Analyzing the distribution of STEM-STEAM-STREAM and Montessori pedagogy centers in Ukraine

Iryna A. Slipukhina[1,2], Arkadiy P. Polishchuk[2], Sergii M. Mieniailov[2], Oleh P. Opolonets[2] and Taras V. Soloviov[2]

[1]*National Center "Junior Academy of Sciences of Ukraine", 38/44 Dehtiarivska Str., Kyiv, 04119, Ukraine*
[2]*National Aviation University, 1 Liubomyra Huzara Ave., Kyiv, 03058, Ukraine*

Abstract

The authors of this paper have analyzed the distribution of educational institutions in Ukraine that use the STEM-STEAM-STREAM approach and methodological tools of M. Montessori pedagogy. The authors used Google Maps to search, identify and quantitatively analyze the distribution of these institutions. The results of data processing are presented in the form of author's maps and diagrams, which indicate the number of Montessori pedagogy centers and STEM-STEAM-STREAM training centers for each region. The authors also analyzed the content and organization of some Montessori centers in Ukraine based on the data of the official websites of educational institutions. The authors used the method of Gartner Hype Cycle to obtain a conclusion about the state of development of pedagogical technologies. Comparison of the principles of pedagogy M. Montessori and STEM approach to education reveals many common didactic features based on the ideas of constructivism in education. In particular, the authors note the features of active interaction of subjects of the educational process, the development of curiosity, change of the teacher functions.

Keywords

STEM-STEAM-STREAM, Montessori pedagogy, constructivism, Gartner Hype Cycle, education, Ukraine

1. Introduction

The rapid changes and challenges of the 21st century require the society to foster the skills and readiness of individuals for successful socialization and adaptation. This leads to the development of variable education in Ukraine, which is reflected in the reform of education at all levels. The autonomy of educational institutions [1] enables the provision of educational services based on a variety of innovative programs and methods. One of the popular and supported by the state [2] approaches in the educational environment is STEM [3, 4, 5, 6, 7], which integrates science, technology, engineering, and mathematics.

The pedagogical system of M. Montessori [8] is recognized as a classic innovative technology of education for children from the early age, which is evidenced by the existence of numerous pedagogical centers. The Montessori approach adheres to the principles of humanitarian pedagogy: the child's personality with all its individuality, similarity and difference from other children is the focus of the educational process [9].

However, the pedagogical challenge of early identification and development of engineering abilities is particularly relevant in the era of fast-paced development of tools and technologies. In this context, innovative learning technologies, such as the STEM approach in education [10, 11], are expected to provide significant assistance.

The emergence of educational centers in Ukraine is a result of the demand of the society and the state. How relevant is M. Montessori's pedagogical technology for domestic educational institutions compared to the STEM-STEAM-STREAM approach? What are the commonalities and differences between these

CoSinE 2024: 11th Illia O. Teplytskyi Workshop on Computer Simulation in Education, co-located with the XVI International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd 2024), May 15, 2024, Kryvyi Rih, Ukraine
slipukhina2015@gmail.com (I. A. Slipukhina); arc.nau@gmail.com (A. P. Polishchuk); msm56msm@gmail.com (S. M. Mieniailov); opolonetso@gmail.com (O. P. Opolonets); tarassoloj@gmail.com (T. V. Soloviov)
https://www.nas.gov.ua/EN/PersonalSite/Pages/default.aspx?PersonID=0000026338 (I. A. Slipukhina); http://zfiz.nau.edu.ua/?p=61 (A. P. Polishchuk); http://zfiz.nau.edu.ua/?p=76 (S. M. Mieniailov)
0000-0002-9253-8021 (I. A. Slipukhina); 0000-0001-6892-5403 (A. P. Polishchuk); 0000-0002-4871-311X (S. M. Mieniailov); 0000-0002-5059-5298 (O. P. Opolonets); 0000-0003-4033-0090 (T. V. Soloviov)

pedagogical systems? Up-to-date data for the answers can be obtained through the use of web mapping service tools Google Maps.

2. Related work

Almost 120 years of implementation of Montessori pedagogical ideas around the world are reflected in numerous scientific works [12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41]. The ideas also prove the relevance in the 21st century: from the earliest works on the introduction of Montessori methods as a didactic tool for speech development of preschool children and teaching them to read and write [8], through the study of sensory and motor skills, game techniques to stimulate communicative activity of preschoolers as a basis of speech skills. The need for integrative techniques based on the STREAM approach is revealed in the work of Krutiy and Hrytsyshyna [10]. Mavric [9] emphasizes on the importance of pedagogical ideas of M. Montessori for educational systems of the 21st century exploring the didactic aspects of personalized instructions; in particular, she points to the dual role of the teacher as "knowledge facilitator who offers advice and is a training specialist" at the same time. The same work shows the best academic results of the pupils comparatively to other public or private primary schools, in particular, in mathematics and physics [9]. Essential for the Montessori teaching method is the dynamic interaction of the triad "child, teacher, environment (prepared situations)". Remarkable is comprehension of the Montessori Method proposed by Marshall [11] in the context of two important aspects: educational materials and the way in which the teacher and the design of the prepared environment promote independent interaction of children with these materials. It also draws attention to confirmed over time significant adaptability of the method.

On the other hand, socio-economic processes and challenges of the 21st century determine the problem of high-quality technical and technological teaching of the younger generation: the STEM abbreviation is actively used in all spheres of our life to describe processes in the agro-industrial complex, medicine, energy, robotics, IT market, transport, industry, and, above all, in education [42, 43].

