2. НАУКА – ПРАКТИЦІ

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INNOVATIVE SCIENTIFIC EDUCATION PRACTICES OF THE JASU: THEORETICAL FRAMEWORK FOR IDENTIFICATION

Summary.

The article describes results of theoretical research aimed at the identification of innovative scientific education practices of the Junior Academy of Sciences of Ukraine (hereinafter referred to as the JASU) – a specialized science-oriented institution that organizes extracurricular activities for intellectually gifted and talented children in 65 scientific fields. The article aims to substantiate the theoretical framework for identification of innovations used by the institution in the context of scientific education. Both theoretical methods and methods of collecting qualitative empirical data were used in the research. Specifically, this article proposes the definition for the term "educational practices", explains the notion and goals of scientific education, and discusses how the term "scientific education" correlates with the concept of "specialized science-oriented education". The article also describes intrinsic characteristics of scientific education: methodological framework, specifics of content and activities, methods and approaches. It provides insight into innovations in education and discusses their manifestations and ways of identification.

The article also proposes the generalized concept for innovative practices in scientific education. In this article, the modern education trends are systemized and substantiated, according to which most innovations have been established. The author describes the approach to standardization of innovative scientific education practices of the JASU and their presentation in the form of the innovation passports. In this article, the results of identifying innovative scientific education practices of the JASU are presented. In addition to large-scale projects, the research also identified creative ideas and promising developments of teachers, not widely promoted and known at the level of certain territorial branches only. The article described the criteria according to which innovative practices were systemized. The most promising practices in terms of potential for the widespread use will be scientifically tested in further research and implemented in all regions covered by the JASU system.

Keywords: *innovations in education; educational practices; scientific education; innovative scientific education practices; specialized science-oriented education; education trends; innovation passport.*

Under socio-economic transformations taking place in Ukraine, public life is also changing very rapidly, which in turn implies constant and continuous improvement of the education system and its components. Currently, modernization of education and a greater focus on rapid innovative development, which will enable the country to adequately address the pressing challenges, are the key trends in the advancement of education. These processes prompted us to study and reconsider the progressive educational experience of the extracurricular research institution, the Junior Academy of Sciences of Ukraine (JASU), from the perspective of global trends in scientific education and evaluate the significance of national methodological developments for our country and the world. Currently, extracurricular education, which is based not on compulsory education but follows the needs and interests of students and parents, requires rapid reforming and updating. As part of the scientific project, "Methodological Framework for Innovative Scientific Education Practices Used at the Regional Network of the UNESCO Centre, Junior Academy of Sciences of Ukraine (State Registration Number 0120U100087)", the innovative activities by the JASU have been monitored to identify, study and disseminate the innovative teaching practices.

Research Methods. The following online resources were used in the theoretical analysis: websites of the National Center "Junior Academy of Sciences of Ukraine" and its territorial branches, their pages on

social media; digitized publications of the JASU; results of competitions organized by the Ministry of Education and Science of Ukraine (All-Ukrainian Professional Excellence Competition, "Source of Creativity", etc.) The analysis also included speeches by the JASU teacher-innovators presented at round tables, seminars, conferences, and other events. The methods of inductive and deductive analysis, synthesis, comparison, modeling, and classification were used in this analytical research.

The study also included a survey conducted at the territorial branches of the JASU using a mixed questionnaire. In addition, we have also drawn up a template for the passport of innovative scientific education practices, guidelines for the development of such passports, and initiated their collection at the territorial branches of the JASU. The results of this initiative were included in the guidance manual issued by the Institute of Gifted Child of the National Academy of Educational Sciences of Ukraine, "Collection of Innovative Practices of Scientific education by Students of the Junior Academy of Sciences of Ukraine".

The *main objectives* of the article are to substantiate the theoretical framework used for the identification of innovative practices in the educational activities of the institution in the context of scientific education and present identified innovations.

The first research task was to identify which educational practices of the JASU belong to the area of scientific education. Firstly, we needed to answer the following questions: 1) What is meant by "educational practices"? 2) What type of education can be called a scientific education and what is its purpose? 3) How does the term "scientific education" correlate with the concept of "specialized science-oriented education"? 4) What are the intrinsic features of scientific education? Below, we provided answers to these questions.

