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Demchenko Iryna Ivanivna Doctor of Pedagogical Sciences, Professor, Professor of the Department of Social Work and Rehabilitation, National University of Life and Environmental Sciences of Ukraine, 15, tel.: (044) 527-80-73, Heroiv Oborony St., Kyiv, 03041, <https://orcid.org/0000-0003-4302-7564>

Kalynovska Iryna Serhiivna PhD in Pedagogy, Associate Professor, Associate Professor of the Department of Special and Inclusive Education, Pavlo Tychyna Uman State Pedagogical University. 28, tel.: (04744) 3-45-33, Sadova St., Uman, 20300, <https://orcid.org/0000-0001-8805-4641>

TRAINING FUTURE TEACHERS TO USE STEM TECHNOLOGIES IN AN INCLUSIVE EDUCATIONAL ENVIRONMENT

Abstract. The article is devoted to the relevance and importance of training future teachers to implement STEM technologies in an inclusive educational environment of primary school in order to ensure social and educational justice, create conditions for the creative development of all children, including those with special educational needs. This approach allows to create an optimal environment for successful learning, development and self-realization of each child, to ensure their full participation in the educational process and social life. The quality of its implementation depends on the level of professional training of future teachers in higher education institutions.

One of the priority areas of inclusive education is the use of STEM technologies as an integrative pedagogical strategy for the development of key competencies of the 21st century through problem-based and project-based learning, research and practical activities. It includes methods, techniques, and methods of teaching aimed at forming a unified picture of the world in students with different levels of development, readiness to successfully solve problem situations, develop critical thinking, creativity, communication and cooperative skills. The introduction of STEM technologies in an inclusive primary school environment allows teachers to interest students, explain and demonstrate the connections between theory and practice, between processes and results, stimulate self-learning, and improve the quality of the educational process.

The authors have supplemented the classification of means of implementing STEM technologies in an inclusive educational environment, in particular, the use of multimedia tools that combine training, education, development, correction and rehabilitation: modern smartphones, tablets and other mobile devices equipped with universal applications for people with developmental disabilities; interactive

whiteboards; interactive sandboxes; interactive floors. The vectors of inclusive learning using STEAM technologies are highlighted: personalized and independent learning; accessible inclusive educational environment; integrated and interactive learning; lifelong learning.

Keywords: future teachers, STEM technologies, STEM tools, inclusive education, competence, training, higher education institutions.

Демченко Ірина Іванівна доктор педагогічних наук, професор, професор кафедри соціальної роботи та реабілітації, Національний університет біоресурсів і природокористування України, вул. Героїв оборони, 15, м. Київ, 03041, тел.: (044) 527-80-73, <https://orcid.org/0000-0003-4302-7564>

Калиновська Ірина Сергіївна кандидат педагогічних наук, доцент, доцент кафедри спеціальної та інклюзивної освіти, Уманський державний педагогічний університет імені Павла Тичини, вул. Садова, 28, м. Умань, 20300, тел.: (04744) 3-45-33, <https://orcid.org/0000-0001-8805-4641>

ПІДГОТОВКА МАЙБУТНІХ ПЕДАГОГІВ ДО ВИКОРИСТАННЯ STEM-ТЕХНОЛОГІЙ В ІНКЛЮЗИВНОМУ ОСВІТНЬОМУ СЕРЕДОВИЩІ

Анотація. Статтю присвячено актуальності та важливості підготовки майбутніх педагогів до впровадження STEM-технологій в інклюзивному освітньому середовищі початкової школи з метою забезпечення соціальної та освітньої справедливості, створення умов для творчого розвитку всіх дітей, включаючи тих, хто має особливі освітні потреби. Такий підхід дозволяє створити оптимальне середовище для успішного навчання, розвитку та самореалізації кожної дитини, забезпечити її повноцінну участь в освітньому процесі та суспільному житті. Якість його реалізації залежить від рівня професійної підготовки майбутніх педагогів в закладах вищої освіти.

