IMPLEMENTATION OF INTERDISCIPLINARY CONNECTIONS
IN THE PROCESS OF PROFESSIONAL TRAINING OF STUDENTS

Natalia Bosko,
Postgraduate Student at the Department of Informatics and Applied Mathematics,
Kryvyi Rih State Pedagogical University,
Lecturer, Kryvyi Rih Professional College of Trade and Hotel and Restaurant Business
(Kryvyi Rih, Dnipropetrovsk region, Ukraine)
ORCID ID: 0000-0002-2828-1954
averyanovanm@gmail.com

Abstract. Interdisciplinary connections (interdisciplinarity) is a universal concept used by teachers of all specialties. The article presents a study of the essence of the concept of "interdisciplinary connections", which we consider as a means of combining theoretical foundations and/or practical methods and techniques of various disciplines, with the aim of improving the quality of the educational process and their effective further use by students in the process of future professional activity.

The specified term, as opposed to the term "integration", must be used during the teaching of basic disciplines in the educational program of specialized secondary education, which include natural sciences. They are involved in the process of forming the professional competence of college students, through the use of the STEM approach to education. Its implementation in the process of training students of higher and professional pre-higher education during the period of martial law prepares them for future professional activity and labour protection in this field. It was also determined that issues needed to understand information about the war situation and ensuring a safe existence during the war, sustainable development of society, the role of modern assets in the field of science and technology, and providing equal access to employment in the STEM field require additional involvement.

Key words: interdisciplinarity, interdisciplinary connections, STEM.

Introduction. Interdisciplinary connections (interdisciplinarity) is a universal concept used by teachers of all specialties, since there is no academic discipline that is completely separated from others, which can be explained by the integrity of the cognitive process itself and the unity of the systems surrounding a person.

The issue of their implementation is not new, but the change in the paradigm of the education process causes a change in approaches to their implementation, accordingly, the introduction of a competency-based approach to the education process in Ukraine stimulates new searches based on the work of both foreign and Ukrainian scientists who conducted research at the intersection areas of competence and interdisciplinarity, in particular M.R. Bañuls, I.M. Bergom, K. Bollard, S.G. Clark, A.M. Claus, J.M. Harbor, J.T. Klein, D.B. Knight, L.R. Lattuca, B.J. Novoselichd, J. Parker, G. Song, T. Stone, I.M.G. Trigueros, R.L. Wallace, Z. Wang, B.S. Wiese, S.U. Honcharenko, I.V. Kovalenko, S.P. Kozhushko, V.V. Kozlov, I.A. Kolodiy, A.M. Kolot, M.I. Kuznetsov, T.S. Mazepa, I.V. Milash, O.M. Muzalyov, V.G. Omelyanenko, O.A. Priyatelchuk, L.P. Semko, V.D. Syrotyuk, S.M. Stadnichenko, L.A. Teryaeva, T.V. Tomashevska, N.M. Chernenko, E.B. Shcherbina and others. Despite the fact that this issue is being actively developed, both by theorists and practitioners, the debate about the terminology used, the choice of technology for the implementation of interdisciplinary connections, etc., does not subside.

The purpose of the work is to consider theoretical and practical approaches to the process of implementing interdisciplinary connections in the process of professional training of students.

The tasks of this study are:

1) To consider the concept of "interdisciplinary connections" and interdisciplinarity.

2) To substantiate the directions of implementation of interdisciplinary connections in the process of studying natural sciences by professional junior bachelors during the period of martial law.

Materials and methods. In the process of research, such general methods as analysis, synthesis, comparison, generalization were used. In the process of studying the practical experience of natural science teachers, such experimental methods as observation and comparison were used.

The results and discussion. It should be noted that there are differences in terminology in the scientific and methodological literature related to the issues of research, in particular, ambiguous terms such as "interdisciplinary" and "interdisciplinary connections", "integration" and others are used.

Let's consider them in more detail.

