Analysis and Prospects of the Future Teachers Training of the Integrated Course "Natural Sciences"

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Abstract: The analysis of four curricula of teachers training of natural sciences in higher education institutions is presented in the paper. The question of curricula developing for pre-service teachers of natural sciences and introducing integrated courses in biology, physics and chemistry studying and conducting a new specialization in the educational branch "Secondary Education" should be studied. We analyzed the characteristics and the current state of curricula implementation into the educational process. The analysis of the normative framework regulated the teacher's activity is also made. In the framework of the components of teacher's professional activity there is considered terms of qualification characteristics. The considered professional standards and qualification characteristics made it possible to conclude the curricula correspond to the normative documents and modern requirements for the professional teacher's activity. The analysis of four curricula by sections is carried out. It made possible to compare the list of their components and the logical sequence of courses and to determine their common and distinctive features. The existence of the integrative component of each curriculum and its conformity to the formation of the professional competences of future teachers was established. The use of problem-oriented learning technology can form the subject competence, formulated in accordance with the basic subjects: physics, chemistry, biology, natural science. Subject competence in science is an integrative part of the course. They are based on the formation of the integrity of representations of nature, the use of science and information on the basis of operation of the basic general laws of nature. The classification of integrated courses is made on the basis of the nature of the relationships between disciplines and the integration degree. The existence of integrative components in the list of the educational-professional/scientific program and their conformity with the classification of the integration of courses is established. We also defined the disciplines of influence on the formation of integrative competences of pre-service teachers of integrated courses of natural sciences.

1 INTRODUCTION

Since 2010, specialized training has been introduced in the senior grades of general educational institutions, according to which students of humanitarian classes study more than 20 individual subjects, including low-hour natural subjects (physics – 2 hours per week, chemistry – 1 hour, biology – 1.5 hours, and geography 1.5 hours). It led to the memorization of a large amount of information that the students did not need in the future.

In accordance with the order of the Ministry of Education and Science of Ukraine, from the 2016/2017 academic year, a new specialty "Secondary education (natural sciences)" has been added to the list of specialties "Secondary education". It is allowed to train applicants for higher education in providing for the second specialty (subject specialty) "... including those that provide the teaching of integrated courses defined by the institution of higher education" (MON, 2016a). The educational program states its peculiarity is "... integrative training for the performance of functional duties of subject teachers: biology teacher, chemistry teacher, physics teacher and teacher of the integrated academic subject "Natural Sciences", class teachers in secondary educational institutions, organizers circles of natural direction in institutions of additional education; formation of readiness for self-education and professional self-improvement throughout life". Students got a bach-

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elor's or master's degree and they have possibility to get the professional qualification/subject specialty of a teacher of natural sciences, physics, chemistry, biology.

Since 2018, an experimental program of teaching students in 10th – 11th grades in the integrated course "Natural Sciences" has begun in one hundred educational institutions of Ukraine (MON, 2019; Nechypurenko et al., 2021). The explanatory note of the course says that "the course is designed only for students who do not study in natural and mathematical profiles, and for whom natural subjects are not decisive for choosing a future profession". The authors define the main goal of the integrated course "... the formation of the natural science worldview of students, providing them with general education in the natural sciences, mastering the methods of scientific knowledge to explain physical, chemical, geophysical, biological, ecological and other natural phenomena; solutions to applied problems that are encountered in the students' life of and their families, in society and in the life of humanity as a whole. These are mainly situations related to health and disease, the natural resources use, the state of the environment, the impact of science and technology".

At present, the four experimental programs for studying the course "Natural Sciences" at school have been developed. These programs integrate topics from the natural sciences, biology, ecology, astronomy, physics, chemistry, and geography into integrated classes and projects. The analysis of the programs and corresponding textbooks showed that the authors suggest the scientific worldview formation in schoolchildren, ideas about the world's natural-scientific picture, the development of scientific thinking.

Such changes in legislation and education require the training of new qualified personnel who are able to conduct educational activities in accordance with the approved study programs of the integrated course "Natural Sciences" and have a high level of STEM culture, to ensure the modernization of these programs throughout the teacher's professional activity in the context of constant development technologies and the impact on society.

