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The ICT usage in teaching mathematics to students with special educational needs

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Abstract. In the article, authors have considered the implication of ICT into mathematics educational strategies in the inclusive class of secondary school. The research includes also a presentation of a teacher's tool, prepared by an author group, on the use of ICT in teaching planimetry and stochastics of children with special educational needs (SEN) in secondary schools. The research has introduced the model of implication ICT and the influence of effective strategies and methods of inclusive education on the math studying process by children with hearing disorder. The possibilities of using the method of educational projects as one of socialization directions are described. The efficiency of the distance learning was discovered that facilitates the self-representation of students with SEN.

1. Introduction

The world standard of inclusive education strategy is based on the idea that students with special educational needs (SEN) require support in getting key life competence such as cognitive, non-cognitive skills, and the acquiring of “functional literacy” for independent life and socialization [71]. The “literacy” in this context implies the ability to recognize, understand, interpret, create, transmit, and assess information based on documents printed and handwritten having relation to various issues of lives to make daily decisions and guide their actions ([9], [23]). The “functional literacy” of mathematics includes basic skills: numbers, fractions, four operations, geometrical shapes, problem-solving, and measurement for students to solve daily problems [71]. Particularly, the success of the students' targeted acquisition of these key math competencies depends on class management, teaching approaches and methods such as the universal design of learning or differential instruction [13].

The philosophy of inclusive education requires the provision of the qualitative education for all children through the development of appropriate curricula, the accomplishment of organizational measures for school and class universal design, preparation of teaching strategies, use of resources, and partnerships with key stakeholders (administration, families, service staff, assistants and other specialists from the team) [70].

The success of using strategies of teaching mathematics in secondary school emanates from the concept of “normalization” in inclusive education which based on individualized learning and determines the specific educational approaches [32]. For this concept, we need to provide for the relevant conditions of overcoming the educational and environmental barriers to the process of studying mathematics by students with SEN. It means that children with SEN are able to acquire math skills in general class only when they are supported in an appropriate educational environment and conditions based on their needs [36]. This task of overcoming educational barriers means the



preparation of individual programs in respect of individual particularities of the educational cognitive activity, for each student with SEN ([32]; [36], pp. 5–7). Particularly speaking, these conditions are attained through integration of ICT strategies in studying mathematics into the education curriculum of secondary school [67].

The current reform of the educational system in Ukraine foresees the development of inclusive education to create conditions for children with special needs to study together with their peers. Consequently, the basic principle of inclusive education aims to minimize external differences in the implementation of learning and to incorporate specific methods and techniques into internal aspects of its implementation. Today, there are several issues in inclusive education in Ukraine. Firstly, at the local level, the pedagogical staff of schools may lack the necessary competencies needed to implement inclusive education in their educational institutions. Although generally supported by the government, coherent practical approaches are lacking as stakeholders in the field of inclusive education act rather independently from region to region with lack of coordination. Secondly, teachers are not psychologically prepared to work in an inclusive class, although pre-instruction is provided to inform a teacher what is necessary to work with a child with special educational needs. It means, that the psychological readiness of working in inclusive education declares that the modern rehabilitation should be directed not at “repair”, and “correction” of defects of a sick child, but at providing conditions and opportunities for its active life and involvement in all social processes of the community life. Thirdly, at the same time in Ukraine educational space there is several wrong formal ways of inclusion: “normalized” and ignore the special education needs of a child (structure and functions of the body, factors of the environment, difficulties), a concentration on correctional education (cognitive, emotional spheres and speech development) without socialization.

Children with SEN have typical for this group features of cognitive and non-cognitive activity inherent in each child. Such special needs of the child require reasonable adaptation and organization of the educational environment, modification of educational tasks, giving more time to think about tasks, and self-fulfillment [32]. We need to highlight the children with hearing impairments (especially students with cochlear implants, hearing aids) most need of using of technical gadgets and time-controlling over their working conditions, assignment modifications, adaptation of educational facilities (improvement of acoustic conditions, additional sound amplification) [13], [44]. Peculiarities of cognitive activity of children with hearing impairment (HI) are presented in the publications of Janet F. Fletcher [15], Wayne M. Garrison [14], Annette Majnemer [33], Terezinha Nunes [44] and others. Learning difficulties of this category of children are related to speech delay and specific problems in conceptual and figurative thinking [6]. In particular, the peculiarity of the formation of visual-action thinking is that it occurs almost without speech, which makes it imperfect and does not contribute to the transition to the visual image level. In turn, the formation of formal-logical thinking is also difficult [13]. Of course, these features of cognitive activity become the subject of correctional and developmental activities of correctional psychologists. At the same time, the greatest fears about this category of children arise in teachers of mainstream schools when teaching the physics and mathematics cycle.