To begin with, let's pay attention to the fact that, according to the results of a preliminary analysis of literary sources, researchers from the European Union, Canada, the USA, and Australia use the adjective "interdisciplinary", which describes the interaction between two or more different disciplines, from the exchange of ideas to the mutual association of concepts, procedures, methodology, data, organization of research and training (Berger, 1972). Educators use it to describe the process or quality of education. In this sense, the noun "interdisciplinarity" is used to indicate the cause or its result of the educational process (Peterson, 2008, p. 43). Scientists of Ukraine and near abroad use the more detailed term "interdisciplinary connections" to indicate the need to involve knowledge and methods from other disciplines in the education process. In particular, S. U. Goncharenko defines interdisciplinary connections as "mutual coordination of educational programs determined by the system of sciences and the didactic goal" (Goncharenko, 1997, p. 210). He emphasizes that the result of their implementation is specific knowledge of the students and their involvement in operating with general scientific cognitive methods (abstraction, modeling, analogy, generalization, etc.). A similar opinion is observed in the dictionary-handbook of professional pedagogy edited by A.V. Semenova, where they are presented as logical connections between educational disciplines, which help to use one's own knowledge in the process of their education to form a holistic view of natural phenomena (Semenova, 2006). V.V. Kozlov and others call interdisciplinary connections a means of resolving the contradictions existing in the education process between the separate assimilation of knowledge of educational disciplines, their further synthesis and application during practical training and in professional activities (Kozlov et al., 2018). Therefore, interdisciplinary connections are a means of combining theoretical bases and/or practical methods and techniques of various disciplines, with the aim of improving the quality of the educational process and their effective further use by students in the process of future professional activity.

Next to the term "interdisciplinary connections" the concept of "integration" is used. In a general sense, it means the combination of disparate things, events or processes in order to improve their full or partial understanding (Clark&Wallace, 2015). The field of integration is broader than interdisciplinarity and interdisciplinary connections. This term is used to refer to activities aimed at overcoming differences between the process of disciplinary and professional training (Klein, 2005). It is implemented by identifying interdisciplinary connections and defining relevant tasks, distinguishing between horizontal (between different disciplines) and vertical (within the study of a discipline according to a spiral curriculum) integration (Costa et al., 2018; Humenna, 2019). In our opinion, the term "integration" should be used when studying professional disciplines, specialized subjects and special courses. And when studying basic disciplines under the educational program of specialized secondary education, which include natural sciences, it is appropriate to use the term "interdisciplinary connections", as only elements are added that combine them with future professional activities and within the framework of topics provided by the recommendations of the Ministry of Education and Science of Ukraine.

Let's consider the role of participants in the process of forming interdisciplinary connections.

It is common knowledge that only trained teachers can exert an organized pedagogical influence on students. In the process of mixed and distance learning, the introduction of competence-based learning, the ideas of NUSH, the role of teachers has changed. They have turned into facilitators and moderators (Sofii et al., 2018, p. 81), which by establishing successful communication between learners, focused on the formation of competence, which manifests itself in the process of their practical activity. Accordingly, the process of forming interdisciplinary connections is considered in three aspects (Tverezovska & Sydorko, 2012):

1) general pedagogical, which sees intersubject connections as a condition and means of forming interdisciplinary, general and professional competences;

2) psychological – generalization of the process of formation of interdisciplinary knowledge, skills and attitudes that form the basis of interdisciplinary competence;

3) methodological aspects, which consider them as a condition and a means of modifying educational technologies used in the educational process.

According to this approach, students are subjects in the broadest sense of the word. We will remind you that "a subject is a person, an organized group of persons, a social, ethnic and political community, society as a whole, carrying out their own activities aimed at the practical transformation of objective reality, the theoretical and spiritual-practical development of objective reality" (Shinkaruk et al., 2002: 613). From the point of view of philosophy, the students, as subjects of implementation of interdisciplinary connections, should possess such features as:

1) objectivity, which consists in the fact that students form interdisciplinary competence only in the process of multidimensional contextualized activity;

2) the consciousness that guides students in an interdisciplinary environment, determines the purpose of their implementation;

3) student activity, which on the one hand stimulates their activity, and on the other – encourages the teacher;

4) the will, which is an integral part of the process of training the students.