The abbreviation STEAM (Science, Technology, Engineering, Arts / All, and Mathematics) is widely used nowadays to indicate that the technology is used to study not only technical sciences but also arty disciplines, for example, industrial aesthetics, industrial design, 3D modeling, architecture, cinema [44, 45]. Another important area is the STREAM approach in education (Science, Technology, Reading + WRiting, Engineering, Arts and Mathematics) aimed at early education of the culture of engineering thinking and the formation of pupils' skills in technology, science, reading and writing, engineering , art and mathematics. This approach is intended to form critical thinking of preschool and primary school children; according to the age characteristics, mainly emotions are used to motivate the children to learn [10]. In general, the key aim of STEM-STEAM-STREAM approaches to curriculum development is to expand the consciousness of participants of the educational process, help to actively respond to changes in reality but not "direct transfer" of knowledge [2].

At the same time, according to Lapon [46], the methods based on the ideas of M. Montessori are focused on the education of respect for learning, encouraging the child's curiosity through realistic experience, creativity and self-understanding.

In order to determine the probable "points of contact" of the STEM / STREAM approach and M. Montessori's methodology, we will consider their peculiarities of educational process. According to the description of Dychkivska and Ponymanska [8], M. Montessori's method is aimed at studying five aspects of life: practical life skills, sensory, mathematics, speech development (reading and writing), space education (history, time, nature). The child's independence and freedom is at the center. Possibility for pupils to make mistakes, analyze them, seek help from more experienced pupils or the teacher. This technique effectively encourages the development of critical thinking and forms the skills of finding creative approaches to problems solving [46].

A long time of research and practical implementation of methods based on the ideas of M. Montessori showed that it is most effective at the early stages of child development. This leads to the assumption

about its similarity with STEM and STREAM approaches aimed at early career guidance of new generations, deepening skills, creating opportunities for research work, conducting scientific and technical activities and more.

3. Research methods

The *aim* of the article is to clarify the roots of common features of Montessori pedagogy and teaching methods based on the STEM-STEAM-STREAM approach. Subsequent aim is a comparison of their applicability in the educational space of Ukraine based on data web mapping service Google Maps.

To compare educational technologies in Montessori schools and STEM-STEAM-STREAM educational centers, the analysis of scientific literature and data from open sources is used, which demonstrate the current practical aspects of the implementation of these methods in Ukraine.

An important indicator of the activity of the use of the above mentioned innovative learning technologies is the public demand for running of the related centers of education. For this purpose, the search and identification by means of the web mapping service of the Google Maps system was used. An example of the result of such a search is shown in figure 1; it demonstrates a screenshot of the Google Maps application for a search inquiry for the keywords “Zhytomyr Montessori School”, “Zhytomyr Montessori Kindergarten”, “Montessori Zhytomyr”.

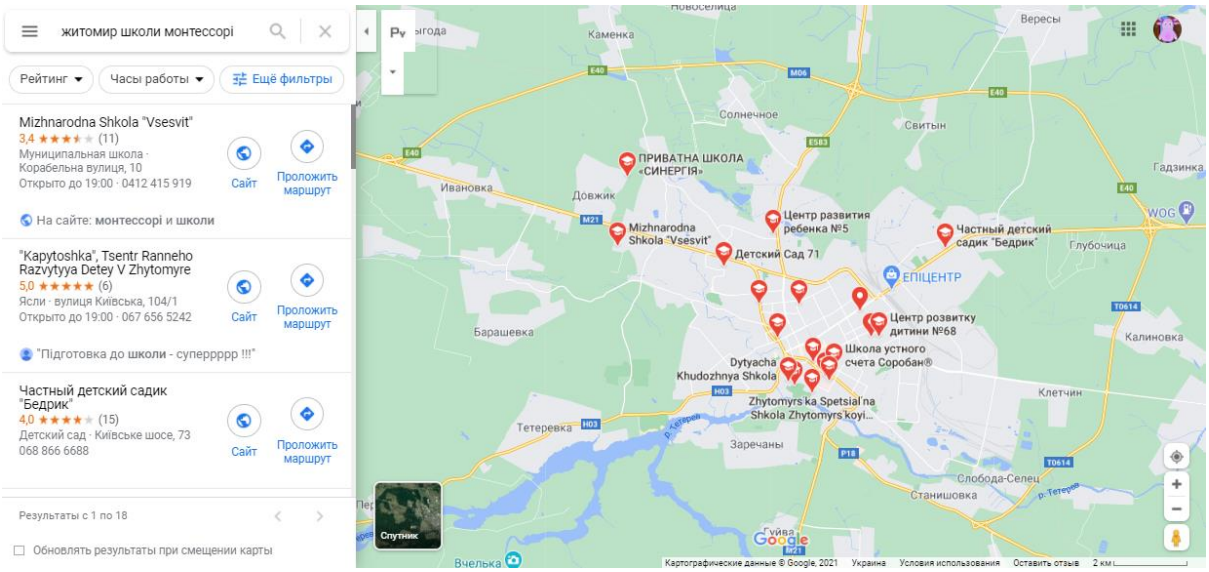

Figure 1: Search for Montessori centers in the city of Zhytomyr using the search and mapping service Google Maps.