That's why the purpose of our research is the modification teaching strategies for children with SEN: to study the possibilities of optimal use of interactive exercises LearningApps and GeoGebra Dynamic Geometry system in order to provide methodical and didactic support of training sessions, independent study, implementation of monitoring activities. Consequently, some aspects of the problem of math teaching students with SEN can be eliminated through the use of ICT as a provider of training materials adapted, assistive devices, and support. There are two benefits of using ICT: technology usage in studying is beneficial in the self-representation of students with SEN; it gives more opportunities for getting a quality education. However, there are some problems with ICT for students with HI. Firstly, ICT as a provider of training materials adapted usage technique for math teaching students with HI is not firmly established and needs further accommodating research and testing. Secondly, there is a problem with the way of learning material representation for students with SEN using ICT technologies as information and communication technologies and support.

2. Literature review

Most researchers agree that the access to appropriate ICTs can reduce differences in inclusive education, and children with SEN must have access to ICT-based programs being a part of the schedule of school [72]. That is why digital inclusion in math education as a process is a system of a student's empowerment through participation in education processes with ICT programs [6]; individual curricula of studying math [44]; providing with reasonable accommodation of materials [6].

Various aspects of digital inclusive education in math have been considered by researchers the problems of social and psychological support of the educational process of students with SEN (Janet Muscutt [41], Alla A. Kolupaieva [22], Sangeeta Singh [63]); the role of information and communication technologies in education of persons with special educational needs (Beatrice Hope Benton-Borghi [1], Antonia Cascales-Martínez [6], Alistair D. N. Edwards [72], Adriana S. Fachal [10], Tamila H. Kolomoiets [21], Yekaterina A. Kosova [8], Yuliia H. Nosenko [77], Hanna B. Varina [47]); inclusive mathematics education (Annemarie Fritz [13], David Kollosche [20], Paula Maccini [32], Terezinha Nunes [44]); preparation for work in inclusive educational environment (Julie Forster [12], Mary A. Mendenhall [34], Josef Slowik [64]); the process of inclusive education establishing in Ukraine (Alla A. Kolupaieva [22], Olena P. Shestopalova [3]).

The scientific analysis articles of the issue teaching mathematics of students with special educational needs in secondary school has shown that the research was conducted in the following areas: the best practices of NCTM standards such as promote hands-on learning and critical thinking [32], diagnosing students' mathematical competences [3], examples of adaptations for an individualized educational plan (tabletops, calculators, ICT) ([6], [32], [44]), cases of behavioral management, types of assignment modification ([6], [20], [32], [41]), effective instruction ([20], [44]). Few general notions have interest for our research in chapters of the handbook edited by Annemarie Fritz, Vitor Geraldi Haase and Pekka Räsänen. It's the analysis of the implementation of competence models as a basis for defining, understanding, and diagnosing students' mathematical competencies ([13], p. 44) and comparative analysis of mathematical learning and its difficulties in Eastern Europe ([13], p. 147). The basic idea of educational standards "functional literacy" of mathematics in secondary inclusive class we highlight in article by Paula Maccini and Joseph Calvin Gagnon [32]: math as problem solving, communication, reasoning and math connections.

In training course for teachers [72] by Alistair D. N. Edwards notes the ideas of assistive technologies for educational purposes concerning the needs of hearing of impairments: design of SNE curriculum content based on ICT usage and model of ICT-based educational/pedagogical skills (skills of general use of ICT hardware and software, learning-to learn skills of using Internet resources on specific subjects). The article by Kateryna M. Bondar and Olena P. Shestopalova explores the pilot project of implementation of the supervision as a model of inclusive educational retraining. The research project includes: 1) training the team to work with the objectives of the individual development plan of a child with SEN; 2) key features of performing observations of the learning process in the class and analysis of school environment factors; 3) team interaction supervision [3].

The article of Yuliia H. Nosenko outlines the main changes in the education system in recent years; reflects the new educational opportunities for children with disabilities; identifies the possible ways of use of ICT to improve the quality of inclusive education [77].

The manual [43] presents the results of studies on ICT support for inclusive education at different levels of education – preschool, secondary, higher. This is one of the first attempts to systematize the experience of domestic specialists in this aspect, in particular on supporting inclusive learning for hearing impaired children ([43], pp. 152–177).

The leading concept "as promote hands-on learning and critical thinking" in article [6] analyzed through the dynamics of studying math by using a multi-touch tabletop system like using technology as an "object-to-think-with" and as a tool to increase the motivation of students with SEN. Svitlana V. Lytovchenko notes that most students with HI face some difficulties in studying disciplines with a large number of abstract concepts, in particular, the disciplines of the mathematical cycle. Therefore, analogies should be applied and case studies should be supported by specific examples [30].