One of the sources of integrated learning can be considered the introduction of interdisciplinary connections, which began to be investigated back in the 1960-1970s as a means of educational knowledge enhancing, the assimilation of scientific concepts, patterns by students (Anan'ev, 1966; Esipov, 1964; Sukhomlinskiy, 1959). Study of the general foundations of didactics in the 1970-1980s, which were engaged in (Danilov, 1974; Lerner, 1964; Skatkin and Kraevsky, 1978) intensified the problems of the school education content improving, the development of cognitive activity and the independence of schoolchildren. The innovation was the concentrism reduction, the integrated subjects and courses introduction, the allocation of intra-subject and inter-subject connections. The integration of the main types of children cognitive activity is widely used in our time in various options for organizing integrated classes at different levels of education from preschool to higher education. The researches (Arnold, 2010; Bannan-Ritland, 2003; Booth, 2011; Booth et al., 2009; Bretz Jr. and Thompsett, 1992; Cambridge, 2008; Dean et al., 2020; Durrant and Hartman, 2015; Eysenck, 1963; Ferrett et al., 2013; Froyd et al., 2007; Galvin, 2006; Gross and Pinkwart, 2015; Gupta and Boyd, 2011; Hinchliffe and Wong, 2010; Kutt et al., 2019; Lowenstein, 2015; Mang et al., 2017; McLoughlin and Thoms, 2015; Park, 2019; Shetty et al., 2001; Walshe et al., 2013; Woodside, 2018) are discussed the issues.

Analyzing scientific and methodological publications, we can conclude the main research areas are related to the development of the individual courses and the integration of the content of various academic subjects. The following issues are also considered: compliance with state standards, an activity approach and project-based training in integrated courses, course content development, competence-based approach. However, the question of the educational programs formation for the future teachers training, teaching the integrated course "Natural Sciences" is not fully covered.

The *aim* of the study is to analyze the educational programs of the specialty "Secondary education (natural sciences)" for preparing teachers for conducting integrated courses at universities.

2 RESULTS

The gradual introduction of STEM education, according to (IMZO, 2021), requires the creation of practice-oriented teaching methods, curricula within the disciplines of training courses. Such methods and programs at the bachelor's and master's level are already being introduced in some higher education institutions (Valko et al., 2020; Morze et al., 2018; Semerikov et al., 2021). In 2019, nine higher educational institutions are training future teachers of integrated disciplines according to curricula "Secondary education (natural sciences)". Such curricula are developed by teams of authors specializing in various scientific fields. For example, at developing of a

specialty program “Secondary education (natural sciences)” at the Ternopil Volodymyr Hnatiuk National Pedagogical University (TNPU), a team from the departments of general biology and methods of teaching natural disciplines, chemistry and teaching methods, physics and methods of teaching it, geography and teaching methods worked. At Mukachevo State University (MSU), representatives of the departments of mechanical engineering, natural sciences and information technology, theory and methods of primary education, tourism and recreation took part in the creation of the program. A team of specialists from the departments of technological and vocational education and general technical disciplines, social work, social pedagogy and culture, general pedagogy, preschool, primary and special education worked on the creation of the program at the Izmail State Humanitarian University (ISHU). At the Poltava V. G. Korolenko National Pedagogical University (PNPU), the program was created by the departments of botany, ecology and teaching methods of biology, chemistry and teaching methods of chemistry, geography and teaching methods, general physicist and mathematics.

In accordance with the requirements of the “Guidelines for the description of the educational program in the context of new standards of higher education” (MON, 2016b), educational programs have a certain structure. It makes possible to compare them and identify common and distinctive features.

Each of the programs provides the formation of integrative competencies, which provide an understanding of the knowledge of the future teacher and his capabilities after successful completion of training. Comparison of these competencies with the requirements for a teacher, according to the above regulatory documents, showed that they fully comply with the established educational standards (Kramarenko and Nochvinova, 2019). The educational program and curricula determine the nature of the relationship between disciplines and the integration degree. There are the following types of integrative courses (Meeth, 1978):

1. *Integration based on one discipline* – focusing on each discipline provides students with specialized skills and concepts in the field. Specialized training provides teachers and students with an in-depth knowledge of the field. At the same time, such a study can lead to information fragmentation and does not reflect the completeness of scientific research. There is a lack of knowledge about the relationship between different subjects. This type is possible for theoretical courses, as a basis for further study of scientific concepts and the formation of an understanding of the directions of scientific research in certain industries.
2. *Study of parallel courses / modules* – in this case, the content of each subject does not change. Thus, the effect is achieved when students can independently or with the help of a teacher to establish connections between individual phenomena. The only drawback is that students do not see the collaboration between teachers. In addition, such work requires sufficient planning time.
3. *Additional courses or disciplines* – the comparison of several disciplines focused on one problem, without a direct attempt at integration.
4. *Integrated courses / modules* – are short-term project activities. Selected activities built on the interaction between different subjects. Efforts are aimed at solving socially important issues.
5. *Integrated days* – long-term projects, primarily on topics and problems arising from their own experience.
6. *Complete program* – fully integrated programs in which the daily learning of students is linked to their lives. An example is the summer science camp.