4. Results and discussion

Comparisons of the system of free education of M. Montessori and STREAM-approach in education reveal many common features, in particular:

- focus on the formation of certain skills, their conjunction with knowledge of the world around, self-awareness and own role in society;
- the possibility of effective implementation of these technologies at all stages of child development;
- joint activities of teacher and pupil aimed at solving practically significant problems;
- use of acquired skills in everyday life with an approximation for future professional activity;
- promoting communication and team spirit;
- development of interest to certain actions, subjects, and the process of new knowledge obtaining;

- introduction of creative and innovative approaches in the educational process;
- preparing the student for future successful socialization and the formation of lifelong learning skills.

4.1. The paradigm of constructivism in education as the basis of similarity of methods

The similarity of these pedagogical technologies, the implementation of which separates 100 years, should be evaluated as a practical embodiment of the constructivist paradigm of education; its origins are in the interdisciplinary field of philosophy, psychology, sociology and education [47]. Note that the development of constructivism as an evolutionary epistemology began with the works of von Glasersfeld [48], Piaget [49], Vygotsky [50] and others. The main idea of this philosophical trend in the context of learning and teaching concerns the mutual influence of participants of the educational process and learning environment [51]: knowledge is formed through active social interaction and communication where shared experience is developed; learner builds during the learning process a new understanding and concept of the learning environment.

The important role of the paradigm of constructivism for the functioning of the digital educational environment is pointed out by Tchoshanov [52]. Lee and Lin [53] demonstrate the paradigm application in the context of distance and blended learning emphasizing that the aim of any methodological system is not transfer of knowledge in a ready form but creation of pedagogical conditions for successful self-development of learners according to their own educational trajectory. In addition, the paradigm of constructivism is characterized by personal orientation and respect for students, promoting independence, teamwork, attention to the formation and development of skills to solve problems of different sources [54], i.e. flexible skills or skills of the 21st century.

Note that STEM education, as well as the method of M. Montessori, in addition to scientific and technological components of education, focused on creative development of personality, critical thinking, independence in decision-making, empathy for society and other characteristics that are key skills of the 21st century.

Another important feature characteristic of the STEM / STREAM approach in teaching and methods of M. Montessori is the use of toys (from simple to technically and technologically oriented) and game techniques to acquire new knowledge and skills [11]. They teach to master the laws of nature, the idea of how our world works and how to explore the surrounding space, first of all, by improvised means. In general, the gamification of the educational process is one of the driving forces of these learning technologies [55, 56, 57, 58, 59, 60].

4.2. Analysis of web mapping data about Montessori centers in Ukraine

The compliance of educational service centers was checked by researching the content of the Institutions site. Based on a detailed analysis of all the results provided by the system for each of the inquiries and the separation of those that do not use the principles of the pedagogical system of M. Montessori, a map showing all institutions of formal and non-formal education of public and private property that fully or partially declare the use of these principles of learning was drawn up (figure 2).

As can be seen in figure 2, the largest number of Montessori centers operating in Ukraine is concentrated in the capital and western regions (Lviv and Volyn), the smallest part is determined in the eastern regions of the country. The study showed that there are 60 centers in the central regions, 24 in the eastern regions, 75 in the western regions, 45 in the northern regions, and 47 in the southern regions. The significant number of Montessori centers in Kharkiv (14) and Cherkasy (12) regions is obviously due to the presence of powerful centers in these regions such as pedagogical universities. This method is the least popular in Luhansk, Zakarpattia and Khmelnytsky regions.

In order to identify the features of modern educational environments of M. Montessori schools, we analyzed the online content of the proposals of such educational centers, which are highly valued by network users (one example from the relevant region of Ukraine). Let us briefly consider the educational