Одним із пріоритетних напрямів інклюзивного навчання є використання STEM-технологій, як інтегративної педагогічної стратегії розвитку ключових компетентностей XXI століття через проблемне та проєктне навчання, науково-дослідницький підхід та практичну діяльність. Вона охоплює методи, способи, прийоми навчання, спрямованих на формування в учнів з різним рівнем розвитку єдиної картини світу, готовності успішно розв'язувати проблемні ситуації, розвивати критичне мислення, творчий потенціал, комунікативні та кооперативні навички. Впровадження STEM-технологій в умовах інклюзії початкової школи дозволяє вчителю зацікавити учнів, максимально доступно пояснити й продемонструвати зв'язки між теорією і практикою, між процесами та результатом, стимулювати самонавчання і підвищити якість освітнього процесу.

Авторами доповнено класифікацію засобів впровадження STEM-технологій в інклюзивному освітньому середовищі, зокрема використання мультимедійних засобів, які поєднують навчання, виховання, розвиток, корекцію і реабілітацію: сучасні смартфони, планшети та інші мобільні пристрої оснащені універсальними додатками для осіб з порушеннями в розвитку; інтерактивні дошки; інтерактивні пісочниці; інтерактивні підлоги. Виокремлено вектори інклюзивного навчання з використанням STEAM-технологій: персоналізоване та самостійне навчання; доступне інклюзивне освітнє середовище; інтегроване та інтерактивне навчання; навчання впродовж життя («lifetime learning»).

Ключові слова: майбутні педагоги, STEM-технології, засоби STEM-технологій, інклюзивне навчання, компетентність, підготовка фахівців, заклади вищої освіти.

Problem statement. The activities of modern society are aimed at forming the personal qualities of each person, regardless of their physical, intellectual, emotional and other characteristics, as well as social status, gender and age. This is due to the construct of inclusion, which has become a global phenomenon, including in the education system. Inclusive education is firmly rooted in the modern international professional thesaurus of psychological and pedagogical science. It reflects a new view of the realities of our time, and is a principle of social and educational justice that declares a system of values and space for the successful self-realization of all children, including those with special educational needs.

In this philosophical context, the education system should be aimed at the creative development of the individual to form ways of adapting to a changing environment, which should become a life norm. Therefore, one of the priorities of state policy (the Law of Ukraine "On Education", "On Complete General Secondary Education", the Concept "New Ukrainian School", "State Standard of Primary Education", etc.) is to create the most favorable conditions for ensuring their self-realization, social adaptation to life and successful integration of children with special educational needs into society. That is, a child-centered environment in which learning centers (books, words, nature, recreation, play) are organized for the diverse development of children; the use of digital technologies and new methods of teaching, upbringing, development and correction (STEM, ICT, TRVZ technologies, etc.) aimed at ensuring the activation and development of intelligence, intuition, creative thinking and abilities, taking into account the capabilities of each child.

It is worth noting that the Concept of Science and Mathematics Education (STEM education) emphasizes the formation of a fully developed, educated, innovative personality, so the use of STEM technologies in an inclusive educational environment provides equal access to learning and innovation, integration of the natural sciences and humanities, increasing and expanding the capabilities of each

student in accordance with individual needs, creating their own trajectory of learning, professional growth and life creativity. The development of STEM education requires high-quality pedagogical, methodological, technological, social, psychological, and other types of training for future teachers, which determines the level of professional functions in an inclusive educational environment.

Analysis of recent research and publications. Important aspects of STEM education implementation in Ukraine are increasingly attracting the attention of domestic scientists (T. Andrushchenko, O. Barna, I. Vasylyashko, S. Horbenko, O. Kuzmenko, I. Parkhomenko, I. Chernetskyi, etc.); practicing teachers (S. Buliga, S. Brevus, O. Zhyhailo, N. Yushchenko, etc.). They see it as an interdisciplinary technology for improving the curricula of educational institutions of different levels, aimed at strengthening the scientific, technical, natural and mathematical components to enhance the creative potential of children and the professional competence of teachers.

The purpose of the article is to reveal the relevance and importance of training future teachers to implement STEM technologies in the inclusive educational environment of primary school.

Presentation of the main material. The quality of the educational process in an inclusive school is largely determined by the extent to which the potential opportunities for learning and development of each child, his or her individual characteristics are taken into account and realized. Whatever the physical or mental limitations, a child always has reserves for development, the use of which can significantly improve the quality of his or her life: promoting the social, emotional and cognitive development of each child so that he or she feels unique and a full participant in public life.