As Kateryna O. Kolchenko [19] notes, the rational combination of verbal and visual means the influences the effectiveness of the studying process of students with HI. Accordingly, it is better to duplicate audio information by visual one. It is advisable for the teacher to provide the students with HI with the printed lecture notes and written explanations of demonstration material in advance so that the students are able to understand its contents. It is appropriate to use some tables, diagrams, graphs with visual comments. All this will eliminate the ambiguity in the perception of oral speech [43].

Problems of distant technologies usage in teaching students (e.g., Mathematics training) were covered by Dmytro Ye. Bobyliev [2], Irina A. Getman [66], Liudmyla H. Havrilova [16], Anna V. Iatsyshyn [80], Hennadiy M. Kravtsov [25], István Lénárt [29], Larysa M. Petrenko [50], Dmytro A. Pokryshen [51], Kateryna V. Polhun [52], Tetiana V. Prydacha [54], Svitlana V. Shokaliuk [61], Myroslav J. Syvyi [65], Iryna M. Trubavina [69], Tetiana A. Vakaliuk [73], Vasyl V. Yahupov [76], Myroslav I. Zhaldak [79], and other researchers. Thanks to combined and e-learning it's allowed to have direct communication and constant interrelation between a student and a teacher.

Problems in teaching students stochastics and preparation of mathematics teachers to present this topic were covered by Myroslav I. Zhaldak, Vasyl M. Franchuk and Natallia P. Franchuk [79]. For solving the problems of mathematical statistics, researchers suggest using the Gran1 software. It is very convenient when constructing polygons of relative frequencies or histograms, to determine the numerical characteristics of the sample.

The paper of Svitlana H. Lytvynova and Oleksandr Yu. Burov [31] is discussed some methods, forms and safety issues of social network usage for school students. Taking into consideration the growing interest of students to electronic communication in social networks (ESN), it was described their place in the information educational environment. There were made the classification of objects and use of ESN to help teachers and school authority to teach students in the corporate social network. The basic components of corporate social networks were revealed: forms of learning activity (individual, group, and collective), forms of learning (quiz, debates, discussions, photo-story, essay contest, a virtual tour, mini design web quest, and conference video-lesson), and database. They were defined particular aspects of the use of certain forms for students training in ESN according to the type of social objects (messages, individual messages, video files, photos, audio files, documents, comments, and blitz-survey).

The use of ICT in mathematics teaching creates additional opportunities for students with SEN: perception of material through different sensory organs (multimodal or polysensory perception), activation of information perception by focusing on the work of stored analyzers; scaling objects on an interactive whiteboard, dynamic polysensory demonstration of environment objects and phenomena of any complexity degree; personalization of educational products by formatting the data view (changes in color, fonts, graphics, sound) etc. [43].

The theoretical analysis of previous studies reveals the following trends:

1. Online delivery has become the most prevalent way of presenting the up-to-date information to students in the quickest, most flexible, and innovative ways possible. Educational courses can utilize a variety of training of ICT specialists in SNE integration of ICTs.

2. The arrangements for successful inclusion of students with SEN of ICT to facilitate effective learning and interaction between participants of pedagogical process: asynchronous and synchronous communication and collaboration tools (e-mail, bulletin boards, whiteboards, chat rooms, videoconferencing, and teleconferencing), interactive elements (simulations, immersive environments, and games), various testing and evaluation methods (self-assessment, multiple choice testing, etc.) ([72], p. 30; [77]).

3. The educational content can be presented in various media: text on a website, multimedia, such as digital audio, digital video, animated images, and virtual reality environments ([5], [42], [45], [68]). This content can be created in a multiplicity of ways, utilizing a variety of authoring tools.

4. As a result, ICTs transform educational dynamics providing alternative, authoritative sources of information, which requires teachers to become facilitators and, in some cases, intermediaries between specific information sources and a learner.

5. The basic components of corporate social networks were revealed: forms of learning activity (individual, group, and collective), forms of learning (quiz, debates, discussions, photo-story, essay contest, a virtual tour, web quest, and conference video-lesson), and database. They were defined particular aspects of the use of certain forms for students training in ESN according to the type of social objects (messages, individual messages, video files, photos, audio files, documents, comments, and blitz-survey).

6. At the same time, the use of online services and the system of dynamic Mathematics through mobile phone applications for students with SEN has not been explored enough yet.

7. The didactic principles in distance learning remain the same. But they are implemented taking into account the specifics of new tools and organizational forms of learning, the possibilities of using modern information resources. It makes it possible to organize distance learning support for Mathematics teaching, in particular through the Moodle learning management system ([37], [38], [40]). One more way is using Google Classroom as a supplement to the traditional methodological teaching system and, as a result, improving, and updating it [4].

The studies above do not consider properly the use of distance technologies and modern technologies for mobile communication in schoolchildren teaching.