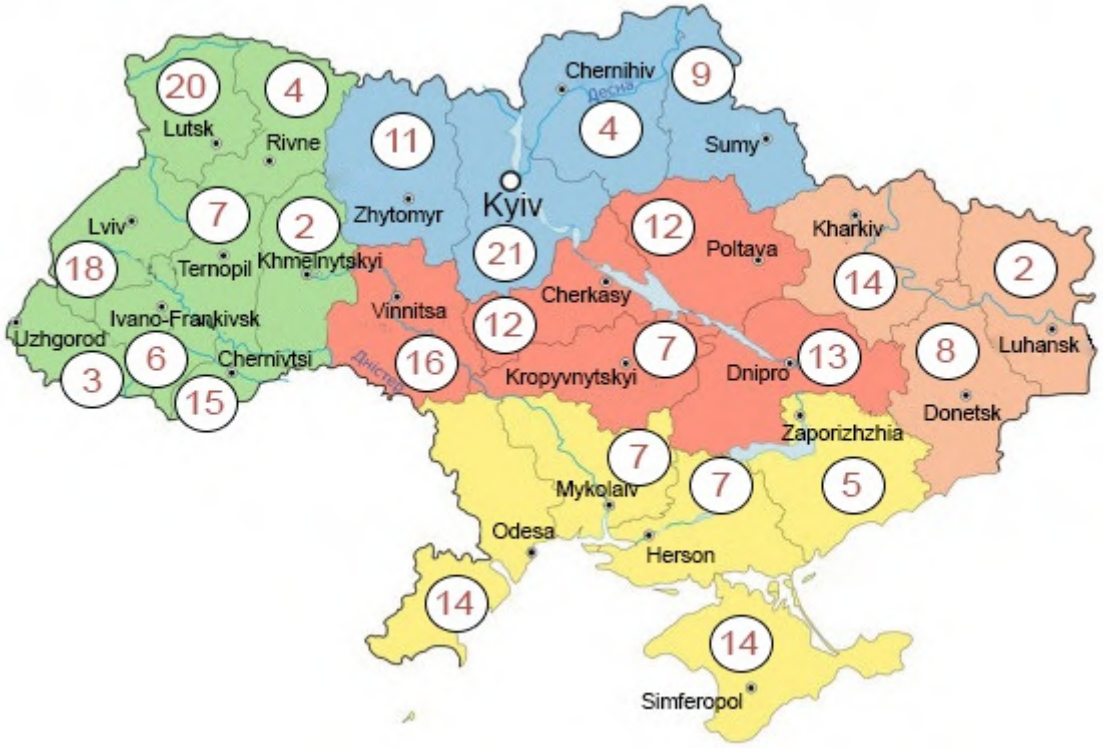

Figure 2: Distribution of Montessori pedagogy centers in Ukraine.

proposals of some of them. Thus, the Center for Child Development mini-kindergarten "Lviv Montessori School" implements a program for children 6–12 years old and is a full-time educational institution where, in addition to standard subjects, children study supplementary subjects: physics, chemistry, worldview, art of photography, painting, choreography, piano, and have thematic excursions [61]. An important feature of the pedagogical methodology of this school, as stated on the website of this educational institution, is the use of active self-assessment by pupils, cooperation (children of different ages spend a significant amount of time together, they have to work together to solve different problems). Based on this, pupils do not get ready for the sake of assessments, but because they are interested in learning and exploring the world around them.

Another example of effective implementation of Montessori's ideas in practice is the program of the Center for Child Development "Anthill" in Ternopil, which combines traditional forms and methods of working with younger pupils and the so-called "events" in a prepared environment where pupils can choose activities, interact with children of other ages, independently study the objects of this environment [62].

Montessori New Age School has a "Montessori class", which is equipped with a complete set of Montessori materials for comprehensive and harmonious development of children and is divided, like the STEM learning space, into several functional areas; some of them are designed to develop a variety of practical skills, improve motor skills and coordination. Also, there are materials for the development of sensory sensations, speech, mathematical abilities, as well as acquaintance with the world around [63]. It is also emphasized the importance of the role of the teacher: "conducts constant observation and ... knows at what stage of development each child is, what occupation should be offered to him for a further step forward". Attention is drawn to the significance of the mixed-age groups of Montessori New Age School, which creates optimal conditions for the social upbringing of children on the principle of a large family and folk pedagogy. The mission of the New Age School is to create a special educational environment in which children learn through their own experiences and feelings.

The study showed that the activities of Montessori pedagogy centers in Ukraine are mainly focused on the education and training of preschool children. Some example is the Montessori World full cycle

school in Kharkiv [64], which uses an interdisciplinary approach to designing courses and curriculum subjects with a special emphasis on preparing children through practical activities for real life. Among the training courses are the following: writing and project activities (for example, spelling is studied on topics that interest children: human structure, animal habitat, rivers or volcanoes of different continents); publication of a school newspaper studies to keep the audience's attention, present the project, ask questions, gain experience in public speaking. Due to special manuals and didactic materials, children can divide the whole into parts, solve geometric problems and prove theorems. The course "Physics, Chemistry, Astronomy" is aimed primarily at experimental activities, creating projects that are the foundation for in-depth study of these sciences at high school, the course "History and Geography" uses elements of museum pedagogy. Communicating with teachers of Karazin University in classes on "Botany and Zoology", children observe plants and insects, care for animals in their own "living space" and grow plants. During classes "Financial knowledge and management" pupils learn to put financial and economic aims, manage finances and plan a budget, in particular, through outings, excursions, teamwork at fairs, holidays, purchasing products. The course "Art and Painting" includes regular master classes on felting wool, origami, etc. Besides, it is aimed at developing practical life skills and social responsibility: children develop menus, prepare dinners, set the table, wash dishes, clean the classrooms, clean up the forest of rubbish, sort garbage, and hand over waste paper. In this Montessori environment, pupils participate individually and in groups. Classes are divided into thematic areas: mathematics, languages, geography, history, biology, space; there is a laboratory. Due to this the learning approach is realized: teach the child to think, find solutions, make discoveries, search for information and be able to apply it when needed.

It should be noted that most educational institutions that use Montessori's ideas are private, such as the Clever Kids Elementary School in Kyiv. In addition to the annual curriculum in accordance with the standard, for each child, taking into account the gifts and flaws of the pupil, his abilities, main interests, age goals, phase of character development, and level of ability to control emotions and interact with the team is worked out a personalized curriculum [65]. Particular attention is paid to the formation of project activities skills that promote children's interest in research, skills of planning and organizing their working time, critical, analytical and abstract thinking skills, and teamwork. Among the pedagogical tasks of the Clever Kids are also assistance in the pupil potential development, development of independence and self-sufficiency of thinking, respect and empathy for others, responsibility and leadership qualities. There are created conditions for the development of children based on their individual step and biological rhythm, formation of skills of independent work, promoting the initiative in the choice of materials, stimulating the development of self-discipline skills, cooperation with parents and more. Emphasis is placed on the importance of the activities of teachers, whose mission is to find ways to inspire children to learn. Such support allows children, first of all, to gain confidence and strive to perform tasks constantly without fear of failure. Emphasis is placed on the gradual complication of tasks, which creates opportunities to go through the process of aim setting and experience of personal victory.