The technological aspect of the quality of primary education is anthropocentric, with a pronounced humanistic essence and a psychotherapeutic focus on the child's versatile, harmonious and creative development. It provides for the use of the latest technologies of pedagogy of cooperation, success and personality-oriented learning. The following criteria are usually used for the initial assessment of the quality of teaching technology in primary education: diagnosis of learning goals and objectives; compliance of the chosen technology with the general goals of the educational content and specific learning objectives; possibility of wide use of reproduction technology; compliance of the technology with the individual style of the teacher, the capabilities of students, and the psychological theory of learning; provision and effectiveness of the use of technical means of teaching and learning materials; introducing new information technologies into the educational process.

Teaching quality indicators depend on the competence and multifunctionality of primary school teachers in their professional activities, taking into account not only age and gender, but also the specifics of the child's individual development, physiological, mental and social characteristics, and the preservation and promotion of the health of all subjects of the educational process. The quality of teaching is also

determined by the level of mastery of effective innovative educational technologies, including STEM (Science, Technology, Engineering and Mathematics). This is a problem-based, project-based, research and practice-oriented integrative pedagogical technology aimed at forming key competencies of the 21st century, which includes methods, techniques and methods of teaching aimed at forming a unified picture of the world and the readiness to successfully solve problems of different scale and nature in students with different levels of development by adapting to changing, dynamic environmental conditions.

The use of STEM technologies in the context of inclusion increases the level of accessibility of education for children with special educational needs, deepens the understanding of natural processes through integration into practical activities, and promotes the development of: top skills (related to complex problem solving, critical thinking, creativity as the ability to implement new ideas; form their own opinions and make decisions) and soft skills (aimed at effective interaction with other people) and meta-skills (aimed at further self-development and self-realization). According to A. Hila, these skills will help children with special educational needs develop their social and emotional intelligence. In general, flexible skills will help children with speech disorders to adapt in life. For children with musculoskeletal disorders, it will help them find willpower, develop their creativity and adapt to changes in life. Children with visual and hearing impairments - to develop perseverance, learning ability, ability to find common ground with others and be socially active. Children with ASD - to find a common language with others, to learn the ability to withstand stress and develop their emotional intelligence [1].

It is worth noting that the World Economic Forum (2020) in its report "A New Look at Education" proposed a list of the well-known Davos "4K" competencies, or social skills, which are the key to success in the labor market in the next 20-30 years:

- Creativity – the ability to navigate information flows, see cause and effect relationships, weed out the unnecessary, understand the causes of failure and draw conclusions;
- Critical Thinking is the ability to be creative, which allows you to assess the situation from different angles, make non-standard decisions and feel confident in changing circumstances;
- Communication is the ability to establish contacts, listen and hear the interlocutor, convey one's point of view and come to an agreement;
- Coordinating With Others - the ability to unite in joint activities as equal partners to achieve a goal [6].

These competencies combine fundamental knowledge and social skills for the child's self-realization, as well as mastering the tools for self-realization in the digital world. According to O. Khokhlina, in an inclusive educational environment, the formation of children's general educational and general labor skills of an intellectual nature (to analyze the conditions of educational and practical tasks, to plan, organize their implementation, to evaluate its correctness and the result obtained) is a

powerful means of intellectualizing the activities of students with special educational needs and an indicator of mental development [4].

Let us dwell in more detail on the ways of their formation by means of STEM technologies in the context of inclusion. Thus, the creative potential of a child with SEN depends on the level of development of cognitive abilities, awareness and assimilation of educational material, readiness to learn, various changes and fluctuations in their performance, emotionality, mood, behavior, natural desire for creative activity and personal characteristics (willpower, responsibility, patience, courage, etc.). Therefore, in order to develop creativity in children with special educational needs, taking into account individual developmental characteristics, it is necessary to determine the type of creative activity, taking into account the interests, inclinations and capabilities of the child.