According to our observations, the term "practice" has been often used recently in professional literature and journalism in association with various fields. In our opinion, this concept may be employed to generalize various forms and types of practical activities, which in some contexts do not require a specific designation. According to scientists, educational practices shall mean:

1) Spatially defined processes of teaching and education, which are structured in terms of time and content. These practices represent a sequence of interrelated activities by the teacher and the pupil, the educator and school or university students. From the standpoint of philosophical and educational anthropology, they are seen as pedagogical connections and relationships that lead to symbolic interactions, i.e. language-mediated interactions due to socio-cultural norms and values, morality, an ideal of social development, etc. [1];

2) Firstly – a purposeful, planned, statutory regulated activity of the educator related to the transfer of a set of knowledge, abilities, skills, and social values, ideals, cultural patterns to those studying within the system of continuing education. This activity includes the completed cycle of actions, from the development of educational materials to the delivery of study sessions in various forms, progress monitoring, and assessment of knowledge, skills, and abilities of students. Secondly - the integrity of more or less conscious and customary actions related to the acquisition of knowledge, skills, abilities, and social values, ideals, cultural patterns within the system of continuing education [2];

3) Certain experience, teaching practice, and practice of educational and pedagogical interaction. A set of ordinary actions and skills developed during the production and absorption of certain knowledge, which includes standardized ways of identification and selection of new information using various tools and resources, as well as types of interaction with other participants of the educational process [3].

By *educational practices of teacher,* we shall basically understand any form of the organized educational process, including both the implementation of activities (lesson, session, project, lecture, training, seminar, course, school, competition, Olympiad, walking tour, excursion, expedition trip, hands-on activities, etc.) and development of the methodological framework for such activities (methodology, curriculum, guidance manual, etc.).

We have done much research on *scientific education* and its main concepts in previous publications and defined it as a set of modern educational approaches that 1) are based not only on the system of scientific knowledge but also incorporate elements of scientific activity into the educational process and promote science; 2) are implemented through a disciplinary or interdisciplinary (also trans-, inter-, multidisciplinary, etc.) models of teaching and learning for different types, forms, and levels of education; 3) aim at developing the problem-solving skills – for addressing both personal and global challenges. In our opinion, scientific education has a multilevel purpose. At the basic level – the development of scientific literacy and global citizenship, and at the advanced level – the development of scientific thinking, scientific creativity, and scientific competency.

The concept of sciense education as a basis of scientfic education emerged in the USA and started to gain global popularity in the middle of the last century. In the post-Soviet territory, it is best known for the popularity of the STEM approach, which is one of the areas of development of scientific education. By *specialized science-oriented education,* we shall basically understand a national legal framework for scientific education, which regulates the activities of respective specialized institutions and is responsible at the legislative level for the development of intellectually gifted youth in the areas of science and technology as a way of their preparation for relevant

professional activities. This term is local (national) and although it belongs to the general field of scientific education, it cannot incorporate the whole spectrum of its meanings but is the culmination of its implementation at the level of higher education. Scientific education involves lifelong learning.

In our view, scientific education may be essentially characterized by the following:

• constructivism, pragmatism, and postmodern philosophy used as a methodological framework;

• disciplinary and interdisciplinary pattern of content and activities;

• use of heuristic, research, engineering, design methods in the educational process;

• representation by such modern educational approaches as: inquiry-/ research-/ discovery-/ problem-/ context-/ evidence-/ process-/ activity-based learning/ learning through conversation, writing and reading; inventive and project-based learning, etc.

The second research task was to determine which educational practices of the JASU may be deemed innovative and identify them. According to the Law of Ukraine on Innovation Activity, innovations in the field of education, or educational innovations, refer to newly created (first-ever applied) and (or) improved competitive technologies, products, or services that significantly enhance the quality, efficiency, and effectiveness of the educational process [4]. Innovations may include both the creation, dissemination, and application of new methods to solve educational problems in authentic, non-standard ways, and the transfer of existing innovative approaches to other conditions by adapting them or introducing gradual changes to existing systems.

Innovations emerge not by chance; they usually appear in an innovative environment and correspond to the level of development of the latest trends in the public life of the country and the world. Initial study of advanced educational activity of the JASU identified innovations that have already asserted themselves on various Internet resources and public events. Their common feature is that innovative practices are implemented through modern educational approaches, which we have classified according to the following education trends:

1. *Digitalization or digital transformation.*

New technologies open new opportunities for us to learn the world, manage economies jointly, communicate, manage the processes of work and study, etc. The transition to a new level in some areas of life requires advances in other areas. This is how the gradual renewal and transformation of today's world takes place – the stepwise transition from existing social systems to the digital age. Education plays a key role in this process as a tool for mastering new technologies essential for survival in the future conditions of accelerating change. The application of new information technologies in education brings learning to a new level of opportunities. The example from activities of the JASU: the use of geographic information systems in remote sensing (GIS and RS), distance and blended teaching in clubs and sections, development of own educational videos and interactive textbooks, establishment and use of online museums in educational activities, etc.