3. Method

Developed visuals for teaching students with SEN were partially implemented in the learning process in the pilot project of retraining 12 school teams who work with children with HI (Project “Supporting inclusive education in Kriviy Rih”, GIZ, 2017-19) and at a course of mathematic the multidisciplinary training and rehabilitation center “Suziria” (conducted with Karyna O. Shavyrina).

The work of the research team was aimed to developing a concept for supporting inclusive math education in Kryvyi Rih in cooperation between Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH, Department of Education and Science of the Executive Committee of the Kryvyi Rih City Council and the Kriviy Rih State Pedagogical University. The first step was the analysis of the answers to the needs for visuals for teaching students with SEN of key stakeholders (teachers, tutors, and other staff: $N=18$). According to the distribution of the needs of educational training of working with children with HI, the selection is as follows 35% have experience of support children with SEN, 65% – specialists-beginners in using ICT programs into mathematics educational strategies. The second step was implementing ICT programs into educational strategies of studying math in 6-7 class inclusive classes (students of 6-7 classes: $N=21$ children with SEN). There were children with HI, children with speech and HI, autism, and others in inclusive experimental classes.

4. Results

The appropriate methodological approach to educate students with SEN takes consideration of the key principles of learning and teaching as well as the identification of individual learning styles. According to the formulation in the Law on Education, inclusive education is a strategy based on the model requires to identify the following components of the lesson in teaching: objectives of the lesson, type of the performance, type of submitting the material, working space [36]. An inclusive model for students with SEN requires the creation of a set of specific learning conditions and contains four interrelated components: the target-oriented component, the content-oriented component (applying the different didactic material – to give a realistic task), the operation-and-action-oriented component (also using various forms of interaction contribute to the development of communication skills) and the control-and-evaluation one [32].

4.1. *The principles and methods of mathematics education in an inclusive class*

The principles and methods of math education in an inclusive general class of the secondary school based on the determination of needs the child with SEN: 1 step – to determine the current level of knowledge and skills of the student; 2 step – to determine the effective teaching style (visual, kinesthetic, poly-sensory and an-other one, especially if one of the styles dominates); 3 step – to

determine particularities of the child's adaptation to the educational institution and peer group; 4 step – to identify specific aspects of the child's learning activities, where it needs the outside help during the educational process ([13], [41]).

We need to highlight, that for teaching children with special educational needs, the same methods as for other children are used. However, the peculiarities of the psychophysical development of the students lead to other ways of applying these methods. In particular, the methods of teaching are remedial and developmental, and they stimulate children with SEN to work independently and to take initiatives.

There are specific methods of class management and teaching were studying students with HI ([10], [44], [63]). Firstly, teachers need to use alternative forms of communication are being actively formed and the strategy of studying math based on non-verbal intelligence, and competences (seriation, analogy, systematization) [44]. Secondly, studying math need an adaptation of training facilities (improvement of acoustic conditions, additional sound amplification means). For example, it's using technical equipment and controlling its operating status (cochlear implants, hearing aids). That is why, the teacher needs some tips for classroom management: never talk while facing the board, try not to speak when handing out extra material, present the topic of the lesson in front of the class, give up the habit of going along the class [72]. Thirdly, socialization children with HI mean that they need to support the establishment of relations with other persons [20]. The ignorance of special needs in socialization students with HI leads to increased anxiety and distrust of others, separation from the hearing collective group. That is why the student with HI needs collaborative group work and cooperative learning and a little more time to process the information and prepare for the answer.

Conceptually, difficulties of children with HI in secondary school on math class depend on the expression of disorders and manifest themselves in the following areas: fundamentally, it's understanding of spoken language and formation of active speech [72]. Generally, the main purpose of studying math is the formation of verbal-logical thinking children with HI and well as the formation of the auditory-visual-tactile perception of mathematical concepts: child with SEN asks questions to clarify details; makes decisions on the use of approaches and materials learned earlier; can explain decisions and establish logical connections; knows how to systemize features; plans activities ([32], [44]).

Students with HI have difficulties using conventional sources of information like books and that is why they have the piecemeal knowledge is formed [44]. Consequently, they need supporting to form ideas about the world around (the basic competencies are child can investigate length, width, area, and perimeter; can determine the time by a clock; understands the relationship between days, weeks, and months; navigates the value of coins and banknotes; compares volume and weight), orientation in open space (child determines flat and volumetric shapes in the environment; uses words that indicate the position and direction; uses a system of coordinates; creates geometric patterns).