The following will help to optimize the directions and actions of developing children's creativity in inclusive languages: creating a positive atmosphere in the classroom, problem-based, group, team learning; use of interdisciplinary connections and interactive technologies; learning based on real situations (cases); learning based on observing others; learning in the game and the widespread use of various types of artistic and creative activities, etc. As rightly noted by scholars N. Andrushchenko, E. Siryk, and O. Shevchenko, by involving art in education, students can develop their aesthetic consciousness, creativity, and perceive the world around them in a new way. Creativity stimulates students to generate new ideas, experiment, and find unconventional ways to solve problems [5]. Therefore, tasks for primary inclusive school students should include: metacognitive learning (when a student is aware of his or her own way of thinking, can identify limitations in their perception and cognition); improvisation and role-play; destruction of stereotypes, the ability to dispel them logically. It is worth remembering that a child's ability to generate unique and useful ideas depends on his or her experience, so at the initial stage, you should encourage the child to gradually move beyond the limits of patterned thinking. And do not demand that they produce innovative ideas right away.

Critical thinking is based on the laws of logic and an understanding of the psychological processes that take place in the mind. Critical thinking skills help to avoid drowning in an avalanche of information, to resist manipulation, and to make informed decisions and defend them. It helps in finding new ways to solve problems based on: system analysis (the ability to determine the relationship between variables in a particular system); argumentation analysis (the ability to draw logical conclusions based on data or statements); creative process (the ability to build a strategy, theory, methodology or line of argumentation based on a set of supporting data (which should be deeper than the obvious information on the surface); and evaluation (the ability to assess the quality of processes and decisions).

Evaluation includes criticism of the final product of thinking, taking into account the specifics of a particular situation). That is, lessons using STEM

technologies focus on: real-world problems; subject integration; design processes; productive teamwork; correct answers; and ways to improve the product of creative work. In such classes, students apply scientific and technical knowledge as close to real life as possible, namely: create products, models, crafts from a variety of materials; design bridges, combines, cars, airplanes; build houses, factories, hotels, cities; develop underwater and aerial structures. They study a specific real-world project, design and create a prototype, test and identify errors, improve and solve all problems on their own, and achieve their goals. A situation of success, the joy of victory, stimulates the desire to gain new knowledge and experience, to move confidently and work with inspiration.

In this sense, critical thinking, scientific methods, technological applications, engineering design, and mathematical modeling are the basis for achieving the expected results of STEM education: integration of academic subjects; synthesis of knowledge and skills; work with projects; research approach to learning; high level of thinking, etc.

Effective communication skills include the ease of establishing contact, the ability to maintain a conversation, the ability to convey one's opinion, negotiate and insist on one's legal rights. Therefore, the key skills in communication are: developing a message that would convey the necessary meaning using non-verbal means of communication (gestures, facial expressions, visual materials); awareness of the level of education, position and emotions of others; ability to follow the rules, norms and discipline appropriate to a particular communication context; awareness of social and cultural differences; selection of the necessary communication channels; active listening; ability to critically analyze text or speech.

STEM lessons are characterized by active communication and teamwork between students. During the project discussion stage, there is an open atmosphere of expressing opinions, observations, and presentations of their results. During creative work, they constantly communicate with their teachers and classmates, express their ideas and ways to implement them, and exchange information on how to use or apply them. Therefore, communication skills can be developed in parallel with any type of task: when processing information, conducting research, interpreting the results of work, summarizing and reflecting. Students work together, exchanging ideas, collaborating on projects where everyone makes a contribution. This teaches them how to communicate effectively, listen to the opinions of others, resolve conflicts, and achieve their goals together. [5].

Cooperation or teamwork consists of the following elements: interpersonal communication, conflict resolution, and management skills. A student's ability to work in a team depends on his or her personal willingness and ability to consider the points of view of others, coordinate the ideas of many people, solve problems in a team, build consensus, and compromise. Assessment can be based on how well the student's skills match their ability to handle certain similar tasks in real life. You can also rely on other children's reactions and evaluation of the student's work. This approach will ensure that the teacher has the children's attention at every lesson.

