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USE OF FRACTALS IN VOCATIONAL EDUCATION

ВИКОРИСТАННЯ ФРАКТАЛІВ У ПРОФЕСІЙНО-ТЕХНІЧНІЙ ОСВІТІ

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ABSTRACT

The **purpose** of the article is to substantiate the possibilities of using fractals in vocational training for higher education students.

Methodology. In the research process, general scientific and pedagogical research methods were used: theoretical analysis, synthesis, classification, systematization, generalization, systematicity, survey and modelling.

Results. A model for using fractals to design the educational process in a higher education institution has been developed. It has been substantiated how fractals act in the components of this model. It has also been substantiated on the basis of the specialties of labour protection and transport logistics, that for the design and structuring of the educational process it is necessary that the competencies developed are consolidated in the following bachelor's or master's courses with additional competencies in accordance with the Standard of Higher Education of

Метою статті є обґрунтування можливостей використання фракталів у професійній підготовці здобувачів вищої освіти.

Методологія. У процесі дослідження було використано загальнонаукові й педагогічні методи дослідження: теоретичні: аналіз, синтез, класифікація, систематизація, узагальнення, системність, опитування, моделювання.

Результати. Розроблено модель використання фракталів для моделювання освітнього процесу закладу вищої освіти. Обґрунтовано як фрактали діють в складових цієї моделі на спеціальностях з охорони праці, транспортної логістики, що для проектування та структурування освітнього процесу необхідно, щоб сформовані компетентності закріплювались на наступних курсах бакалаврата чи магістратури з додатковими компетентностями відповідно до Стандарту вищої освіти України, освітньої програми підготовки здобувачів, спеціалізації,

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Ukraine, the educational program for preparing applicants, specialization, and work program. Patterns, as well as fractals, can be used to identify recurring concepts in various disciplines, simplifying learning. During the implementation of fractals in the educational process for vocational higher professional education students, it was confirmed that fractals, as well as recurring patterns, were rationally used in the design of training modules, in assessing the individual trajectory of a student during professional training, as well as in the study of complex systems, which helped to structure the educational process.

Conclusions. During the fractal use in the vocational professional training for higher education students, it was confirmed that fractals, as well as repeating patterns, were rationally used in research, in the design of training modules, as well as in the study of complex systems, which helped to structure the educational process. The result of the developed model allows us to provide higher-quality and safer education in difficult conditions, in particular in the fields of transport, professional and technological education.

Keywords: fractal, pattern, student, higher education institution, transport logistics, occupational safety, pedagogy.

робочої програми. Патерни, як і фрактали, можна використовувати для ідентифікації повторюваних концепцій у різних дисциплінах, спрощуючи навчання. Під час впровадження фракталів в освітній процес здобувачів вищої професійної освіти підтверджено, що фрактали, як і повторювані патерни, раціонально використовувались в проектуванні модулів навчання, при оцінюванні індивідуальної траєкторії навчання студента під час професійної підготовки, а також у вивченні складних систем, що допомагало структурувати навчальний процес.

Висновки. Фрактали, як і повторювані патерни, раціонально використовувати в дослідженнях, в проектуванні модулів навчання, а також у вивченні складних систем, це допомагало структурувати навчальний процес. Результат розробленої моделі дає змогу оцінювати індивідуальну траєкторію навчання студента, надати більш якісну і безпечну освіту у складних умовах, зокрема у галузях транспортної, професійної та технологічної освіти.

Ключові слова: фрактал, патерн, студент, заклад вищої освіти, транспортна логістика, охорона праці, педагогіка.

INTRODUCTION

In accordance with the National Strategy for the Development of Education in Ukraine, key areas of state policy in the field of education have been identified, including: ensuring favourable conditions for learning and development, developing scientific and innovative activities in education, supporting research and implementing innovations to improve the quality of education, etc.

In this context, teachers, students and other teaching staff of higher education institutions need to improve the quality of higher professional education in connection with the emergence of new modern technologies and methods to improve the educational process. Among these technologies and methods is the possibility of using, for example, fractal theory in the educational process of professional training for higher education students in vocational field has not been studied.

