possible solutions, and search for the optimal variant. Moreover, the game encourages a learner to show initiatives, to develop activity, stimulates memory development, initiative thinking, releases emotions.

Using computer can realize the benefits of playful learning to the full extent. Exploring the specifics of computer games in education, there are the benefits as we know: increase learning motivation, encouragement of initiative and creative thinking, inclusion all learners into activities, getting experience of cooperation and teamwork, establishment of interdisciplinary connections, creation an informal environment for learning, favorable conditions for different strategies formation for solving problems, etc.

The emotional appeal of computer games, competitive game aspect, variety of events, exciting plot, realistic graphics, ability to control characters by oneself can instigate learners to achieve only a gaming purpose. Therefore, an important prerequisite for using computer games in education is to provide conversion of a gaming purpose (to help the character, to win, to release someone, to get the prize) into achieving educational goals.

For example, amid spectacular finding a way out of the labyrinth, there may be a process of mastering of subject skills. Playful presentation of a task, its dynamic nature, the practical purpose (to color a picture, to collect the keys, to rescue the princess, etc.) turns a routine work on developing skills into an interesting game that motivates learners to perform typical tasks. In addition, ability to compare the results of their own work with other learners' ones, gives such activities as sport excitement and an incentive to improve the obtained results.

There are some principles of construction interactive authors' apps. With the development of tools, the availability of information sources a teacher-to-be is able to create interactive authors' apps that take into account the specifics of training learners of a particular grade on a particular topic, their individual characteristics and hardware of educational process. Authors' apps can be directed to practice exactly the skills that cause difficulties for learners.

4.2 The principles of construction interactive authors' apps

Based on the analysis of existing experience of using tools and apps in the practice of primary education, we have identified the following principles of their construction to ensure successful teaching primary school children.

The first principle to be taken into consideration at app design is the following: *developed apps should generate learners' interest*.

The matter is a child who works with an interactive model is unobtrusively involved in educational and cognitive activity. It is important to emphasize that a learner is got involved in this activity by not direct teacher's instructions, but on his own desire to resolve the situation occurred on a computer screen. Plot design of a training material encourages him/her to educational activities. These actions require revealing subject knowledge and skills as well as the ability to apply them to a new environment. The combination of training and practical purpose that is achievable and understandable for a child gradually transforms into the learning motive. Such a transformation is promoted by the circumstance that at summarizing the child's work with a didactic model, his attention is focused on the importance of the knowledge and skills that have helped to achieve a successful outcome.

In primary school it is crucial to include pure life realities into the learning content. It provides implementation of the didactic principle of training and practice connection.

Tools and apps must allow applying a learning task with all its attributes: for example, travelling cars, a chocolate bar that is being eaten, a pie which is being divided etc. A learner can move the car, divide the chocolate bar, cut the pie in different ways.

Tools and apps allow expanding the diversity of training tasks, suggesting the problem having various solutions. So, a learner is assigned not only to solve the problem correctly, but also to make a rational choice of the solution method. The second principle to be taken into consideration at app design is the following: *apps should be visually presented to create pleasant emotional background*.

Child's emotions at classroom activity have a significant impact on it. Emotions initiation of primary schoolchildren usually is associated with a particular situation. It might be nice visual design, familiar objects or characters, valid comments. All this calls up a learner's pleasant feelings.

Development of positive emotions and aesthetic senses is also promoted by the series of techniques. They include friendly interface of didactic interactive models, harmoniously picked up colors, using special techniques to attract and focus learner's attention, to develop his imagination, thinking, and memory. A positive emotional background of a child's learning with interactive models is also guaranteed by the possibility to cancel his actions at any moment and to return to the previous step. A learner has an opportunity to feel free doing his trials at searching right or effective task solving. He is not afraid of any negative consequences. It promotes creation of a learner's positive emotions, forming his persistence and confidence. The third principle to be taken into consideration at app design is the following: *problem definition should involve learners into critical analysis of input data as for their adequacy, redundancy, actuality*.

For this purpose, the developed apps have redundant information, so that a child could choose what he/she needs. For example, additional measurements, additional data etc. The fourth principle to be taken into consideration at app design is the following: *apps should allow learners to operate free, for example, to perform transformations of geometric solids (rotate, drag, resize them)*.