Thus, the study of information about Montessori education centers in Ukraine showed that the modern interpretation of pedagogical postulates for socialization and upbringing of the child is indisputable and can resolve the contradictions associated with the implementation in practice of the basic requirements for the modern educational process: individualization, reliance on sensitive periods, the priority of personal independence, the ability to make choices and respect the choices of others, freedom and discipline in different age communication, etc.

Our study showed that there are more than 250 educational institutions in Ukraine that use the methods and principles of teaching Maria Montessori. For comparison, in Germany there are about 1000 preschool institutions and 400 schools operating on the basis of Montessori pedagogy: gymnasiums are 40 percent, general schools – 25%, primary – 20% and real schools – 15% [66]. Thus, the ideas and pedagogical system of M. Montessori remain relevant in the education of the 21st century.

4.3. Analysis of web mapping data about STEM-STEAM-STREAM centers in Ukraine

For comparison, a map of the development of STEM-STEAM-STREAM centers was created in a similar way (figure 3).

Figure 3: STEM-STEAM-STREAM centers in Ukraine.

Our research showed that there are more than 190 teaching centers in Ukraine that use STEM-STEAM-STREAM technologies. 45 STEM centers are functioning in the central regions, 9 centers in the east regions, 62 centers in the western regions, 41 centers in the northern regions, 30 centers in the southern regions. This is due to the fact that STEM education in Ukraine is only gaining popularity, and their largest number we have only in large cities (Kiev, Lviv). The smallest number of STEM institutions is located in the eastern and southwestern regions.

The obtained data on the development of educational centers in Ukraine based on the pedagogy of M. Montessori and STEM-STEAM-STREAM centers are presented in the form of diagrams (figures 4, 5).

The development of Montessori pedagogy, which is presented on figure 4, shows that the Montessori concept is widely known in Ukraine. Nonetheless, since this practice is used only by private schools and kindergartens, it is not available for many children and its percentage is small in some regions. The largest centers and networks of STEM centers and Montessori schools are located in Kyiv.

5. Conclusions

We have analyzed the similarities and differences between M. Montessori methodology and STEM approach in education, both based on the constructivist philosophy in education. We have demonstrated the relevance and complementarity of these ways in formal and non-formal education in Ukraine by using web mapping service Google Maps to visualize the distribution and growth of Montessori and STEM educational centers. We have argued that the organizational and pedagogical condition for their effective integration is the creation of a special learning environment that can adapt to the personal ideals and cognitive needs of the learners, as well as foster the development of soft skills [67, 68].

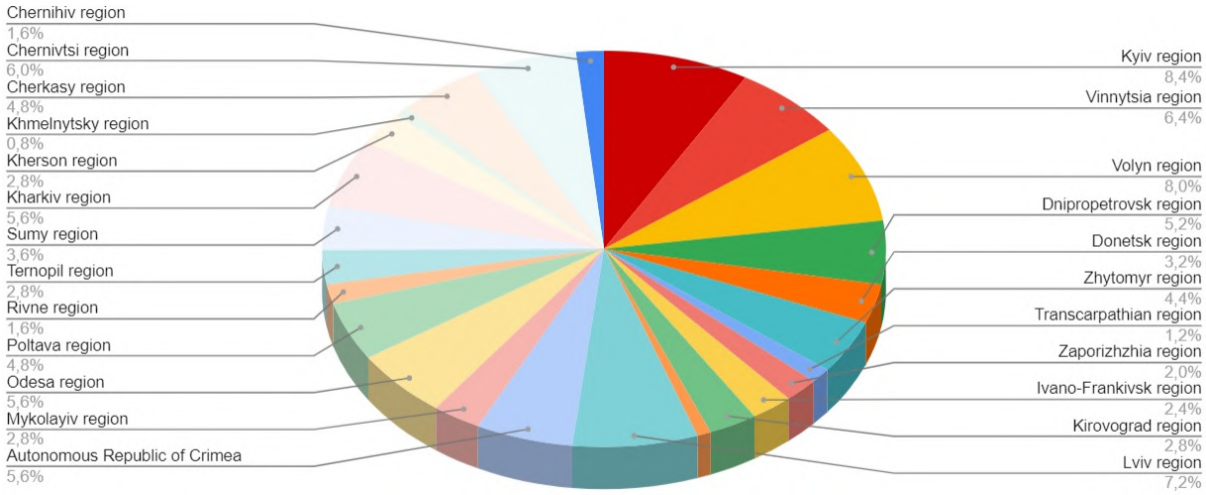

Figure 4: Quantitative distribution of Montessori pedagogy centers in Ukraine.