The **purpose** of the study is to substantiate the possibilities of using fractals in vocational education during the professional training of future specialists in higher education institutions.

The problem of using fractals during professional training in higher education institutions has been studied by many scientists. We agree with Vozniuk (2012) that each element of the whole is fundamentally necessary, since without it the whole will no longer be itself; therefore, the whole is ontologically equal to the parts, and the parts to

the whole. The author substantiates the fractal-holographic principle of integrity, when the goal of developing the components of the whole, is as if set in advance. As Vozniuk (2012) rightly points out, the fractal-holographic principle of “all in all” involves the development of a synergistic approach to building a socio-pedagogical environment, which reveals the main aspects: the subject-subject nature of relationships in the educational process; formation of an active, multifaceted educational and pedagogical environment in the system; restoration of the pedagogical system.

The importance of developing a synergistic approach to building a socio-pedagogical environment is substantiated by Shvets (2022). She determined that synergistic and systemic approaches contribute to the formation of an appropriate, adequate formulation of the essence of the problems under study in specific sciences and the selection of effective ways to solve them.

As a result of their research, Tkachenko and Krasnobokyi (2020) came to the conclusion that the process of professional teacher training belongs to dynamic systems that are actively developing.

The components of such systems, as scientists rightly point out, require constant improvement: the goal, content and technology of methodological training, the educational environment, the teacher, the subjects of the educational process.

It is worth noting Donchenko's (2005) conclusion that his model of the world is fractal in nature, and that these fractals exhibit rotational properties.

According to Yurzhenko (2012), the comparative characteristics of fractal psychology and Gestalt psychology make it possible to implement them in modern pedagogical science. In particular, Yurzhenko came to the correct conclusion that for the fractal concept of activity, which is built on a dichotomous structure, there are objectively two motivational aspects: positive and negative.

In another work, Yurzhenko (2014) justifies the fractal approach to determining the content and structure of learning using the example of the educational field of “Technology”. He rightly notes that the basis of technical and technological fractal reflection of personality is develops on the basis of cognitively methodical constructs.

The use of fractal dimension in foundry production was studied by Thinlegged et al, (2024). They reasonably noted that the fractal type model is based on determining the self-similarity of the object; the main property of fractal objects is independence from scale; the results of research on the properties of one of the dimensional levels extend to other scale levels.

As the researcher of fractal psychology Donchenko (2005) correctly notes, patterns (repeated elements or structures that can be used for analysis, creation of something or prediction of events) and any organized structure are combined into a single whole.

Theoretical analysis of promising approaches to the use of scientometric methods based on the theory of fractals was successfully used by Svyrydiuk (2017). Using scientometric methods of content analysis, Svyrydiuk, using the Hurst Index and Hausdorff-Bezиковych dimension, investigated 137 master's theses submitted to the Zhytomyr Institute of Nursing, He came to the conclusion that the theory of fractals has broad prospects for applied use in medicine, both social and clinical.

Worthy of note is the research of Bridger (2023), founder of NeuroCo and The Mindlab, and site director of the NeuroStrata agency, on the interactionist approach to

understanding design, which involves searching for recurring elements capable of influencing people.

Vozniuk and Dubaseniuk (2009) came to the same conclusion. They rightly believe that in modern education an integrative psychological-pedagogical and philosophical-naturalistic approach to the goals and mechanisms of personality development in the context of the educational trajectory should be widespread.

However, one should agree with Dubaseniuk and Vozniuk (2022) that in the context of educational changes, trends in the development of higher education systems in the context of global integration processes stand out, including the formation of the digital generation, the development of the network space, an improved structure of the educational process (which is focused on developing the ability of future teachers to enhance the differentiation and individualization of the educational space), and the creation of new generations of curricula taking into account the individual trajectory of the future teacher's development.