Therefore, in the process of implementing interdisciplinary connections, teachers, being in the role of facilitators and moderators, should stimulate the acquisition by students of such traits as objectivity, consciousness, activity and will. On the one hand, this is a condition for the success of this process, and on the other hand, it is one of the results of the implementation of interdisciplinarity.

In the stereotypical sense, interdisciplinarity is perceived as a process of knowledge transfer, but it is not limited to them, the teacher must use interdisciplinary methods, which allows to classify interdisciplinary connections into (Bugerya, 2009):

1) interdisciplinary connections that explore a common object;

2) manipulate one theory or law;

3) use the same research method or technique;

4) apply a joint approach to activities in the educational process.

The specified classification removes the priority of knowledge and orients the teacher in the process of implementing interdisciplinary connections, through the use of interdisciplinary methods, to the formation of competence, which is a requirement of the modern educational process.

When designing the process of implementing interdisciplinary
connections, it is necessary (Man-Ho Lam, 2022):

1) to formulate clear and precise main educational goals based on the principle of purposefulness;

2) to consider the specific positioning of the curriculum in the middle of the educational institution, taking into account cross-cutting content lines and the future professional activity of the students;

3) adhering to the principle of continuity, interdisciplinary connections should be coordinated with professional disciplines;

4) to coordinate them with the general learning outcomes and age characteristics of the students;

5) to develop a consistent and integrated structural design, each inclusion of interdisciplinarity should be thought out;

6) predict further interdisciplinary initiatives in which the student may be involved in the future.

Therefore, in the process of implementing interdisciplinary connections, the teacher must conduct preparatory work, which consists in formulating his clear and precise goals, studying the purpose of the educational discipline and its connection with professional ones. It requires a coherent and integrated design that involves the use of interdisciplinary methods.

While studying at the college, students study basic disciplines, the teachers of which must implement interdisciplinary connections with professional ones. This requires choosing a pedagogical technology that would be effective. In order to solve this problem, we conducted oral interviews with teachers of natural sciences at the Kryvyi Rih Applied College of Trade and Hotel and Restaurant Business, studied the experience presented by them during pedagogical and methodical meetings, the work of the advisory and training club "Pedagog", which operates in an educational institution, during regional meetings of teachers of natural sciences, during participation in scientific and practical conferences and studied practical tools presented in scientific and methodological sources. The results of the study demonstrate that STEM is one of the approaches to the process of implementing interdisciplinary connections that teachers consider effective and actively implement in the process of educational activity. It is well known that the acronym "STEM" stands for "Science (Natural Sciences), Technology, Engineering and Mathematics". It is used to refer to educational or research activities aimed at solving real-world problems that are known to be at the boundaries of disciplines (Wang et al., 2011).