The curricula provides theoretical and practical training aimed at mastering the basics of fundamental knowledge in basic (compulsory) disciplines and optional disciplines, during which general and professional competencies are formed. The analysis of the curricula made it possible to classify some of the disciplines as those that provide subject competencies in the following areas (Valko, 2019):

- *scientific* (S) – disciplines form the scientific picture of the world, provide the ability to identify, analyze scientific models, apply theories. Basic disciplines such as chemistry, biology, basic scientific research, and the like were included in this category;
- *technological* (T) – disciplines form the ability to use modern technologies in professional activities and have an idea of their development trends. This category includes disciplines such as programming, information technology, etc.;
- *engineering* (E) – disciplines form competencies in the design and modeling of objects using modern technologies. This category included such disciplines as the demonstration experiment, the basics of electronics;
- *mathematical* (M) – basic disciplines introduce mathematical models and methods for describing objects and processes. Disciplines in this area, for

example, mathematical analysis, higher algebra, probability theory.

The ratio of the number of credits between the directions is shown in figure 1. As you can see, the ratio between the different directions is different, which indicates a difference in educational approaches and scientific profiles of universities.

Since the disciplines of technological, engineering and mathematical blocks for specialization are not basic, then in educational programs the basis is formed by the disciplines of biology, chemistry, geography and physics (figure 1). Within the framework of these disciplines, conducting integrated classes of the first and second types. Conducting other types of classes requires significant preparation and delivery resources. Therefore, their use is possible during periods of educational and pedagogical practice or in disciplines of free choice.

In the curricula of specialties among the disciplines of free choice, there are courses that allow creating an integrated short-term project activity. As can be seen from the presented diagram (figure 1), integrative courses comprise more than twenty academic credits in the block of disciplines (S). Here is a list of such courses:

- Natural-scientific picture of the world
- Concepts of modern natural science
- Simulation of "smart" IoT devices
- STEM education of science teacher
- Trends in energy and resource conservation in the modern world
- Modern information technologies and technical teaching aids
- Modeling and forecasting the state of the environment
- Computer modelling
- Electrical engineering
- Fundamentals of engineering and technology
- Material and technical support of natural sciences
- Statistical methods in natural sciences
- Information technology and technical training aids

These disciplines integrate the knowledge of mathematics and science training. The modern technologies use allows modernizing the approaches to teaching basic disciplines and disciplines of a professional direction. Most of these disciplines belong to the selective block; students are given the opportunity to choose an area of research that is interesting for them. The presence of such disciplines as Computer Modeling, the Internet of Things ensures the construction of the educational process in accordance with the criteria of integration and innovation, since these courses should be at their core. Each of these disciplines is responsible for the process of research, innovation and social development of future professionals, in particular, future science teachers.

On the basis of the conducted researches we made the SWOT-analysis of prospects of preparation of future teachers of the integrated course "Natural sciences" (figure 2).

Increasing attention to the future teachers training to teach integrated courses solves several tasks:

- ensuring the quality of natural sciences and mathematics teaching;
- be aware of innovations and independently build the teaching of the subject using modern technological and engineering knowledge with the help of modern technological means;
- creating conditions for the development of secondary education students' interest in the study of natural and mathematical sciences, technologies;
- involvement of young people in the study of exact sciences and achievements in STEM direction;
- organization of schoolchildren for research and management using innovative technologies;
- preparation of the person for the decision of global questions with application of technological decisions in the course of training and being based on innovations in the field of technologies;
- opportunities to identify trends in the modernization of world technologies and their impact on educational activities;
- dissemination of innovations and knowledge about them in the professional circle and use in everyday life.

To ensure their successful implementation, teachers of natural sciences and mathematics are needed, who themselves would be the bearers of the ideology of these changes, as well as have the necessary competencies in STEM education. Therefore, in accordance with the new educational requirements, the professional training system of natural sciences and mathematics future teachers should change, in particular in terms of their preparation for the use of STEM technologies in future professional activities. A comprehensive solution to these challenges is possible only with a systematic approach to the introduction of STEM technologies in the educational activities of future teachers.

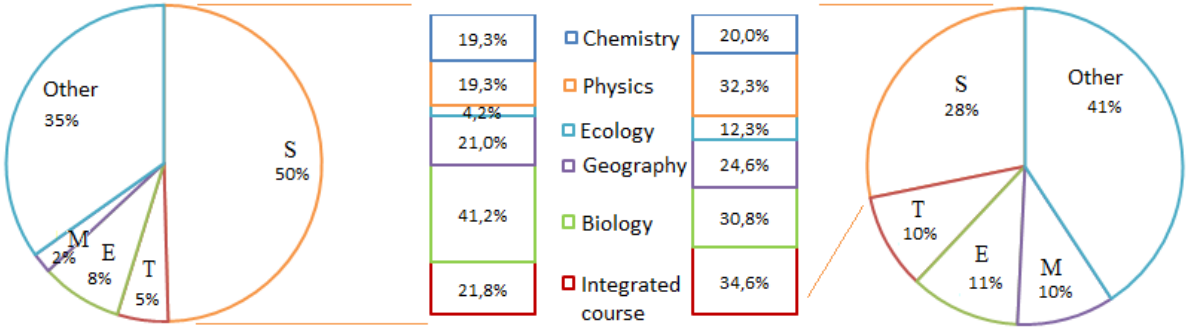

Figure 1: Percentage of subjects of specialization “Natural Sciences” in educational programs.