There are some species of typing of the performance and submitting the math material for students with HI. Generally, all adaptations are noted in the individual development program of the student. The adaptation of the education math content to the cognitive abilities of the students for children with HI, this is the removal of complex verbal material. Firstly, it's visual learning. Taking into account the specificity of the SEN, the types of showing objects are additionally selected. For example, for children with HI, the visual manuals should be specific, with details that concentrate on the perception of main things. Secondly, slowing down the educational process. Communication of the information for children with HI is carried out with consideration of the slower perception of the verbal information. For children with HI, more time is given to think about the answer ([44], [63]). Thirdly, repeatability in teaching. The repetition variability should be used to fill the gaps in the perception of students with HI especially if we use ICT [10]. Fourthly, optimization of the work pace and fatigue dynamics student with HI. This tool is aimed at activation of the students' cognitive activities, support of their ability to work and includes, in particular: switching the students to different types of activities to prevent fatigue (gamification, visualization, modeling, extrapolation examples in classroom environment); using interesting facts, examples, and details in the process of presentation of the

material; emotional presentation; organizing the minutes of rest at the lessons; creating success situations for the child [10].

4.2. Online service LearningApps usage for teaching the students with SEN

Based on the conducted research the writing team developed the teaching aid [28]. The first part covers general guidelines for teaching pupils with special educational needs using ICT and tools of distant technologies. The second section focuses on the usage of LearningApps online training. The teaching aid provides both references on worked out exercises and QR codes which are generated through the service.

The use of a variety of online resources, including online services and learning environments, is becoming increasingly popular ([7], [17], [18], [24], [35], [39], [49], [56], [75], [78]). One of the prime examples of such environments is the LearningApps multimedia didactic exercising service (<https://learningapps.org/>). It is intended for the development, storage, and usage of interactive exercises in the educational process. Such exercises can be applied not only on a lesson with an interactive whiteboard but also as individual tasks for students with special needs (see figure 1). A significant advantage of this service is the ability of task integration Moodle into learning management systems.

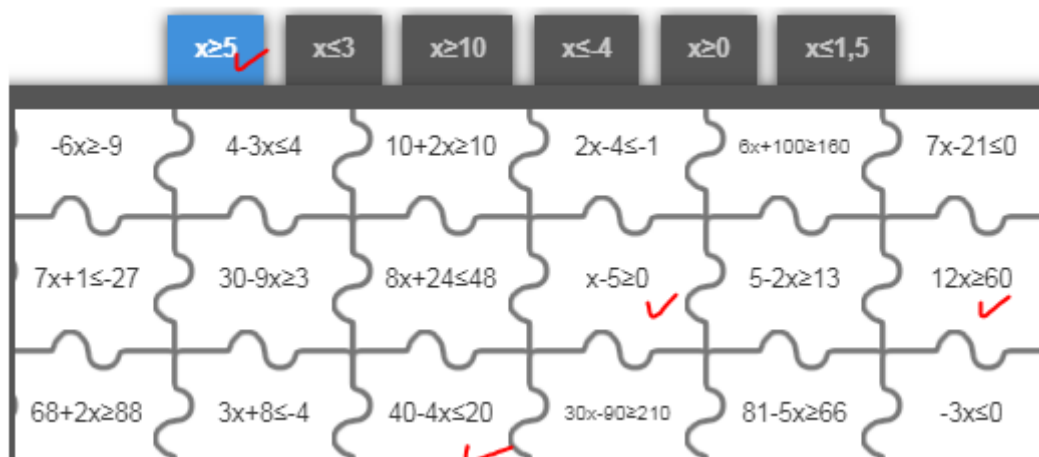


Figure 1. Task: to find equal inequalities.

The educational aim of using interactive exercises of the LearningApps service in the study of Mathematics and in particular stochastics is to achieve strong mastering of knowledge, the formation of practical skills to solve problems on the basics of combinatorics, probability theory, and mathematical statistics, to show the connection between stochastics and real life and to teach students to carry out non-typical tasks.

Let's demonstrate how LearningApps service interactive exercises can be applied at different stages of learning mathematics. For example, at the stage of learning about the concept of an event, an impossible, accidental, and probable events, it is reasonable to offer students an exercise to determine the type of event. The following events appear alternately in the exercise window. A student should determine which events are probable, which are impossible, and which are accidental.

Task 1. Determine `which` type is the event.

In this task, each word is stressed. It is reasonable to introduce exercises to children with HI in such way. In the following lessons, this exercise can be also used at the stage of refreshing students' basic knowledge on the topic.

Students with SEN may find it difficult to understand and memorize theoretical material, so it is best first to demonstrate examples of learned concepts and then return to the theory when necessary. For this purpose, it is reasonable to offer the students with special educational needs the opportunity to

find a pair in the LearningApps online service during the initial consolidation stage. In the process of studying events operations, one should use as many examples as possible, reflecting not only the essence of these operations but also the differences between them. Students with SEN can easily find both sum and value of events using definitions. So, solving applied problems is important in this process.

After students have mastered the theorems of adding incompatible events and multiplying independent events, they use them to calculate the probability of events, solving the corresponding problems.

Here are some other examples of tasks that can be conveniently created in LearningApps templates and used in Stochastics teaching.