The peculiarity of young learners' perception is a close connection with an action. For schoolchildren, especially in their 6–7 years, to perceive the subject means to do something with it, for instance, to touch, to rotate, and to change. Practical actions play a significant role for the development of child's cognitive processes. Therefore, apps should allow manipulation with learning objects.

Apps which are focused on learners' research activities should provide possibility of the figures transformations such as rotation of geometric shapes, overlapping some shapes on others for their comparing and resizing. Making changes with shapes meets child's need to experiment. At the same time it allows to see results of his activities and to make his/her own conclusions.

Some additional principles to be taken into consideration at interactive models design are: developed apps should provide support (step by step assistance) of learners' activity to achieve success and completeness at tasks performing; developed apps should provide an opportunity to verify the correctness of the obtained result.

On the one hand, to succeed in learning it is important for a child to have an opportunity to achieve his intended result. Timely assistance is crucial for learners who have just started learning. Developed apps contain elements that provide necessary support for a learner. Every child who works with the model can get help in time. A child can get help after his request in the form of textual commentary, additional constructions, and solution. The system of multi-level assistance in tools and apps focuses on achievement the result by each child.

On the other hand, training should be accompanied by overcoming difficulties feasible for a learner. Depriving a learner of difficulties we, however, deny him feeling joy and pleasure of success gained through his/her own efforts. Difficulties in the learning process are essential to meet learner's needs in cognitive activity. Therefore, learner's assistance at difficulties should be dosed, not excessive, but sufficient to support his efforts and aimed at making him/her overcome obstacles himself/herself. Learners in their learning activities should not act on a pattern and algorithm and retain the right to initiative, possible errors and their correction. A learner should be relaxed in his own actions. The experience in this activity is now appreciated higher than well learned rules in solving typical tasks as this experience teaches a learner how to acquire knowledge.

Taking dosage help for learners in apps is a complex task and is currently being implemented fairly rarely, but this assistance will help developing initiatives to identify creative abilities, creating strong-willed child. Successful and progressing schoolchildren can employ maximum available to overcome difficulty level tasks for schoolchildren.

4.3 Interactive tools for construction authors' apps by primary teachers-to-be

We would like to show the basic tools for construction interactive authors' apps. A teacher-to-be, creating apps, independently, can use modern tool kits to create interactive exercises and didactic computer games. The interface of many tool kits, oriented to design author's didactic resources, is simplified and intuitive for an average user and it does not require additional training. In addition, as a rule, these tools include a set of templates for rapid development and offer the available examples.

To develop apps a teacher-to-be can use programs that are part of an integrated Microsoft Office package, spreadsheets and applications to create presentations.

The choice of these applications is due to several reasons:

- wide spread of Microsoft Office package among different specialists;
- preparedness of teachers-to-be to use office technology in teaching;
- presence of large collections of teaching resources developed by teachers for their own educational activities. Ready didactic resources are available to teachers and can be adapted to the conditions of a particular grade and lesson;
- teachers' experience of usage software package for the preparation of teaching and learning materials, documents, etc.;
- possibilities to integrate various forms of information in apps, so, slide or book may contain author's drawings prepared in appropriate graphics software, sounds, prepared in music editors, text fragments.

There are the examples of authors' apps. Apps developed by our students from H. S. Skovoroda Kharkiv National Pedagogical University, teachers-to-be for young learners for primary school to teach Math in Microsoft Excel spreadsheet are presented in the form of tests, didactic games, crossword puzzle (Fig. 1).

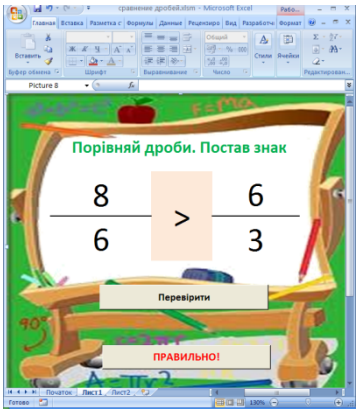


Fig. 1. Apps for learning fractions developed in Microsoft Excel

Basically, such capabilities provide convenience to create training systems in Microsoft Excel:

- data exchange between applications which facilitates the process of preparing the environment for apps and enables to provide an attractive appearance;
- modifications and additions to the tasks when they are needed;
- programmable generation of numerical values in the text of tasks and answers. This allows to prevent memorizing the answers by learners and provides variation of the tasks.
- simplification of the analysis of the assignment correctness by the relevant functions;
- presentation of the test results in the form of tables, charts, graphics, etc.;
- storage of test results and the ability to further analysis;
- availability of templates to create tests that are available to teachers-to-be at any time.