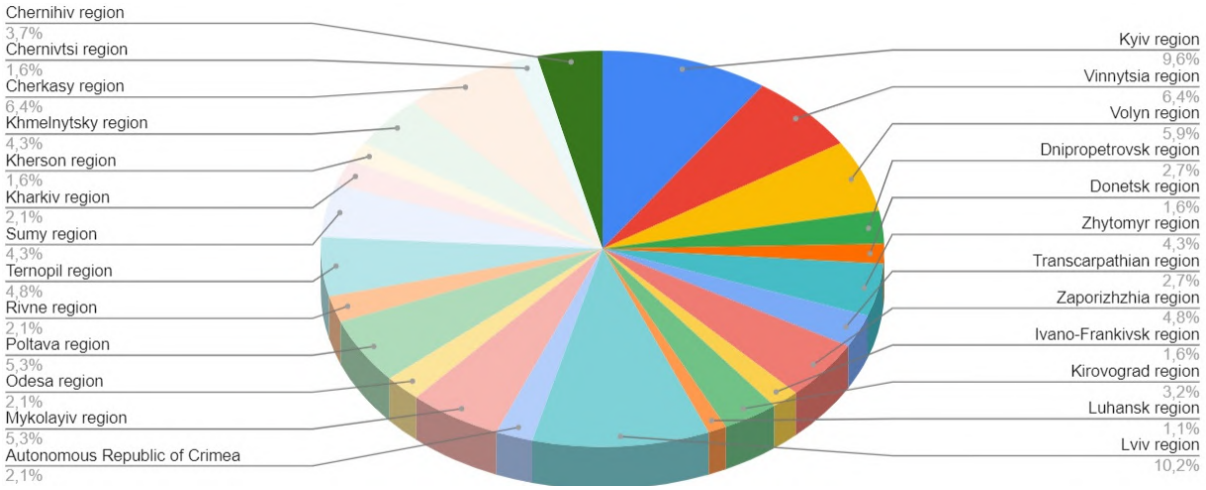

Figure 5: Quantitative distribution of STEM-STEAM-STREAM centers in Ukraine.

We have also identified some common didactic features of Montessori and STEM technologies, such as:

- the emphasis on the formation of a lasting interest in the processes and phenomena in the world, the development of curiosity based on research using the steps of the scientific method and the engineering design process;
- the transformation of the role of the teacher, from a transmitter of knowledge to a facilitator of learning, a motivator of productive activities, a stimulator of development, and a creator of a pedagogical ecosystem that fosters the formation of a scientific worldview and the key skills of the 21st century in the students.

By comparing the maps created by Google Maps, we have concluded that the Montessori methodological system has adapted to the rapid development of technology and machinery in the 21st century; the popularity of STEM educational centers is increasing rapidly in Ukraine (almost 200 new centers in 10 years). We have used the Gartner Hype Cycle method to describe this process [69] and suggested that Montessori pedagogy is now on a "plateau of productivity" and that STEM approaches in education are in a state of active implementation, which corresponds to "innovation trigger" and approaches the "peak of inflated expectations".

We have proposed that STEM technologies of teaching and pedagogical ideas of M. Montessori can harmoniously complement each other, especially in the context of forming the ability to successful self-development based on maintaining the relationship between the child and the developmental subject-spatial environment (M. Montessori), which can be digital (STEM) in the present time.

References

[1] Law of Ukraine On Education, 2017. URL: https://zakon.rada.gov.ua/laws/show/2145-19#Text.

[2] Institute for Modernization of the Content of Education: STEM-education, 2016. URL: https://imzo.gov.ua/stem-osvita/.

[3] S. O. Semerikov, M. M. Mintii, I. S. Mintii, Review of the course "Development of Virtual and Augmented Reality Software" for STEM teachers: implementation results and improvement potentials, in: S. H. Lytvynova, S. O. Semerikov (Eds.), Proceedings of the 4th International Workshop on Augmented Reality in Education (AREdu 2021), Kryvyi Rih, Ukraine, May 11, 2021, volume 2898 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2021, pp. 159–177. URL: https://ceur-ws.org/Vol-2898/paper09.pdf.

[4] R. P. Kukharchuk, T. A. Vakaliuk, O. V. Zaika, A. V. Riabko, M. G. Medvediev, Implementation of STEM learning technology in the process of calibrating an NTC thermistor and developing an electronic thermometer based on it, in: S. Papadakis (Ed.), Joint Proceedings of the 10th Illia O. Teplytskyi Workshop on Computer Simulation in Education, and Workshop on Cloud-based Smart Technologies for Open Education (CoSinEi and CSTOE 2022) co-located with ACNS Conference on Cloud and Immersive Technologies in Education (CITEd 2022), Kyiv, Ukraine, December 22, 2022, volume 3358 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2022, pp. 39–52. URL: https://ceur-ws.org/Vol-3358/paper25.pdf.

[5] M. M. Mintii, N. M. Sharmanova, A. O. Mankuta, O. S. Palchevska, S. O. Semerikov, Selection of pedagogical conditions for training STEM teachers to use augmented reality technologies in their work, Journal of Physics: Conference Series 2611 (2023) 012022. doi:10.1088/1742-6596/2611/1/012022.

[6] M. M. Mintii, STEM education and personnel training: Systematic review, Journal of Physics: Conference Series 2611 (2023) 012025. doi:10.1088/1742-6596/2611/1/012025.

[7] Y. Fan, Integrating online and offline teaching to promote creativity for STEM learners, Educational Technology Quarterly 2024 (2024) 241–254. doi:10.55056/etq.723.

[8] I. Dychkivska, T. Ponymanska, Montessori: Theory and technology, Slovo Publishing House, 2009.

[9] M. Mavric, The Montessori approach as a model of personalized instruction, Journal of Montessori Research 6 (2020). doi:10.17161/jomr.v6i2.13882.

[10] K. Krutiy, T. Hrytsyshyna, STREAM-education of preschool children: We bring up the culture of engineering thinking, Preschool Education (2016) 3–7.

[11] C. Marshall, Montessori education: a review of the evidence base, Science Learn 2 (2017). doi:10.1038/s41539-017-0012-7.

[12] T. Smith, Dr. Maria Montessori and her houses of childhood, Pedagogical Seminary 18 (1911) 533–542. doi:10.1080/08919402.1911.10532799.