METHODOLOGY

In the process of research, general scientific and pedagogical research methods were used:

- theoretical: comparative, retrospective analysis of pedagogical literature and generalization and classification of scientific research in pedagogical sources to substantiate the possibility of use in pedagogy;
- systematicity: observation of the relationship and interaction of fixed fractals during the professional training of future teachers among students in different courses;
- synthesis; (general scientific, interdisciplinary, interdisciplinary) when teaching the disciplines of the transport industry and occupational safety of vocational education to substantiate the unity of interconnected competencies in higher education institutions using these specialties. That is, formulating a conclusion; analysis of the educational and work programs of the bachelor's and master's degree programs in vocational education (Transport, Occupational Safety) to clarify the state of professional training of future specialists of the pedagogical direction in the transport industry and occupational safety;
- method of surveying teachers, students and members of the administration of the above-mentioned industries to identify problems in consolidating and forming the following competencies depending on the year of study;
- modelling method to create a model of the use of fractals in higher education institutions.

RESULTS

Using the theoretical research method, pedagogical scientific works among Ukrainian scientists and scientists from other countries were analysed. The analysis focused on the possibilities of using fractals in the educational process. Using fractal theory, students were assessed when mastering the initial material. Based on the modelling method, a model of using fractals in pedagogy was developed.

During the study of how the use of fractals can influence the educational process and what competencies should be formed and consolidated, a survey was conducted in the

form of a questionnaire, in which respondents (teachers and students of transport and labour protection, members of the administration) were asked the following questions: *"In your opinion, what competencies of first-year undergraduate students should be consolidated during the assimilation of educational material?"* *"Why, in your opinion, should repetitive patterns be used when mastering educational material in different years of study?"* This survey revealed shortcomings in the organization of the formation of competencies in students.

The survey included 160 respondents from the Faculty of Technological and Mathematical Education, specialty "015 Vocational Education (Occupational Safety)" and students of the transport industry of the Educational and Scientific Centre of the National Centre of Vocational and Technical Education of the National Academy of Sciences of Ukraine, as well as members of the administration of the relevant institutions. All participants in the study were informed about its purpose and content, and they gave their consent to participate with the assurance of confidentiality and anonymity of their responses. In accordance with the Code of Ethics of the American Sociological Association (1997), the data collected were used for scientific purposes and were not disclosed to anyone.

To the question: *"What competencies do you think should be established in first-year undergraduate students during the acquisition of educational material?"* 70% of respondents noted that in the first year of undergraduate studies, students should develop general competencies, in particular, the ability to work independently, to carry out interpersonal interaction, to search, process and analyse information from various sources, and academic integrity.

Among the specific competencies developed in the first year of the bachelor's degree, 75% of respondents indicated the ability to apply knowledge of legislation, state standards, and industry regulations.

Regarding the educational results of the educational activities of first-year bachelor's degree students, 80% of respondents noted students' mastery of the basics of information and digital technologies, integrity, pedagogy, psychology, methodology, culture, national and patriotic education.

To the question: *"Why, in your opinion, should repetitive patterns be used when mastering educational material in different years of study?"* 90% of respondents indicated consolidation of acquired competencies, obtaining additional competencies in accordance with the Standard of Higher Education of Ukraine, the educational program for preparing applicants, specialization and the work program.

Therefore, based on the survey results, we can conclude that the use of fractals allows for better learning of educational material and consolidation of competencies developed in the educational process.

The development of professional education, in particular in labour protection and transport logistics, requires adaptive changes in connection with the war. As shown by the work at Hryhorii Skovoroda University in Pereiaslav at the Departments of Theory and Methods of Professional Training, Methods of Technological Education and Computer Graphics, as well as at the Educational and Scientific Centre of the National Centre of Vocational Training and Technical Education of the National Academy of Sciences of Ukraine (during the professional training of future specialists in the transport industry), the development of professional education using the theory of fractals is shown in Figure 1 in the form of a model.