The advantage of using presentation software to develop automated tests is the possibility of their attractive design, providing a soundtrack, the ability to support each task or question with a desired scheme or pattern. In addition, the PowerPoint environment allows the construction of matching tasks, where the correspondence between the elements of two sets is defined, the tasks of ordering the sequence of actions.

Of special convenience for a teacher-to-be is access to ready-made templates that have a programmed tasks check. In the environment of Microsoft PowerPoint presentation the apps developed by our students are presented (Fig. 2, Fig. 3). The apps include controls designed for automatic creation of tasks for learners and elements that analyze user actions.

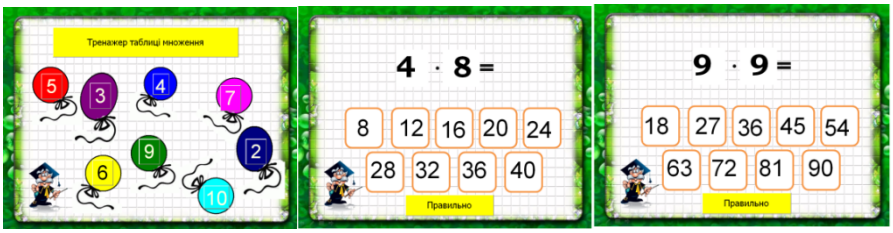


Fig. 2. Apps for learning multiplication tables developed in Microsoft Power Point

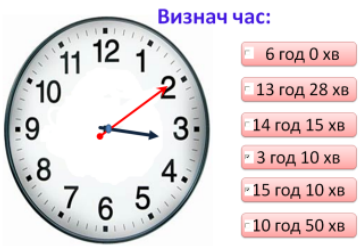
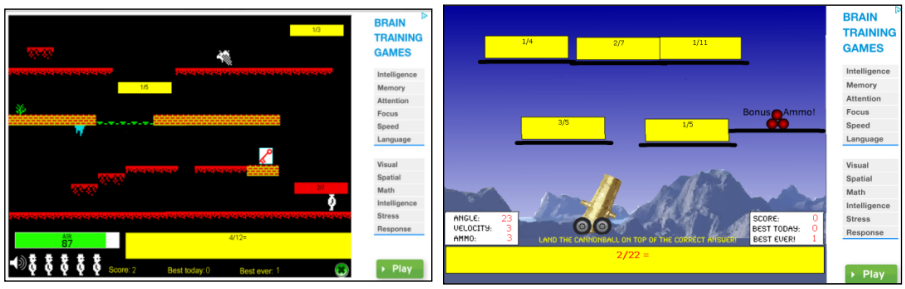


Fig. 3. Apps for learning analog clocks developed in Microsoft Power Point

However, the development of apps in these packages requires knowledge of the programming language Visual Basic for Application and it is a painstaking task for a teacher-to-be. To create apps primary school teachers-to-be can use designing environments which include a substantial set of templates and patterns associated with school material. In particular, such app designers can be useful for a teacher-to-be. They are the designers: Classtools.net, Zondle, Learningapps.org, Studystack and others.

Within the environment Classtools.net (http://classtools.net/) a teacher-to-be can develop interactive posters, charts, diagrams, computer educational games to support any school subject such as Math, Science, Reading and more. The environment is an online resource that offers a set of templates for creating teaching tools. In particular, the template "Arcade Game Generator" used by our students (Fig. 4a) enables to create computer games such as quizzes in the form of arcade games (search for pairs of questions and answers, hitting the target with the answer), pattern "Dustbin Game" used by our students (Fig. 4b) creates tasks related to the grouping of elements, template "Post It" allows to create interactive posters in which an explaining text is shown when you hover your mouse on a specific part of the image. Options of patterns are improved and their number is constantly growing.



a *b*

Fig. 4. The template "Arcade Game Generator" (a) and pattern "Dustbin Game" (b)

Of special convenience for teachers-to-be is that developed apps can be stored on the server for the organization of joint work of learners, on the local computer for future use in the classroom, or printed out.