One of the alternatives to STEM is STEAM education, which is essentially STEM, but supplemented with elements of art and creativity (Perignat&Katz-Buonincontro, 2019). We compared the number of unfiltered samples of actual searches for the keywords STEM and STEAM education (in their English version) on Google using the Google Trends service. It should be clarified that only the search terms "STEM-education" and "STEAM-education" can be equally compared, since the static data will be distorted by queries related to the STEAM game of the same name. According to the results of the analysis, the number of requests related to STEM significantly exceeds the number of requests related to STEAM education, both among Ukrainian users (see Fig. 1) and worldwide (see Fig. 2). It should be noted that the number of requests is not a qualitative characteristic, it only characterizes interest, therefore the sample is only the result of a preliminary analysis and requires more serious theoretical research, however, in addition to the above, STEM can be given priority.
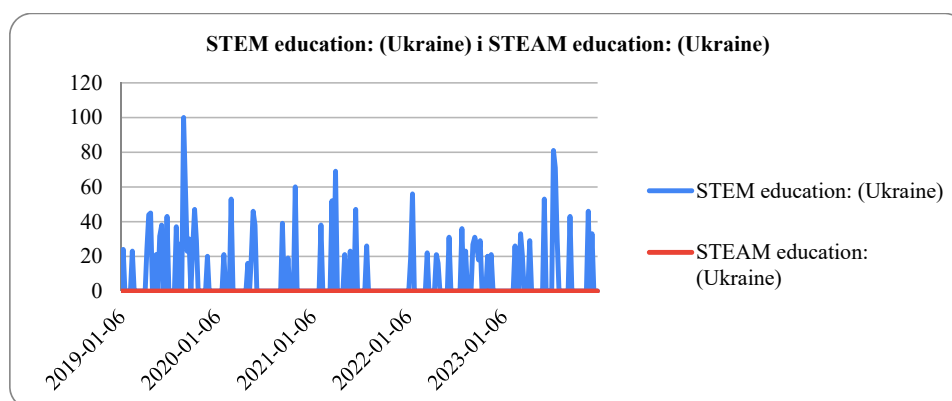
Fig. 1. The results of comparing the number of requests for the keywords "STEM education: (Ukraine)" and "STEAM education: (Ukraine)" using the Google Trends service (request from 01.06.2024)
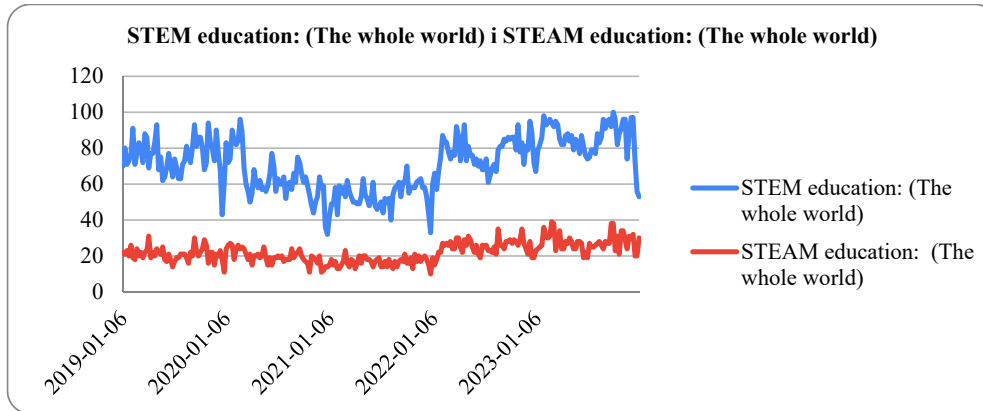
Fig. 2. The results of comparing the number of requests for the keywords "STEM education: (The whole world)" and "STEAM education: (The whole world)" using the Google Trends service (request from 01.06.2024)

Since the process of training professional junior bachelors is also aimed at solving real problems that arise or may arise for students during their future professional activities, STEM education becomes a means of forming and developing their professional competence. The importance of STEM education for future professional self-realization is emphasized by N.I. Polihun et al., who in a broad sense define it as a "pedagogical technology for the formation and development of mental, cognitive and creative qualities of students, the level of which determines the competitiveness of an individual in the modern labor market" (Polihun et al., 2019: 6). N.O. Goncharova understands STEM education as a series or sequence of courses or training programs that require the formation of complex technical skills, in particular the application of mathematical knowledge and scientific concepts, which prepare students for successful employment, further education, or both (Goncharova, 2018).

The end result of the pedagogical influence of science teachers is a competent learner in a field that combines natural sciences, engineering, technology, and mathematics. Such a student, according to UNESCO's definition, must possess "knowledge – what" (knowledge, attitudes and values related to disciplines) and "know-how" (skills to apply knowledge taking into account ethical attitudes and values necessary in the process of professional activity) (White, 2014).