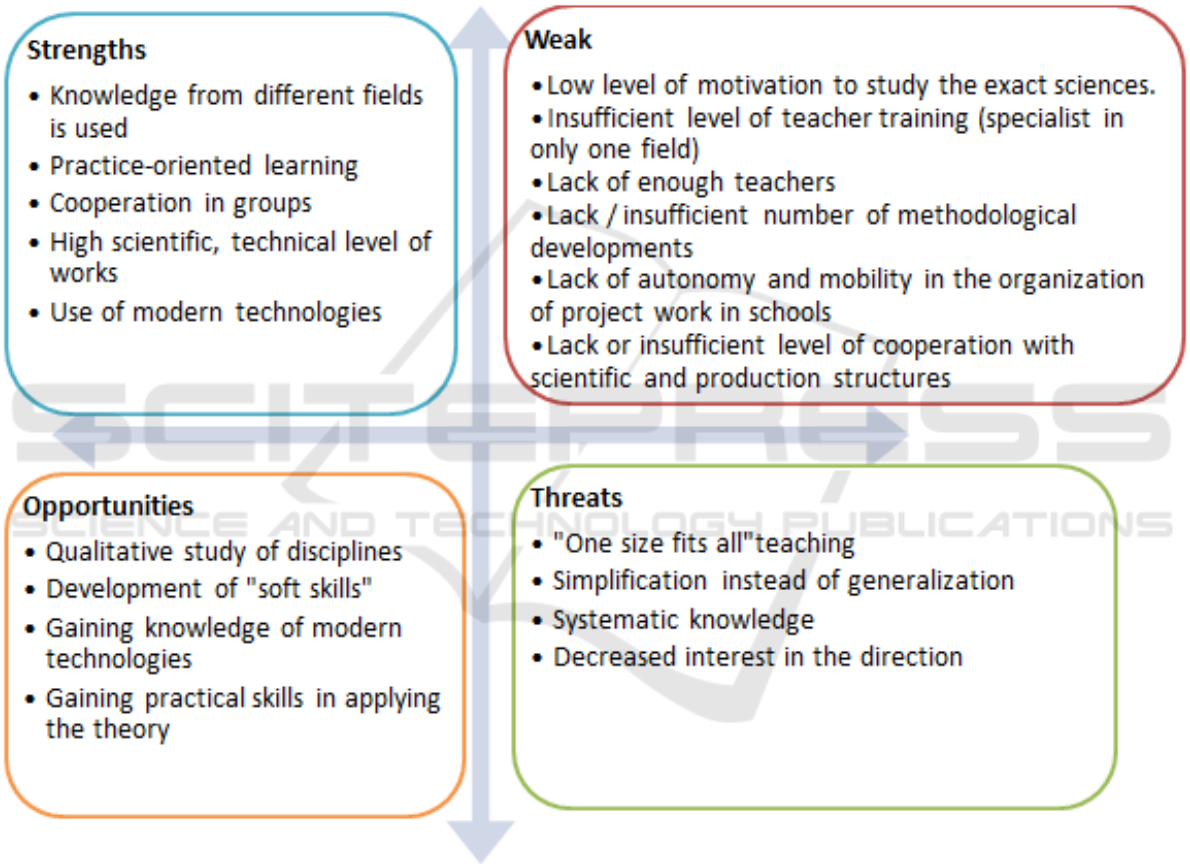

Figure 2: SWOT-analysis of STEM education implementation.

3 CONCLUSIONS

The curricula analysis of specialties of the course Natural Sciences allowed to establish that in educational programs of these specialties integrativity is provided both in the form of separate disciplines, and in a course of disciplines of a methodical cycle. Educational programs partially take into account the scientific and technical level of development of the modern world, creating disciplines of innovative content, such as “STEM teacher education” etc. The SWOT analysis helped to establish that in order to ensure quality future teachers training of integrated courses, it is necessary to focus on creating sufficient resources and infrastructure of the educational institution; ensuring equal access and involvement in integrated learning; training of teachers who will teach integrated courses. The study will further build the curriculum of integrated disciplines with a balanced presentation of materials and taking into account the innovative content.

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