The didactic games designer Zondle (http://www.zondle.com) allows a teacher-to-be to create apps for any subject. The designer offers template games to fill in with the subject content. In this case, a teacher-to-be needs only to prepare assignments and choose a template of the offered. Designer offers to use certain types of tasks, among them the tasks that include:

- select the correct answer from the offered;
- enter the correct answer from the keyboard;
- confirm the correctness of a statement;
- insert missing words into the statement and others.

The environment also provides an option to develop the game scenario, chose the characters and fill in substantive tasks by oneself. Creating author's games does not require programming and additional training.

In Fig. 5 the examples of education games made by our students for young learners are shown, reviewing the multiplication table and the formation of ideas about true and false statements.

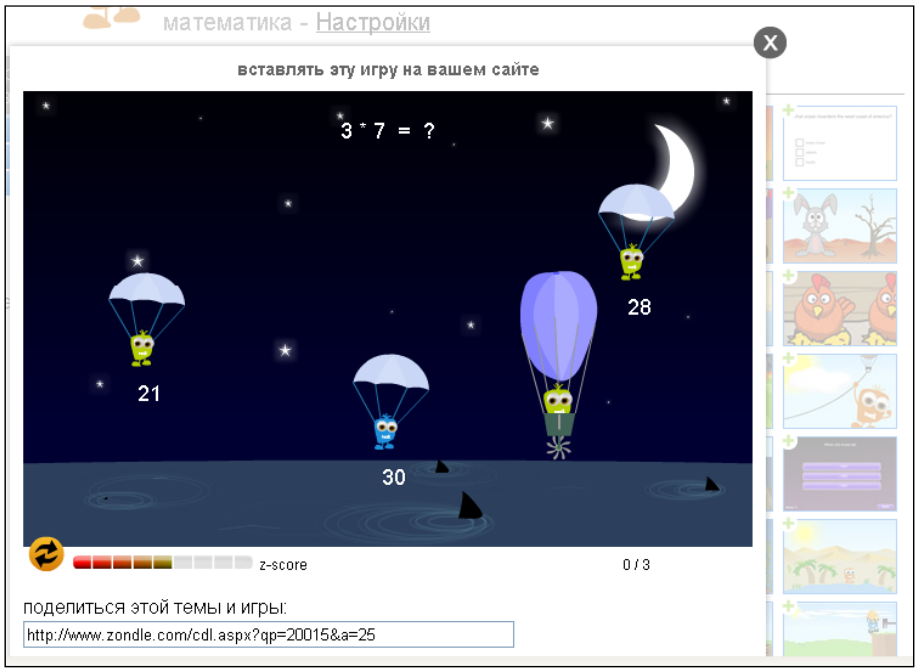


Fig. 5. Example of education games in Mathematics in Zondle environment.

The developed educational games are stored in a network that allows to use them in extra-curricular activities for learners. The designer of interactive exercises Learningapps.org (http://learningapps.org) allows you to create training exercises that require practical actions from user: to place in the correct order, to choose the correct answer, to solve a crossword puzzle, to solve a puzzles, to group etc. Many templates are offered to a teacher-to-be as well as a set of ready-made interactive exercises that can be used as templates. They help in creation of such didactic exercises that would be appropriate in a particular grade, in the study of a particular topic. Ready projects can be stored on a local storage or network.

In Fig. 6 some examples of developed interactive exercises made by our students are shown, they illustrate mathematical operations to learners and train their verbal counting.

The designer of education games Studystack (http://www.studystack.com/) allows not only to create interactive exercises using the set of templates, but also offers

practical tasks already available from a variety of subjects: Mathematics, Nature, Art, History, etc. Projects are stored on the server, which allows using them both in the school and home training. The designer has been working since 2001 and has accumulated a significant amount of ready interactive exercises for children from preschool to high school. The advantage of using this designer is ease of preparation of training exercises: a teacher-to-be simply enters tasks text and correct answers, on which base different versions of interactive exercises are created automatically such as quizzes, crosswords, hit on target games and hangman games, etc.