The Global STEM Alliance (GSA) Core STEM Education Curriculum presents the core and supporting STEM competencies needed to thrive in today's workplace. In addition to content knowledge, core competencies include critical thinking, problem solving, creativity, communication, collaboration, data literacy, and digital literacy. Supporting attributes, those that contribute to self-development and improvement are STEM mentality, perseverance, freedom of will, social and cultural awareness, leadership, ethical attitude (Childress et al., 2016).

From the above, it can be concluded that STEM competence and related competencies are not formed spontaneously. Purposeful activity of science teachers is necessary. They can realize the full potential of STEM through the use of training courses focused on the future professional self-realization of the students.

To design a system for implementing interdisciplinary connections in the process of STEM education at the Kryvyi Rih Applied College of Trade and Hotel and Restaurant Business, the system approach ADDIE (Analysis, Design, Development, Implementation, Evaluation) was used, which is oriented to the needs of students (González&Quiroz, 2019) of the specialties "Food technologies", "Hotel and restaurant business", "Accounting and taxation", "Entrepreneurship and trade". Due to the restrictions associated with the emergence and further spread of the coronavirus infection (COVID-19), the introduction of martial law in Ukraine, most types of educational activities

were planned and conducted in an online format, and some, if possible, were conducted face-to-face in safe conditions.

Using the above-mentioned theoretical principles of implementation of interdisciplinary relations with the help of STEM, the following stages were covered:

1. Analysis – preliminary needs of students were established, educational goals were determined, taking into account their professional orientation and additional needs for successful self-realization in the modern world. Since training is carried out in 5 specialties at the the Kryvyi Rih Applied College of Trade and Hotel and Restaurant Business, at this stage, teachers of special disciplines and masters of industrial training, a practical psychologist, etc. were involved.

2. Design – based on the data of the previous stage, educational materials for students containing STEM elements were created.

3. Development – courses are placed on the lCloud platform, extracurricular work is planned.

4. Implementation – continuous access to work with online courses was provided, extracurricular activities were held.

5. Evaluation – evaluation of the quality and effectiveness of the educational process was carried out, student feedback was analyzed.

We try to increase the effects of STEM implementation by using various non-standard forms of classroom and extracurricular work, project activities, relying on practice, flipped learning technology, providing support to students with the help of social networks, using online services and making.

The process of introducing interdisciplinary connections is cyclical. Educational and teaching-methodical materials created as a result of designing a course based on the ADDIE model require constant updating and modification, changing forms and additional subtopics that reveal the potential of STEM.

Let's consider the areas of renewal of STEM education related to martial law.

For the past 5 years, at the forefront of the process of learning STEM disciplines, the main issues were related to natural sciences, technologies, engineering and the future professional activities of students, labor protection in the industry, traditional additional topics that are considered are:

– Life safety;

– Sustainable development;

– Modern development of science and technology;

– Gender equality.

The introduction of martial law in Ukraine made adjustments to the educational process as a whole. They were reflected in the process of implementing interdisciplinary connections. According to the results of our observations, surveys and questionnaires of students, topics related to the academic discipline "Defense of Ukraine" needed additional involvement. The elements related to it are reflected in the courses of natural sciences.

Thus, the main motive for the introduction of interdisciplinary connections by means of STEM in the process of training students of higher and professional pre-higher education in the period of martial law remains their future professional activity and labor protection in this field. The issue of the functioning of military equipment (air defense, missiles, weapons, etc.), which is necessary for understanding information about the military situation, ensuring a safe existence during the war (disciplines "Defense of Ukraine", "Safety of life" and others), sustainable development, the role of modern assets in the field of science and technology and ensuring equal access to employment in the field of STEM requires additional involvement.

The discussion. Some statements presented in the study require additional consideration. In particular, it should be clarified that the process of implementing interdisciplinary connections does not detract the importance of interdisciplinarity, but on the contrary, "interdisciplinarity welcomes disciplinarity, it requires a strong disciplinary foundation" (Clark&Wallace, 2015: 10). Disciplinary knowledge, methods and approaches become the tools used.