Figure 1

Fractal model of competence development for higher education students

Fractals in the educational process of a higher education institution													
MASTER'S DEGREE													
Competencies developed in the sixth year	1	2	3	4	5	6	7	8	9	10	11	12	13
Competencies developed in the fifth year	1	2	3	4	5	6	7	8	9	10	11		
BACHELOR'S DEGREE													
Competencies developed in the fourth year of higher education	1	2	3	4	5	6	7	8	9				
Competencies developed in the third year of higher education	1	2	3	4	5	6	7						
Competencies developed in the second year of higher education	1	2	3	4	5								
Competencies developed in the first year of higher education	1	2	3										

To build the fractal model, the following were used: the educational and professional programs in “Professional Education (Occupational Safety)” at both the first (bachelor’s) and second (master’s) levels of higher education within the specialty “015 Professional Education (Occupational Safety),” which belongs to the field of knowledge “01 Education / Pedagogy.” These programs correspond to the qualifications of *Bachelor of Vocational Education* and *Master of Vocational Education*, with the respective professional titles *Teacher of Vocational Training* and *Master of Vocational Education*.

Also used were the educational and scientific program of the third level (educational and scientific level) of higher education in the field of knowledge “01 Education / Pedagogy”, in the specialty “015 Professional Education”, leading to the qualification of *Doctor of Philosophy in Vocational Education*.

In addition, the educational and professional programs in “Secondary Education (Labor Training and Technologies)” at both the first (bachelor’s) and second (master’s) levels of higher education in the specialty “014 Secondary Education (Technologies)” were used. These correspond to the qualifications of *Teacher of Labor Training and Technologies in Secondary Education Institutions* and *Master of Secondary Education*, respectively.

The Educational and professional program “Maintenance and repair of automobiles and engines” for obtaining the educational and qualification level *Junior Specialist* of the initial level of higher education in the specialty: “274 Motor transport”, with the specialization: “Maintenance and repair of automobiles and engines” field of knowledge “27 Transport” qualification mechanic etc were used too.

According to the model of using fractals in the educational process of a higher education institution (Fig. 1), the competencies that students develop at the beginning of their studies are fractally repeated in subsequent courses with the formation of new competencies, as shown in the model. For example, in the first year of undergraduate studies in the above-mentioned specialties, students develop general – and particularly key – competencies such as the ability to work independently, engage in interpersonal interactions, search for, process, and analyze information from various sources, apply

knowledge in practical situations, make informed decisions, and demonstrate academic integrity and personal responsibility.

These include the student's value orientations, moral and spiritual qualities, the development of patriotism, communicative skills gained during professional training and internships, the cultivation of culture within the educational environment, mastery of safety measures in the learning process, the ability to follow an individual educational trajectory, as well as independence and self-realization. (Vaintraub, 2024a). Among special professional competencies, for example, in the first year of the bachelor's degree, the students develop the ability to apply knowledge of legislation, state standards, industry regulations.

The integral competence of first-year bachelor's degree students is associated with the ability to solve specialized tasks of a research and innovative nature. Program results of educational activities of first year bachelor's degree students include the ability to master the basics of ICT, integrity, pedagogy, psychology, methodology, culture, national and patriotic education (Vaintraub, 2024b).

All these competencies should be consolidated in subsequent bachelor's or master's degree courses with additional competencies in accordance with the Standard of Higher Education of Ukraine, the educational program for preparing applicants, specialization, and work program.

The competencies considered, repeated and consolidated in the following training courses, are fractals, which are known to propagate in three main ways. According to the first method, iterative functions are included using geometric substitutions and transformations into geometric fractals. Fractals generated using iterative functions often exhibit exact self-similarity. This occurs when the fractal looks the same at different magnifications.

It is appropriate to consider the second common method of creating fractals, using recurrence relations. Fractals using these relations are created at every point in space. Fractals generated using recurrence relations are usually almost (but not exactly) self-similar. And, finally, the third method is associated with stochastic processes in which some parameters change randomly. Probabilistic fractals are examples of fractals that are statistically, but not almost or exactly, self-similar.

Using these and other methods, fractal theory can help design and structure the educational process, demonstrating how the acquisition of knowledge and skills at different levels repeats similar patterns. This approach contributes to a deep understanding of the educational material and the development of critical thinking in students.