Task 2. Calculate the probability of an accidental event.

Task 3. Determine the likelihood that a certain event will occur.

Task 4. Choose the name of the formula to be used to solve the problem.

The purpose of exercise 5 is to test the students' ability to attribute the suggested signs, definitions, or examples to the two indicated concepts. This exercise is useful for students with SEN because it develops students' logical thinking and memory.

Task 5. "Classification" exercise. The essence of this exercise is that the screen on the student's computer or mobile phone is divided into two fields: a right triangle and an isosceles triangle. Next, students are given definitions, properties, constituents, or examples of triangles to be referred to a right triangle or an isosceles one. After completing the exercise, the student can "push" the button to the right from the bottom to check if the tasks are done correctly.

Task 6. "Match" exercise. The essence of this exercise is that a student should connect the notion with its definition or example. For instance, the term "bisector" refers to the definition of a bisector of a triangle, to a certain notion corresponds a picture that illustrates it, to calculate the perimeter of a triangle, if the lengths of its sides are given, etc.

The use of similar tests allows a teacher to determine the level of success of a student with SEN and to identify gaps in his/her knowledge. It will help to correct his learning and to plan further work.

For example, the possibility of repeated repetition of the exercises created with LearningApps will give students confidence. It will also contribute to better learning.

We have found that the LearningApps learning environment can be applied at different stages of a lesson: during the organization of independent, individual activity and in joint research activities. Due to interactive exercises, students with special educational needs become active participants in the educational process. The toolkit of the service allows you to create training classes inviting them to your students by hyperlink. Because, while carrying out the task, a student with special educational needs makes much more effort than a perfectly healthy peer, the system of evaluating the educational achievement of such students can be stimulating. After each student has completed each exercise, the teacher must analyze and compare the expected results with the actual results of the students' works. A prerequisite for teaching students with special educational needs in mathematics is to provide feedback: to find out if the students are satisfied with their work and the knowledge they have acquired and whether they understand the importance of this knowledge for further study of the subject.

4.3. Using GeoGebra in mathematics teaching

The third section of the teaching aid focuses on the usage of GeoGebra Math Apps ([11], [26], [28]). The Mathematics teacher is offered several visuals for visualization of geometric constructions, hypothesis concerning the properties of geometric figures, and the proof of theorems. GeoGebra (<https://www.geogebra.org/>) visuals include the usage of mobile phones applications such as Geometry, 3D-Calculator, Graphing Calculator, and the visuals demonstrating stochastic experiments in teaching of probability theory and mathematical statistics.

It is extremely positive that using both of the above mentioned services allows students to collaborate in the offered virtual classes (Google Classroom). These features have recently appeared.

And they can play a significant role in socialization, especially for students with SEN. As our research has shown, Mathematics teachers practically do not use them in their work. Partly because of lack of competence in this matter.

GeoGebra has become the leading provider of dynamic mathematics software, supporting science, technology, engineering and mathematics (STEM) education and innovations in teaching and learning worldwide ([27], [46], [57], [58], [60], [59], [62], [74]). We consider it reasonable to use the GeoGebra Math Apps in teaching students with SEN. The authors offered a mathematics teacher a teaching guide and tasks for students to use GeoGebra in teaching Planimetry and Stochastics [26]. In particular, the use of built-in functions for calculating the values of combinatorial compounds, testing using GeoGebra and examining electronic visuals that simulate accidental events by Manuel Sada [55].

To present an experiment demonstration, a teacher can use the GeoGebra dynamic geometry program. In an exercise developed by a teacher in advance, a student will be able to simulate a large number of bone tosses and monitor their results. In developing visuals that model accidental events, we used the ideas of Manuel Sada. We have upgraded the set of visuals offered by Manuel Sada [55] to adapt it to students learning in Ukrainian. For example, one of the exercises allows to see changes and patterns in the process of any number of the tests carried out. The student can observe whether there is any tendency as the number of falls in a single number increases, and compare it with the number of falls in another number. Such activity on the lesson should be structured for a student with special needs in the form of clearly formulated actions, algorithm for completing the task. Instructions should be brief and clear, repeated several times. It may be difficult for a student with disabilities to concentrate, so he or she has to be repeatedly urged to carry out, to control this process until its completion. The task should be adapted so the student has time to work at the pace of the whole class.

The task is complicated when the student is offered the following exercise: modeling and counting the results when throwing two, three or more dices and calculating the sum of the falling numbers, etc. By practicing research on the tossing of two and three coins, it may be easier for the student to imagine the situation of tossing 4 coins and others.

It gives a good result and use of the developed by us the lessons of planimetry, the library of electronic visibility.

Research Task 7. How the position of the center of a circle described around a triangle is related to the view of a triangle (see figure 2).