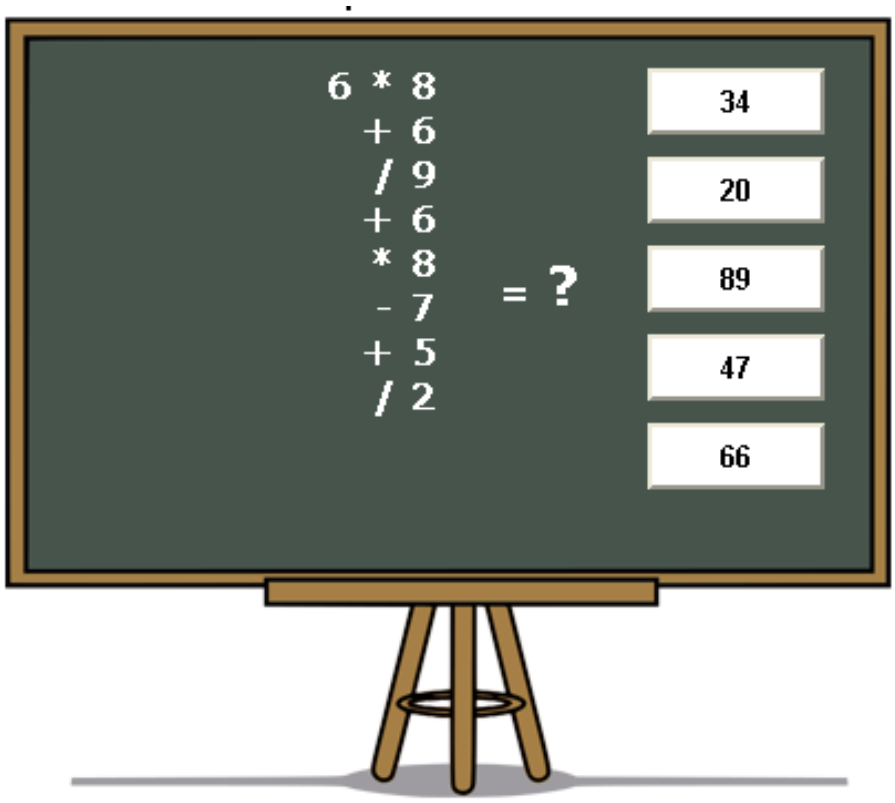


Fig. 6. Examples of interactive exercises created in the Learningapps.org environment

To create apps a teacher-to-be can also use an environment GeoGebra (http://www.geogebra.org). It is very popular nowadays [6]. Some examples of apps developed by our students for young learners on GeoGebra are shown in Fig. 7–11.

All apps were developed by teachers-to-be for primary school during their studies at H. S. Skovoroda Kharkiv National Pedagogical University. Apps in figures are original and tested by the students during teaching practice. They are always available for primary school teachers. We think that the experience for the development of these apps will be useful for teachers-to-be, and working teachers in their professional activities.

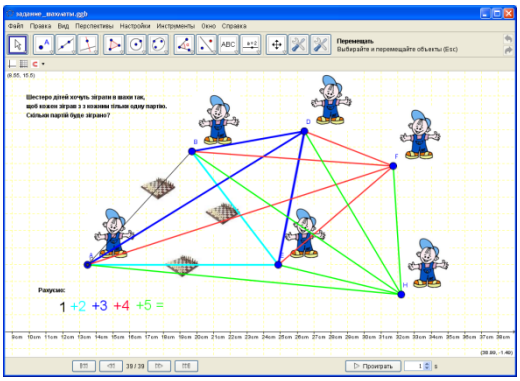


Fig. 7. Apps for task about chess: Six children want to play chess, so that everyone plays with each player once. Find how many parties will be played

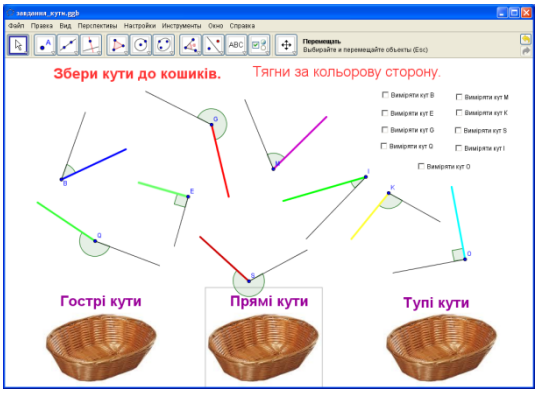


Fig. 8. Apps for tasks about angles. Children collect right, obtuse and acute angles into baskets