Patterns can be used to identify recurring concepts, in particular in different disciplines, simplifying learning, for example, in science for classification, in pedagogy for solving similar problem situations.

Fractals, like recurring patterns, have been rationally used in practice, in research, modular learning, and in the study of complex systems, which helped to structure the educational process. When designing the educational process, students incorporated recurring modules such as video lectures, tests, interactive tasks, group projects, and online discussions. This, as practice has shown, helped to consolidate the material and increase student engagement.

Fractal learning modules can be implemented through a methodically planned structure that allows for the breakdown of complex material into smaller, easily digestible parts. This will promote deeper understanding and active student engagement in the learning process. Fractal patterns in vocational and technological education have been revealed through recurring concepts that are deepened at different levels of the educational process, allowing students to build strong knowledge by jointly studying similar topics in new contexts.

At the same time, it is important to assess with sufficient probability various aspects of the educational process. In particular, the Hausdorff-Bezikovitch dimension D (a quantitative measure of the non-ideality of an object) and the Hurst index H (its opposite) made it possible to assess the quality of acquired competencies in bachelors and masters.

This quality was predicted with the appropriate correction for the next year. In this aspect, the decisive factor is that with the help of fractal theory, the student's learning will be monitored by analysing his progress (or regression) and success (or failure) at different levels with the identification of recurring patterns in his learning habits.

Such studies made it possible to assess, in particular, the individual trajectory of the student during professional training, as well as to predict his development of acquired competencies in the future.

This contributed to the correction of the educational process, in particular in the case of unsuccessful mastering of the educational program. Of course, it was important to analyse the reasons for failure, provide additional support, adapt teaching materials and methods, and introduce regular monitoring of student performance.

Thus, fractals in pedagogy, in particular in vocational and technological education, have the prospect of practical use in the educational process and of improving the quality of the pedagogical field itself.

DISCUSSION

The relevance and necessity of developing teachers' professional skills in martial law conditions are substantiated. The model developed of using fractals in the educational process of a higher education institution determines how to structure the educational process to form competencies in applicants. The result of this model makes it possible to provide higher-quality professional education, assess the individual trajectory of a student, predict the development of acquired competencies and adjust the educational process.

Fractals should be used in the design of training modules when studying complex systems which helps to structure the educational process. This will help teachers develop the ability to crisis manage the educational process and educational work with students when teaching in emergency conditions, in particular during the war in Ukraine. The possibility of using fractals in education is confirmed by the research of Barnsley (1993). He rightly emphasized the omnipresence of fractals everywhere, in science, nature, and the environment. The use of fractals in mathematics, physics, and other natural sciences has been examined by Falconer (2003), Mandelbrot (1982), and Peitgen et al. (2004).

Providing moral and emotional-psychological support to colleagues and students in stressful situations is a key aspect of managing the educational process. One of the most important challenges is maintaining and adjusting the emotional and psychological state of all participants involved. In this context, it is also worth highlighting the effective use of information and digital technologies, which was an important focus of the study.

One cannot but agree with Tkachenko and Krasnobokyi (2020) that the educational process requires constant improvement, in particular, the goal, content and technology of methodological training, the educational environment, the teacher, the subjects of the educational process, etc.

This is especially true in modern conditions, during the consequences of the military, aggressive actions of the Russian Federation against Ukraine. In this regard, one should agree with researchers such as Vozniuk and Dubaseniuk (2009) and others about the importance of improving the educational process in non-standard conditions, and the spread of an integrative approach to personal development in the context of the educational trajectory.

CONCLUSIONS

The relevance and necessity of using fractals in the educational process of a higher education institution, in particular under martial law, is considered. A model for using fractals in the educational process of a higher education institution in the form of a table has been developed. The material proposed will be of interest to teachers of higher education institutions in the following areas: transport, professional and technological education. It is based on the specialties of labour protection, transport logistics, and proposes that for the design and structuring of the educational process, it is necessary that the competencies developed be consolidated in subsequent bachelor's or master's courses with additional competencies.