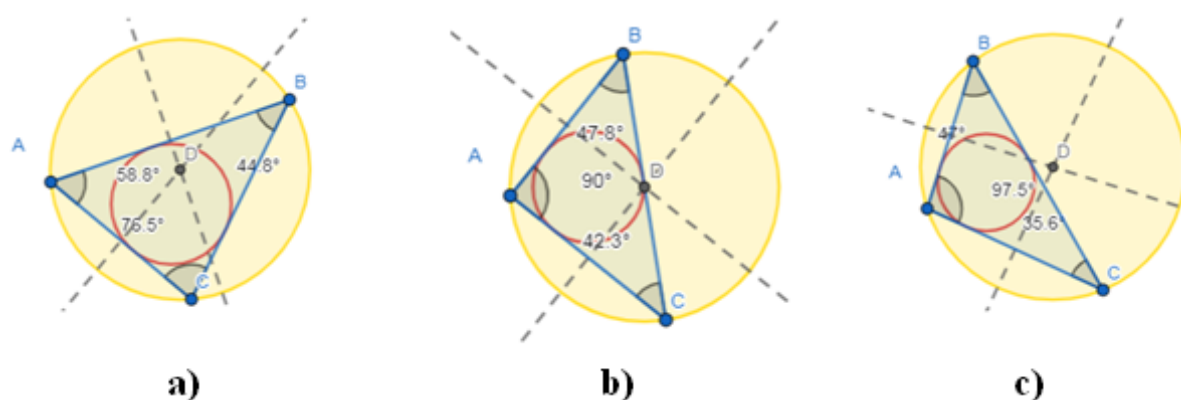


Figure 2. Investigation of the position of the center described around a triangle of a circle (GeoGebra Geometry): (a) an acute-angled triangle, (b) rectangular, (c) obtuse.

It should be taken into consideration that GeoGebra Dynamic Mathematics system can be installed on smartphones. So, the students with SEN will be able to check the correctness of their tasks during the lesson, especially when working independently or in groups. One can also start the exercise by using the link or QR code for the exercise. It is enough for the student to install a code scanner on

his/her smartphone. One of these is the free Qrafter application, which allows you instantly to read QR codes using only your smartphone’s camera and Internet access.

The use of GeoGebra in preparation for admission to higher education institutions provides ample opportunities for students with special educational needs. Using GeoGebra 3D Calculator, they will be able to develop spatial imagination, master the techniques of constructing spatial figures. A number of illustrations for solving problems of open type of external independent evaluation (EIE) are given below. These are two open-ended tasks with a detailed answer, which are evaluated by examiners according to special rules (EIE-2018).

Task 8. In a regular quadrangular pyramid SABCD, the side of the base ABCD is equal to c , and the side edge SA forms an angle α with the plane of the base. A plane π is drawn through the base of the height of the pyramid parallel to the plane ASD. Construct a section of the pyramid SABCD plane π , justify the type of section and determine its perimeter (see figure 3).

Task 9. Solve the inequality depending on the values x of parameter a :

$$\frac{\log_a x}{x^2+(a-4)x+4-2a} < 0 \tag{1}$$

In preparation for the external independent assessment, students will be able to use GeoGebra Graphing Calculator to identify all possible ramifications for the parameter and to evaluate visually possible solutions of the inequality (see figure 4). This will provide visualization, help students better understand the process of solving such complex problems.

Using the suggested refinements will help a student with special needs better to understand the material. Thus, a student receives full information if it is supported by visual perception of the text, tables, diagrams.

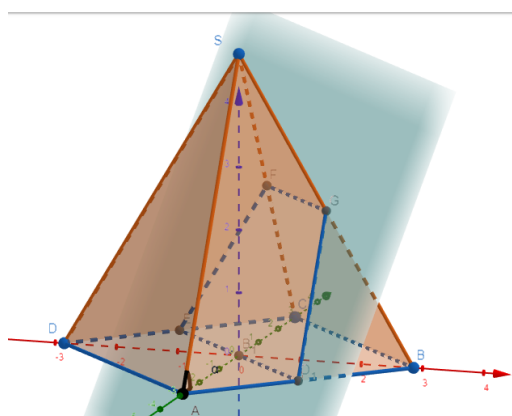


Figure 3. Examples of open-ended tasks (EIE-2018). GeoGebra 3D Calculator.

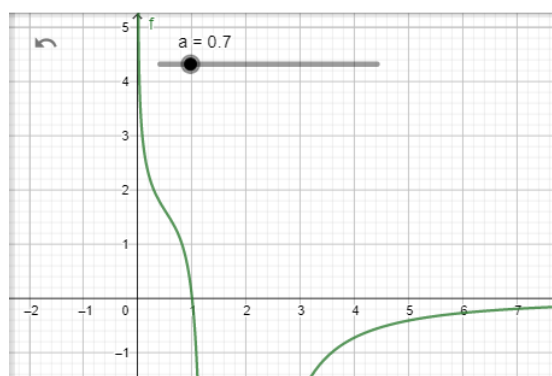


Figure 4. Examples of open-ended tasks (EIE-2018). GeoGebra Graphing Calculator.