Another debatable issue is the issue of choosing an approach to the implementation of interdisciplinary connections. In the study, we favored STEM over STEAM, but the study of their advantages and disadvantages is still ongoing. In particular, a detailed development, evaluation of competence and competencies formed for each of the approaches is necessary.

The choice of additional topics to be covered is also subject to discussion. They demonstrate our subjective vision of students' needs, formed on the basis of previous research and pedagogical experience. It is quite clear that they are not universal for students of educational institutions with a different specialization, a different age category. Their list will be completely different.

Conclusions. Interdisciplinary connections are a means of combining theoretical foundations and/or practical methods and techniques of various disciplines in order to improve the quality of the educational process and their effective further use by students in the process of future professional activity. In the process of their implementation, teachers, in the role of facilitators and moderators, should stimulate the students of such traits as objectivity, consciousness, activity and will, which, on the one hand, is a condition for the success of this process, and on the other hand- one of the results of the implementation of interdisciplinarity. During the preparatory stage, the teacher must formulate clear and precise goals of the given process; study the purpose of the educational discipline and its connection with professional ones. The process of applying interdisciplinary connections requires a consistent and integrated design that involves the using of interdisciplinary methods.

One of the means of implementing interdisciplinary connections in the process of science education of students of institutions of professional preliminary higher education is the STEM approach to education. The main motive for its introduction into the process of training students of higher and professional pre-higher education in the period of martial law is their preparation for future professional activity and labor protection in this field. Additional engagement is needed for issues related to understanding information about the war situation, ensuring a safe existence in times of war, sustainable development of society, the role of modern assets in the field of science and technology, and ensuring equal access to employment in the field of STEM.

References:
1. Clark, S. G., & Wallace, R. L. (2015). Integration and interdisciplinarity: Concepts, frameworks, and education. *Policy Sciences*, *48*(2), 233–255. https://doi.org/10.1007/s11077-015-9210-4
2. Kozlov, V. V., Tomashevska, T. V., & Kuznietsov, M. I. (2018). Use of interdisciplinary links in the training of future specialists in statistics. *Statistics of Ukraine*, *80*(1), 52–60. https://doi.org/10.31767/su.1(80).2018.01.07 [in Ukrainian].
3. Semenova, A. V. (Ed.). (2006). *Dictionary – handbook of professional pedagogy: dictionary-handbook.* Palmira. https://www.pedagogic-master.com.ua/public/semenova/slovnik.pdf (in Ukrainian).
4. Peterson, V. (2008). Against interdisciplinarity. *Women and Language*, *31*(2), 42–50.
5. Berger, G. (1972). Introduction. У *Interdisciplinarity: Problems of teaching and research in universities* (c. 21–24). Organisation for Economic Cooperation and Development.
6. Honcharenko, S. U. (Ed.). (1997). Ukrainian pedagogical dictionary. Lybid. https://lib.iitta.gov.ua/106820/1/%D0%93%D0%BE%D0%D%D1%87%D0%B0%D1%80%D0%B5%D0%BD%D0%BA%D0%BE%200%9F%D0%B5%D0%B4%D0%B0%D0%B3%D0%BE%D0%B3%D1%96%D1%87%D0%BD%D0%B8%D0%B9%20%D1%81%D0%BB%D0%BE%D0%B2%D0%BD%D0%B8%D0%BA%20%281%29.pdf (in Ukrainian).
7. Klein, J. T. (2005). Integrative learning and interdisciplinary studies. *Peer Rev.*, (7 (4)), 8–10.
8. Humenna, N. V. (2019). Interdisciplinary integration in the professional training of medical industry professionals. *Innovate Pedagogy*, *18*(1), 121–126. https://doi.org/10.32843/2663-6085-2019-18-1-26 [in Ukrainian].