Practitioners identify a number of ways to implement STEM technologies:

- printed teaching aids: textbooks, electronic textbooks, study guides, task cards, teaching instructions, teaching algorithms;
- visual aids: natural - equipment, devices, tools, materials, samples, etc.;
- figurative (pictorial) - photographs, reproductions of artists' paintings, posters;
- sign and symbolic - iconic models, graphs, diagrams, tables;
- open educational resources - educational websites, virtual laboratories, simulation training, interactive museums, etc.;
- technical teaching aids: information - video equipment (computers, multimedia technologies, movie projectors, projection screens of various models, slide projectors, interactive whiteboards, projection tables, etc.) and controlling - simulators, devices for process diagnostics [3].

We would like to pay special attention to the use of multimedia tools for STEM education of children in an inclusive environment, which combine training, education, development, correction, and rehabilitation. Namely:

- modern smartphones, tablets and other mobile devices are equipped with universal accessibility features that allow users to use built-in or easily downloadable assistive technologies (speech recognition, screen reading, Braille displays, voiceover, sound amplification, sign language, etc.);
- interactive whiteboards with multitouch function for working with children individually or in groups (used as: a method of video communication; visualization of the curriculum for better learning; creation of a game environment taking into account correctional tasks; variety of presentation of educational materials; regulation of complexity, as well as the optimal pace of completion of tasks by each child; development of cognitive functions (development of visual and motor memory, development of visual-action and visual-figurative thinking); development of reaction speed; formation of motivational behavior, etc.);
- interactive sandboxes, which makes it possible to create your own world that can be changed in an instant (increases motivation for motor activity; formation and development of motor planning; promotes correction of perception properties (objectivity, integrity); development of cognitive functions (development of visual and motor memory, development of visual-action and visual-figurative thinking); skills of self-regulation, general motor skills and coordination of movements; formation and development of communication skills; speed of reactions, flexibility of thinking; ability to respect game partners, establish friendly relations with them and enjoy joint activities; formation of personal qualities: independence, tolerance, sensitivity, perseverance and endurance in achieving the goal;
- interactive tables combine a multimedia center with specific applications for learning, development and entertainment (solves the problem of communication and socialization, development and/or restoration of fine motor skills in children and

adults, as well as work with children with mental disorders; formation of motivational behavior of children with mental retardation to perform certain movements, cognitive activity in general; development of imagination, flexibility of thinking and self-control; development of imagination, flexibility of thinking and self-control);

– interactive floor (smart floor) with the help of a special projection allows you to interact with the image (aimed at solving specific problems that together ensure the realization of modern educational goals: the development of intellectual abilities in the process of cognitive research and involvement in scientific and technical creativity of young children, promoting interaction with the virtual environment, to master as much knowledge as possible in a more interesting format).

As we can see, the use of STEAM technologies by primary school teachers integrates educational content with real life and the future, because learning can take place both inside and outside the classroom, where everyone is constantly improving their existing skills and acquiring new ones based on individual needs.

We can identify vectors of inclusive learning using STEAM technologies:

1) personalized and independent learning that takes into account the interests, capabilities, individual characteristics, experience of each individual student, which uses the method of guided learning (teacher's prompts that guide and provide feedback in the process of students' independent search for new knowledge) and learning through research (educational material is presented in the context of open questions);

2) Accessible inclusive education that embraces the diversity of people, teaches the values of an inclusive culture, a key component of global citizenship, and provides access to education for students of all abilities and backgrounds;

3) integrated and interactive learning, which combines the following areas: project-based (promotes the development of social and emotional skills, understanding of interdependence in a group and personal responsibility to the team) and experiential (promotes the development of positive relationships between students, teachers and society as a whole; raising environmental awareness, awareness of political issues and social needs; cultivating views and values related to civic responsibility);

4) lifelong learning, as a system from early childhood and throughout life ("lifetime learning"), where everyone constantly improves their existing skills and acquires new knowledge and skills based on individual needs.

Conclusions. The relevance and importance of preparing teachers to implement STEM education in an inclusive educational environment of primary school is due to improving the quality of the educational process, taking into account the individual characteristics and potential of each child, promoting social, emotional and cognitive development for successful integration into society. The technological aspect of the quality of this process involves the widespread use of STEAM technologies as a tool for developing creativity, innovative thinking,

communication and cooperation in various activities and life-creating activities of children as unique, full-fledged participants in social life.

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