[13] R. Allen, The Montessori method and missionary methods, International Review of Mission 2 (1913) 329–341. doi:10.1111/j.1758-6631.1913.tb01627.x.

[14] L. Paton, Montessori education for children with defective sight, Journal of the Royal Society of Medicine 8 (1915) 100–106. doi:10.1177/003591571500801632.

[15] D. Levy, P. Bartelme, The measurement of achievement in a Montessori school and the intelligence quotient, Pedagogical Seminary and Journal of Genetic Psychology 34 (1927) 77–89. doi:10.1080/08856559.1927.10533063.

[16] K. Stern, Beobachtungen des Spontanverhaltens vorschulpflichtiger Kinder über lange Zeitintervalle im Montessori-Kinderhause, Psychologische Forschung 13 (1930) 79–100. doi:10.1007/BF00406761.

[17] C. Claremont, In Memory of Dr. Montessori, British Medical Journal 1 (1952) 1304. doi:10.1136/bmj.1.4771.1304.
[18] M. Montessori, Maria Montessori's contribution to the cultivation of the mathematical mind, International Review of Education 7 (1961) 134–141. doi:10.1007/BF01433363.
[19] F. Drenckhahn, Montessori materials and the teaching of mathematics, International Review of Education 7 (1961) 174–186. doi:10.1007/BF01433367.
[20] R. Beck, Kilpatrick's critique of Montessori's method and theory, Studies in Philosophy and Education 1 (1961) 153–162. doi:10.1007/BF00367848.
[21] C. Stendler, The Montessori method, Educational Forum 29 (1965) 431–435. doi:10.1080/00131726509339429.
[22] T. Denny, Montessori resurrected: Now what?, Educational Forum 29 (1965) 436–441. doi:10.1080/00131726509339430.
[23] W. Argy, Montessori versus orthodox; a study to determine the relative improvement of the preschool child with brain damage trained by one of the two methods., Rehabilitation literature 26 (1965) 294–304.
[24] A. Roeper, Gifted preschooler and the Montessori method, Gifted Child Quarterly 10 (1966) 83–89. doi:10.1177/001698626601000207.
[25] T. Denny, Once upon a Montessori, Educational Forum 30 (1966) 513–516. doi:10.1080/00131726609339760.
[26] L. Gitter, The promise of Montessori for special education, Journal of Special Education 2 (1967) 5–13. doi:10.1177/002246696700200101.
[27] L. Gitter, Montessori principles applied in a class of mentally retarded children., Mental Retardation 5 (1967) 26–29.
[28] L. Gitter, A centenary for Montessori, Intervention in School and Clinic 5 (1970) 247–248. doi:10.1177/105345127000500402.
[29] M. Morra, The Montessori method in the light of contemporary views of learning and motivation, Psychology in the Schools 4 (1967) 48–53. doi:10.1002/1520-6807(196701)4:1<48::AID-PITS2310040112>3.0.CO;2-0.
[30] S. Cohen, Educating the children of the urban poor: Maria Montessori and her method, Education and Urban Society 1 (1968) 61–79. doi:10.1177/001312456800100105.
[31] R. Edgington, For the classroom: Montessori and the teacher of children with learning disabilities: A personnel odyssey, Intervention in School and Clinic 5 (1970) 219–221. doi:10.1177/105345127000500306.
[32] C. Edwards, Three approaches from Europe: Waldorf, Montessori, and Reggio Emilia, Early Childhood Research and Practice 4 (2002).
[33] C. Lopata, N. Wallace, K. Finn, Comparison of academic achievement between Montessori and traditional education programs, Journal of Research in Childhood Education 20 (2005) 5–13. doi:10.1080/02568540509594546.
[34] K. Rathunde, M. Csikszentmihalyi, Middle school students' motivation and quality of experience: A comparison of Montessori and traditional school environments, American Journal of Education 111 (2005) 341–371. doi:10.1086/428885.
[35] A. Lillard, N. Else-Quest, Evaluating Montessori education, Science 313 (2006) 1893–1894. doi:10.1126/science.1132362.
[36] A. Lillard, Preschool children's development in classic Montessori, supplemented montessori, and conventional programs, Journal of School Psychology 50 (2012) 379–401. doi:10.1016/j.jsp.2012.01.001.
[37] A. Lillard, M. Heise, E. Richey, X. Tong, A. Hart, P. Bray, Montessori preschool elevates and equalizes child outcomes: A longitudinal study, Frontiers in Psychology 8 (2017) 1783. doi:10.3389/fpsyg.2017.01783.
[38] K. Dohrmann, T. Nishida, A. Gartner, D. Lipsky, K. Grimm, High school outcomes for students in a public Montessori program, Journal of Research in Childhood Education 22 (2007) 205–217. doi:10.1080/02568540709594622.