2. *Integration in education.*

Currently, integration processes take place in many spheres of life. In terms of the development of a social environment, we live in the period of postmodernism, when the boundaries of concepts are broken, and everything that was previously isolated or separated (for easier perception and understanding) starts to unite in different combinations. This worldview has affected education as well, which includes different models of teaching and learning: cross-disciplinary, multidisciplinary, transdisciplinary, interdisciplinarity. The integration involves not only the interaction of disciplines but also the links between science, education, and enterprises/ businesses, or cooperation between institutions, the succession of different levels of education, the interpenetration of structural elements of different sciences, etc. Ukrainian researchers claim that integration approaches aim at increasing the level of systematic thinking of students and reducing their workload [5]. The example from activities of the JASU: the use of CLIL methodology, establishment of STEM-centers, holding the Creativity Olympiad, use of arts in teaching science.

3. *Subjectivization of teaching or learning based on one's own inquiry through experience and reflection.*

By the subjectivization of teaching, we shall basically understand a change in the student's role: from the object of teaching to the subject of learning. We see the origins of this process in constructivism and its educational approach, "inquiry-based learning". This modern approach to learning, which emerged in the 1960s, is based on the idea that people can learn by exploring real-life situations and scenarios, as well as through social experience, solving problems, creating solutions, and providing answers to real questions [6, p. 7]. Learning begins with the student's interest in solving a problem and finding answers to interesting questions. The example from activities of the JASU: the use of "Philosophy for children" (P4C) and "La main à la pâte" approaches, projects by the "Agents of change" school.

4. *Transfer of professional and business technologies from the adult world to education.*

Another recent trend is the use of methods, forms, technologies of the adult world in teaching students, especially the gifted ones. Intellectually gifted youth is now proposed to learn things, which have used to be the prerogatives of adults and elements of their professional life. Such educational practices appropriately prepare young people for their future profession, pave the way for their successes in adult life.

The example from activities of the JASU: organization of business incubators, international scientific competitions, TED-conferences, educational and research expeditions.

5. *Interesting science.*

In the age of technical and technological progress, science is becoming so complex that it is necessary to prepare the next generation of scientists from early childhood to enable them to gradually absorb the vast amount of knowledge accumulated by humanity. For this reason, the combination of science and games and the use of the "science made simple" approach help children take the first steps in pursuing science and warrant high engagement in scientific cognition. The example from activities of the JASU: Science Museum, scientific lectures, use of game-based learning techniques.

6. *Environmental education and culture, formation of environmentally conscious consumption patterns.*

Environmental culture, ecological safety, and sustainability have recently become virtually the main values that unite people around the globe. Many important documents drawn by international organizations and national agencies address sustainable development and global citizenship issues. Naturally, these initiatives have influenced educational activities as well. Environmental education is becoming both a priority of state institutions and a popular area of teaching and learning. The example from activities of the JASU: Ecoview competition, Green Energy workshop.

Our further research focused on the identification of less-known innovative practices, which can be distinguished not only by a new methodological approach. Innovations may also be identified by the updates of the pedagogical theory, teaching methods, educational tools or process, institutional structure, which implementation produces significant changes in teaching and learning and improves student outcomes [7]. The authors of the OECD project, Measuring Innovation in Education, note that educational organizations (e.g. schools, universities, training centers, education publishers) can introduce the following as innovations: 1) new products and services, such as new curricula, textbooks or educational resources; 2) new processes for delivering their services, such as e-learning services; 3) new ways of organizing their communication with students and parents through digital technologies; and 4) new marketing techniques, such as differential pricing of postgraduate courses, etc. Such new practices aim at improving the provision of education in one way or another, and should therefore be regarded as intended "improvement" [8].

In the context of the pedagogical process, innovation can be characterized as the introduction of novel goals, content, methods, and forms of teaching, development, and education. Therefore, any innovation of the goals, content, methods, and forms of the educational process, which corresponds to the realities of modern life and optimizes the educational outcomes may be regarded as an innovation. For example, the introduction of satellite images analysis or a qualitative interviewing of participants of historical events in the teaching of geography and history, respectively, can make a huge difference in the educational process improving the learning outcomes and adapting them to the needs of the time.