It is confirmed that fractals, as well as repeating patterns, are rationally used to identify repeating concepts in various disciplines, in research, in the design of training modules and in the study of complex systems. Using the Hausdorff-Bezikovitch dimension formulas D and the Hurst index H from fractal theory, it is possible to assess the quality of competencies acquired in bachelor's and master's degree students, correct and predict this quality, which makes it possible to assess the individual trajectory of the student, and predict the development of these acquired competencies in the future.

The material proposed will be of interest to teachers of institutions of higher and higher education in the fields of: transport, professional and technological education. Prospects for further research in this direction are the development of a model that provides new aspects of the use of fractals in pedagogy in war and post-war times, examples of the model, which foresees new components of professional training of scientific and pedagogical workers of higher education institutions under martial law.

CONFLICT OF INTERESTS

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REFERENCES

- Barnsley, M. F. (1993). *Fractals everywhere* (2nd ed.) Academic Press.
- Darren, B. (2023). *Neurodesign: The key to the minds of buyer*. Phoenix
- Donchenko, Y. O. (2005). *Fraktalnaia psikhohyia (Dohlubynni osnovaniia individualnoi i sotsialnoi zhyzny) [Fractal Psychology (Deep Foundations of*

Individual and Societal Life]). Znannia [in Ukrainian].

- Dubaseniuk, O. & Vozniuk, O. (2022). Suchasni tendentsii vprovadzhennia informatsiinykh tekhnolohii u protses pidhotovky maibutnikh pedahohiv: dosvid ta perspektyvy [Current trends in implementation of information technologies in the process of training the prospective teachers: experience and perspectives]. Suchasni informatsiini tekhnolohii ta innovatsiini metodyky navchannia v pidhotovtsi fakhivtsiv: metodolohiia, teoriia, dosvid, problemy – *Methodological problems of implementation of digital technologies and innovative teaching methods*, 65, 20–30. <https://doi.org/10.31652/2412-1142-2022-65-20-30> [in Ukrainian].
- Falconer, K. (2003). *Fractal geometry: Mathematical Foundations and Applications*. John Wiley & Sons Ltd. <https://doi.org/10.1002/0470013850>
- Mandelbrot, B. B. (1982). *The Fractal Geometry of Nature*. Freeman. <https://archive.org/details/fractalgeometry00beno/mode/2up>
- Peitgen, H., Jürgens, H., & Saupe, D. (2004). *Chaos and fractals*. Springer New York, NY. <https://doi.org/10.1007/b97624>
- Shvets, T. E. (2022). Systemnyi ta synerhetychnyi pidkhody yak metodolohichna osnova doslidzhennia tiutorynhu [Systemic and synergetic approaches as a methodological basis of tutoring research]. *Naukovyi chasopys Natsionalnoho pedahohichnoho universytetu imeni M. P. Drahomanova. Serii 5: Pedahohichni nauky: realii ta perspektyvy: zb. nauk. prats – Scientific Journal of the National Pedagogical Dragomanov University. Series 5: Pedagogical Sciences: Realities and Perspectives: Collection of Scientific Papers*, 87, 107–112. <https://doi.org/10.31392/NPU-nc.series5.2022.87.22> [in Ukrainian].
- Svyrydiuk, V. V. (2017). Teoriia fraktaliv ta yii vykorystannia v pedahohitsi [Fractal theory and its application in pedagogy]. *Profesiina osvita: problemy i perspektyvy – Vocational education: problems and prospects*, 12, 46–50. http://nbuv.gov.ua/UJRN/Profos_2017_12_12 [in Ukrainian].
- Tkachenko, I. A., & Krasnobokyi, Y. M. (2020). Systemno-synerhetychnyi pidkhid u fakhovii pidhotovtsi maibutnoho vchytelia pryrodnychkykh nauk [System-synergetic approach in professional training of the future teacher of natural sciences. Physical and Mathematical Education]. *Fizyko-matematychna osvita – Physical & mathematical education*, 4(26), 112–118. <https://doi.org/10.31110/2413-1571-2020-026-4-019> [in Ukrainian].
- Tonkonohyi, V., Holofieieva, M., Levynskyi, O. & Klimov, S. (2024). Vykorystannia fraktalnoi rozmirnosti pry modeliuvanni skladnykh system u mashynobuduvanni [Application of fractal dimension in the modeling of complex systems in mechanical engineering]. In *Application of knowledge for the development of science: Proceedings of the VII International Scientific and Practical Conference. Stockholm, Sweden* (pp. 411–412). International Science Group. <https://doi.org/10.46299/isg.2023.1.7> [in Ukrainian].
- Vaintraub, M. A. (2024a). Formuvannia kompetntnostei i rezultativ navchannia u studentiv profesiinoi ta tekhnolohichnoi osvity pedahohichnoho spriamuvannia [Formation of competences and learning outcomes in students of professional and technological education of pedagogical education]. *Naukovi zapysky. Serii «Psykhologo-pedahohichni nauky» (Nizhynskyi derzhavnyi universytet imeni Mykoly Hoholia) – Research Notes. Series "Psychology and Pedagogy Research"*