[39] B. Beatty, The dilemma of scripted instruction: Comparing teacher autonomy, fidelity, and resistance in the Froebelian kindergarten, Montessori, direct instruction, and success for all, Teachers College Record 113 (2011) 395–430.
[40] K. Whitesgarver, J. Cossentino, Montessori and the mainstream: A century of reform on the margins, Teachers College Record 110 (2008) 2571–2600.
[41] A. Dodd-Nufrio, Reggio Emilia, Maria Montessori, and John Dewey: Dispelling Teachers' Misconceptions and Understanding Theoretical Foundations, Early Childhood Education Journal 39 (2011) 235–237. doi:10.1007/s10643-011-0451-3.
[42] N. V. Morze, O. V. Strutynska, Advancing educational robotics: competence development for pre-service computer science teachers, CTE Workshop Proceedings 10 (2023) 107–123. doi:10.55056/cte.549.
[43] M. M. Mintii, Exploring the landscape of STEM education and personnel training: a comprehensive systematic review, Educational Dimension 9 (2023) 149–172. doi:10.31812/ed.583.
[44] I. Stetsenko, Substantiation of the need for transition from STEM-education to STREAM-education in preschool age, Computer in School and Family (2016) 31–34. URL: http://nbuv.gov.ua/UJRN/komp_2016_8_8.
[45] T. Tkachenko, O. Yeremenko, A. Kozyr, V. Mishchanchuk, W. Liming, Integration Aspect of Training Teachers of Art Disciplines in Pedagogical Universities, Journal of Higher Education Theory and Practice 22 (2022) 138–147. URL: https://doi.org/10.33423/jhetp.v22i6.5236.
[46] E. Lapon, Montessori middle school and the transition to high school: Student narratives, Journal of Montessori Research 2 (2020). doi:10.17161/jomr.v6i2.13854.
[47] S. Bada, Constructivism learning theory: A paradigm for teaching and learning, IOSR Journal of Research & Method in Education 1 (2015). doi:10.9790/7388-05616670.
[48] E. von Glasersfeld, A constructivist approach to teaching, in: L. P. Steffe, J. Gale (Eds.), Constructivism in education, 1995.
[49] J. Piaget, The psychogenesis of knowledge and its epistemological significance, in: M. Piattelli-Palmarini (Ed.), Language and Learning: The Debate Between Jean Piaget and Noam Chomsky, Harvard University Press, 1980, pp. 1–23.
[50] L. S. Vygotsky, Thought and language, MIT Press, Cambridge, MA, 1962.
[51] O. Komar, Constructivist paradigm of education, Philosophy of education 2 (2006) 36–45.
[52] M. Tchoshanov, Engineering of Learning: Conceptualizing e-Didactics, UNESCO Institute for Information Technologies in Education, Moscow, 2013. URL: https://iite.unesco.org/pics/publications/en/files/3214730.pdf.
[53] J. Lee, L. Lin, Applying constructivism to online learning, Information Technology and Constructivism in Higher Education (2009). doi:10.4018/978-1-60566-654-9.ch005.
[54] V. Dagar, A. Yadav, Constructivism: A paradigm for teaching and learning, Arts and Social Sciences Journal 7 (2016). doi:10.4172/2151-6200.1000200.
[55] T. A. Vakaliuk, V. V. Kontsedailo, D. S. Antoniuk, O. V. Korotun, I. S. Mintii, A. V. Pikilnyak, Using game simulator Software Inc in the Software Engineering education, CEUR Workshop Proceedings 2547 (2020) 66–80.
[56] L. Bilousova, L. Gryzun, N. Zhytienova, Interactive methods in blended learning of the fundamentals of UI/UX design by pre-service specialists, Educational Technology Quarterly 2021 (2021) 415–428. doi:10.55056/etq.34.
[57] I. P. Varava, A. P. Bohinska, T. A. Vakaliuk, I. S. Mintii, Soft Skills in Software Engineering Technicians Education, Journal of Physics: Conference Series 1946 (2021) 012012. doi:10.1088/1742-6596/1946/1/012012.
[58] L. Kalashnikova, I. Hrabovets, L. Chernous, V. Chorna, A. Kiv, Gamification as a trend in organizing professional education of sociologists in the context of distance learning: analysis of practices, Educational Technology Quarterly 2022 (2022) 115–128. doi:10.55056/etq.2.
[59] O. V. Prokhorov, V. O. Lisovichenko, M. S. Mazorchuk, O. H. Kuzminska, Implementation of digital technology for student involvement based on a 3D quest game for career guidance and assessing students' digital competences, Educational Technology Quarterly 2022 (2022) 366–387.

doi:10.55056/etq.430.
[60] E. Polat, Gamification implementation for educational purposes: a scoping review (2013-2018), Educational Technology Quarterly 2023 (2023) 367–400. doi:10.55056/etq.589.
[61] Lviv Montessori School, 2021. URL: https://www.facebook.com/LvivMontessoriSchool/.
[62] Child development center Murashnyk, 2021. URL: https://www.facebook.com/murashnyk.
[63] Montessori new age school, 2021. URL: http://mnas.com.ua/course-details.html.
[64] The world of Montessori. Alternative education according to the Montessori system of the full cycle, 2021. URL: http://montessoriya.kh.ua/.
[65] Private elementary school and kindergarten Clever Kids, 2021. URL: https://cleverkids.com.ua.
[66] A. Priboschek, 150. Geburtstag von Maria Montessori – Warum ihre Pädagogik heute noch so wichtig ist, 2020. URL: https://www.news4teachers.de/2020/08/150-geburtstag-von-maria-montessori-warum-ihre-paedagogik-heute-noch-so-wichtig-ist/.
[67] N. V. Bondar, T. V. Konovalenko, Developing soft skills in future foreign language teachers through ICT, CTE Workshop Proceedings 11 (2024) 52–66. doi:10.55056/cte.692.
[68] B. M. Oliinyk, V. P. Oleksiuk, Social engineering as a component of professional competence in information security of future computer science teachers, Educational Dimension (2024). doi:10.55056/ed.778.
[69] M. Brown, Hype Cycle for Higher Education, 2024, 2024. URL: https://www.gartner.com/en/documents/5624891.