9. Costa, A. R., Ferreira, M., Barata, A., Viterbo, C., Rodrigues, J. S., & Magalhães, J. (2018). Impact of interdisciplinary learning on the development of engineering students' skills. *European Journal of Engineering Education*, *44*(4), 589–601. https://doi.org/10.1080/03043797.2018.1523135

10. Shynkaruk, V., Bystrytskyi, Ye., Bulatov, M., Ishmuratov, A., Yolon, P., Kovadlo, H., Kolodnyi, A., Krymskyi, S., Lukianets, V., Liakh, V., Malakhov, V., Mokliak, M., Ozadovska, L., Polishchuk, N., Proleiev, S., Stratii, Ya., Tabachkovskyi, V., & Khamitov, N. (Ed..). (2002). *Philosophical encyclopedic dictionary: dictionary.* Abrys. https://shron1.chtyvo.org.ua/Shynkaruk_Volodymyr/Filosofskyi_entsyklopedychnyi_slovnyk.pdf [in Ukrainian].

11. Tverezovska, N. T., & Sydorko, V. P. (2012). Modern approaches to defining the essence of the concept of "interdisciplinary connections". *Educational dimension,* 34, 315–320. https://doi.org/10.31812/educdim.v34i0.3615 [in Ukrainian].

12. Sofii, N. Z., Onopriienko, O. V., Prystinska, M. S., & Bolshakova, I. O. (2018). *New Ukrainian school: a teacher's guide* (N. M. Bibik, Ed.). Litera LTD. https://mon.gov.ua/storage/app/media/news/Novyny/2018/12/12/11/20-11-2018rekviz.pdf [in Ukrainian].

13. Buheria, T. M. (2009). The essence of interdisciplinary connections in the process of learning professionally oriented disciplines in the professional training of future physical rehabilitators. *Scientific works [of the Petro Mohyla Black Sea National University of the complex "Kyiv-Mohyla Academy"]. Ser. : Pedagogy.*112(99), 166–172. https://lib.chmnu.edu.ua/pdf/naukpraci/pedagogika/2009/112-99-32.pdf [in Ukrainian].

14. Lam Man-Ho, A. (2022). Making sense of interdisciplinary general education curriculum design: case study of common core curriculum at the university of hong kong. *ECNU review of education*, *6*(3), 410–432. https://doi.org/10.1177/20965311221142888

15. Wang, H.-H., Moore, T. J., Roehrig, G. H., & Park, M. S. (2011). STEM integration: Teacher perceptions and practice. *Journal of Pre-College Engineering Education Research*, *1:2*, 1–13. https://doi.org/10.5703/1288284314636

16. Perignat, E., & Katz-Buonincontro, J. (2019). STEAM in practice and research: An integrative literature review. *Thinking Skills and Creativity*, *31*, 31–43. https://doi.org/10.1016/j.tsc.2018.10.002

17. N. I. Polikhun, K. H. Postova, I. A. Slipukhina, H. V. Onopchenko, & O. V. Onopchenko. (2019). *Introduction of STEM education in conditions of integration of formal and informal education of gifted students: methodological recommendations*. Institute of the Gifted Child of the National Academy of Sciences of Ukraine. https://core.ac.uk/download/pdf/286032301.pdf [in Ukrainian].

18. Honcharova, N. (2018). *Glossary of STEM education terms. An information collection for the school director and the head of the kindergarten*, (10 (79)), 89–95. https://imzo.gov.ua/stem-osvita/glosariy/ [in Ukrainian].

19. White, D. W. (2014). What is STEM education and why is it important? *Florida Association of Teacher Educators Journal*, *1*(14), 1–9. http://www.fate1.org/journals/2014/white.pdf

20. Childress, J., Culp, K., DeBarger, A., Easton, J., Griffin, P., & Hurley, K. (Compiler). (2016). *STEM education framework*. The New York Academy of Sciences. https://www.nyas.org/media/13051/gsa_stem_education_framework_dec2016.pdf