(*Nizhyn Mykola Gogol State University*), 3, 118–124. <https://doi.org/10.31654/2663-4902-2024-PP-3-118-124> [in Ukrainian].

Vaintraub, M. A. (2024b). Profesiina pidhotovka studentiv u zakladakh vyshchoi osvity v umovakh voiennoho stanu [Professional training of students in institutions of higher education under the conditions of marital state]. *Naukovi zapysky. Seriiia «Psykhologo-pedahohichni nauky» (Nizhynskiyi derzhavnyi universytet imeni Mykoly Hoholia) – Research Notes. Series "Psychology and Pedagogy Research" (Nizhyn Mykola Gogol State University)*, 1, 76–82. <https://doi.org/10.31654/2663-4902-2024-PP-1-76-82> [in Ukrainian].

Vozniuk, O. & Dubaseniuk, O. (2009). *Tsilovi oriientyry rozvytku osobystosti u systemi osvity: intehratyvnyi pidkhid [Target Guidelines for Personality Development in the Education System: An Integrative Approach]*. Vyd-vo ZhDU im. I. Franka. <http://eprints.zu.edu.ua/id/eprint/5031>

Vozniuk, O. V. (2012). *Pedahohichna synerhetyka: henezha, teoriia i praktyka [Pedagogical Synergetics: Genesis, Theory, and Practice]*. Vyd-vo ZhDU imeni Ivana Franka.

Yurzhenko, V. V. (2012). Porivnialni kharakterystyky fraktalnoi psykhologii i heshtaltpsykhologii ta mozhlyvosti yikh realizatsii v suchasni pedahohichni nauki (na prykladi osvitnoi haluzi «Tekhnolohiia») [Comparative characteristics of fractal psychology and gestalt psychology and the possibilities of their implementation in modern pedagogical science (based on the example of the educational field "Technology")]. *Zbirnyk naukovykh prats Umanskoho derzhavnogo pedahohichnoho universytetu imeni Pavla Tychyiny – Collection of Scientific Papers of Uman State Pedagogical University*, 2, 335–340. http://nbuv.gov.ua/UJRN/znpu2012_2_48 [in Ukrainian].

Yurzhenko, V. V. (2014). Synerhetychnist osvitnikh system ta fraktalnist yikh strukturuvannia: praktyka realizatsii pidkhodiv u osvitni haluzi «Tekhnolohiia» [Synergetics educational systems and their fractal structuring: practical implementation approaches in the educational branch "Technology"]. *Visnyk Chernihivskoho natsionalnoho pedahohichnoho universytetu. Seriiia: Pedahohichni nauky – Chernihiv National Pedagogical University Bulletin. Series: Pedagogical Sciences*, 120, 215–218. http://nbuv.gov.ua/UJRN/VchdpuP_2014_120_65 [in Ukrainian].