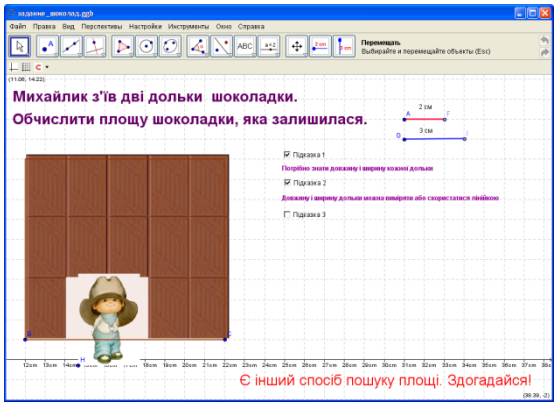


Fig. 9. Apps for a task: Mykhailyk has eaten 2 pieces of the chocolate bar. Find the square of the chocolate bar that remained

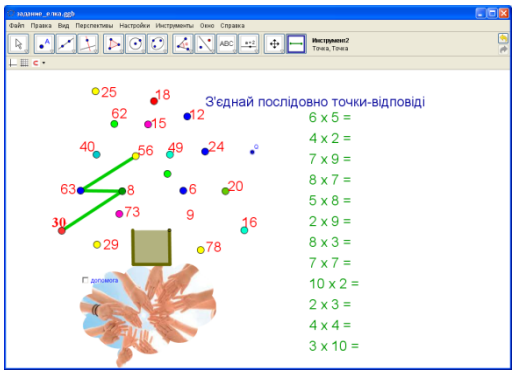


Fig. 10. Children solve arithmetic tasks and connect in series points-answers. As a result, children get a Christmas tree

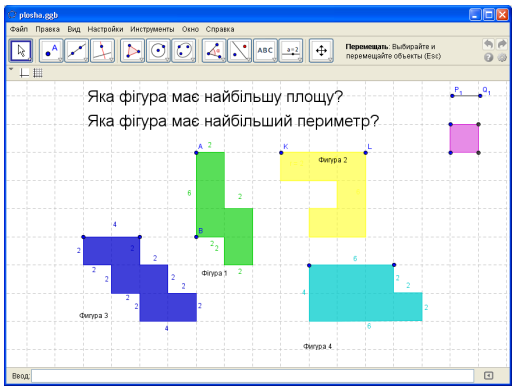


Fig. 11. Apps for a task about square and perimeter of shapes. Children determined which of the shapes has the largest square and the largest perimeter

5 Discussion

The main results of effectiveness of tools and apps are confirmed by many scholars, namely:

- instead of being knowledge-focused, tools and apps are built around the skills [1] necessary to carry out specified Math tasks in primary school; the focus is on what young learners can do at Math lessons rather than on what they know;
- young learners are expected to demonstrate practice-added skills which are assessed by looking at outcomes of apps rather than process [8];
- young learners' performance is evaluated during the instructional process against common learning standards [68], and all forms of assessment are standards-based and criterion-referenced [7]. After all, teachers-to-be will be able to deliberately choose the most effective direction in learning young learners with tools and apps.

6 Conclusions

Use of tools and apps is an effective way of developing successful general study skills for young learners. Tools and apps feature the ability to provide real variability of tasks, uniqueness of exercises, operative assessment of correctness in each task, adjustment of task difficulty, ability to provide a shade of competitiveness and gaming to the exercises. Tools and apps can be created by the universal software tools, such programs that are part of an integrated Microsoft Office package or special designing environments.

The capabilities of the tools and apps are covered, which ensure successful acquisition of knowledge, for developing young schoolchildren's skills. Considered tool kits enable a teacher-to-be to design independently author's apps that meet the needs of a particular lesson, enable to achieve the lesson goal with the peculiarities of the educational process in primary school.

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