Understanding that innovation may be manifested in any modernization of ordinary activities, we continued our search for innovations in the regional branches of the JASU. In addition to large-scale projects, we were also interested in creative ideas and promising developments of teachers, not widely promoted and known at certain territorial branches only. Offering insight into such activities can be useful for educators in other regions and contributes to the spread of innovations throughout the country. Based on the example from the study "Creating a Catalog of Educational Innovations and Innovative Educational Projects (general secondary education)" [9], we have initiated the development of passports of innovative scientific education practices used at the territorial branches of the JASU according to the following adapted template:

Table 1

Passport of innovative scientific education practices

1. ***Title of innovative scientific education practice:*** ____
2. ***Author(s) (surname, name, patronymic, position, scientific degree, educational, academic rank)***: _____
3. ***Major innovation (teaching approach, forms, methods, technologies, techniques):*** _____
4. ***Information about innovative scientific education practice:***
• brief description of innovation (half a page maximum in *.doc (Microsoft Word); font size – 12 (text typeface – Times New Roman), line spacing – 1): _____
• expected / obtained results of the experiment / testing / implementation of innovation (up to half a page in *.doc (Microsoft Word); font size – 12 (text typeface Times New Roman), line spacing – 1 : _____
• additional sources (bibliographic descriptions of publications, e-mails): _____
5. ***Stage of innovative educational activity (experiment, testing, or dissemination of innovation):*** _____
6. ***Educational institution(s), where experiment / testing of innovation takes place or where innovation is used:***
• full name: _____
• head of institution, facility, organization (surname, name, patronymic, position, scientific degree, educational, academic rank): _____

This initiative resulted in the development of passports of innovative scientific education practices for International Summer School on the Fundamentals of Remote Sensing, Interactive Hackathon on

Cyber Security, "My Hobby as a Step to Personal Growth" practice-oriented project, "Educational Hub – Territorial Community" project, "Psychological Support of Research Activities of JASU Student" practice-oriented project, Prediction Grids Method and Forecasting by Variables, "Creative Youth" teamwork, Snapology Method in Origami Club, "Club as a Portal to the World of Scholarly Communication" project, Adaptation of educational process at the JASU courses to scientific research carried by the institutions of the National Academy of Sciences of Ukraine, Introduction of modern research outcomes obtained by the JASU students into the educational process, Student archaeological expedition "Moliukhiv Bugor", etc.

The identified innovative educational practices influence in one way or another the development of scientific literacy, scientific thinking, scientific creativity, and competency of students, promote scientific activities and assist young scientists in their research. Detailed analysis of the characteristics of practices allowed to differentiate them according to the following criteria: major innovation type – teaching approach, forms, methods, technologies, techniques; scope of innovation practice – global, all-Ukrainian, regional; stage of development and implementation – experiment, testing, scaling.

Conclusions. Summing up the results of our theoretical study, we can propose the following definition for *innovative scientific education practices* – any form of practical activities of educators aimed at the development of scientific thinking, scientific literacy/creativity/competency in students as well as skills required for the solving of important social problems, which includes the innovation of any educational process constituent in line with realities of modern life and optimizing achievement of educational results.

Based on the analysis, modern education trends were described and substantiated, which contain the greatest number of innovations, namely: 1) Digitalization or digital transformation; 2) Integration in education; 3) Subjectivization of teaching or learning based on one's own inquiry through experience and reflection; 4) Transfer of professional and business technologies from the adult world to education; 5) Interesting science; 6) Environmental education and culture, formation of environmentally conscious consumption patterns.

The findings of this research are of direct practical relevance. Based on the preliminary monitoring of innovation activities and active participation of regions in the development of innovation passports, we have identified prospective innovative teaching and learning practices used by the JASU educators, which will undergo scientific testing in the next stages of our research.

Further research on the issues addressed in this paper will involve a detailed study, scientific testing, and the development of guidelines for the implementation of the practices that are the most promising in terms of potential for widespread use.

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ІННОВАЦІЙНІ ПРАКТИКИ НАУКОВОЇ ОСВІТИ МАЛОЇ АКАДЕМІЇ НАУК УКРАЇНИ: ТЕОРЕТИЧНІ ЗАСАДИ ВИЯВЛЕННЯ

Анотація.

У статті представлено результати теоретичного дослідження з виявлення інноваційних практик наукової освіти "Малої академії наук України" – спеціалізованого закладу наукового спрямування, який здійснює організацію позашкільної роботи з інтелектуально обдарованими і талановитими дітьми за 65-ти науковими напрямами. Насамперед зроблено спробу відповісти на питання, що мається на увазі під терміном "освітні практики", яку освіту можна назвати науковою і яка її мета, яким чином термін "наукова освіта" співвідноситься з поняттям "спеціалізована освіта наукового спрямування". Описано сутнісні характеристики наукової освіти. Розкрито сутність інновацій в освіті й узагальнено поняття інноваційних практик наукової освіти. Обґрунтовано сучасні освітні тренди, за якими встановлено найбільше інновацій. Висвітлено теоретичне підґрунтя, спосіб і результати виявлення інноваційних практик наукової освіти.

Ключові слова: *інновації в освіті; освітні практики; наукова освіта; інноваційні практики наукової освіти; спеціалізована освіта наукового спрямування; освітні тренди; паспорт інновацій.*

Стаття надійшла до редколегії 16 липня 2021 року