4.4. Educational projects method usage as one of the directions of students with special educational needs socialization

As we have already noted, inclusive education involves the education and upbringing of students with special needs in secondary school with a view to their social adaptation in society. The right of such children to integrate into society is a fundamental principle of international standards, and providing them with access to quality education is the basis of real integration. Therefore, the main purpose of the new standards is to reveal the child’s personality, his/her talents, ability to self-study, teamwork, responsibility for his actions, creation of a comfortable environment.

The fourth section of the teaching aid focuses on the usage of project-based learning technologies in Mathematics, in particular STEM projects, to enhance, first and foremost, the socialization of students with SEN. Students can use cell phones to access the developed materials.

The project activity is a joint educational-cognitive and creative activity of a student, a teacher and parents of a child with special needs. It has a common purpose, agreed methods, methods of activity and is aimed at achieving a general result. The purpose of the project is to form and develop the ability to find solutions to the problem; to teach students with SEN to organize individual work; to develop communicative competences and critical thinking of students with SEN; to develop their research skills, observation, the ability to hypothesize and generalize.

The peculiarity of STEM education is that it helps to master these areas not in isolation, but by integrating all disciplines into a single system of learning. The project activity is organized correspondently – the chain “from theory to practice” is the opposite: first thinking and designing, and only then, in the process of this activity – mastering theory and new knowledge. The study object is not studied separately, but in combination with other subjects. Therefore, STEM projects that aim to address the goals of different areas prepare a student for real life better.

Working on a STEM project causes students with SEN to desire thinking independently, to get to know the world and to make discoveries. It also generates non-standard, engineering thinking, nurtures an interest in the exact sciences, develops inventive abilities, since when combined with knowledge, their practical application is created. teaching. When using STEM projects, it is important to focus not on memorizing, but on understanding and applying new knowledge in practice, and the focus should be on the practical task or problem.

At the preparatory stage, a teacher selects the content of the subject, develops tasks for students, means of assessing the quality of knowledge and educational products, involving students in this activity. It is important for a teacher working in an inclusive classroom to anticipate the nuances of implementing project technologies in the learning environment of students with special educational needs.

When planning a teacher’s work, it is advisable to offer the student with special educational needs to choose the feasible, interesting tasks for him / her, according to his / her abilities. With this personal approach, the student develops cognitive interests, the desire to find new facts, which intensifies the intrinsic motivation, and ultimately, promotes the formation of a positive self-image of the student, adds confidence in their abilities.

Especially important in a control is assessment - the process of establishing a student’s educational achievement in mastering the subject knowledge and skills, in accordance with the curriculum. The assessment is expressed in the evaluative judgments and conclusions of a teacher, which are qualitative (verbal) indicators, or in points, that is, quantitative indicators.

In an inclusive class, it is reasonable to maintain a teacher’s portfolio and a student’s portfolio. A teacher’s portfolio is considered as a way of recording, accumulating and evaluating a student’s individual achievements during a certain period of study.

In order to investigate progressive shifts in the study of mathematics students with SEN using ICT tools, it is advisable to compare the shifts in the scores of the diagnostic test and the test. Statistical groups can be analyzed for two G-test and Wilcoxon tests. These algorithms involve the use of small volumes of samples. So, they used it and tested it for individual academic groups. We observed a trend of increasing values of the trait (points scored) in the transition from training exercises to controls.

5. Conclusions

1. Based on the analysis of psychological-pedagogical, educational and methodological literature, it was concluded that the problem of using distant technologies in teaching children with special educational needs is urgent. Inclusive education is not just the coming of a child with special educational needs into a secondary school.

2. The study of problems of Mathematics teaching of students with SEN (with hearing impairment) by means of distance technologies have made the following conclusions: it is reasonable for students with hearing impairments to emphasize each word so that they know how to read those words correctly; one of the tasks of the teacher and a teacher assistant is to encourage children with SEN to study.

3. The most important thing is to socialize children with hearing impairments. It can be done by engaging hearing impaired children in group work or in pairs, both at home and during lessons. The effectiveness of teaching Mathematics depends to a large extent on software tools that allow to apply a fresh approach of teaching Mathematics, exempting students from routine computing, providing them with effective and visual methods of solving a rather wide range of problems.

4. Forms, methods, techniques of teaching processes have been examined that ensure the formation of mathematical competence in students with special needs. The expediency and the necessity of using the research method of learning, the heuristic method, the method of the problem statement, the method of projects, the method of learning by cooperation, as well as information and communication technologies along with adaptive ones have been proven.

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