Implementation of STEM education in the process of training of future specialists of engineering and pedagogical specialties

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ABSTRACT

The article reveals the role of STEM education in today's technological society and its impact on the development of students' skills, necessary for building career in the modern world. The need to modernize methodological principles, educational content, and educational technologies is emphasized. Initial, basic, profile, higher/professional levels of STEM education development are described. The directions of STEM education in training of future specialists of engineering and pedagogical professions are highlighted. The STEM project "Spectroscope" was implemented to test innovative method of studying the phenomenon of light dispersion by means of robotics.

Keywords: professional education, training, engineering and pedagogical specialties, STEM education, spectroscope, dispersion

1. INTRODUCTION

The rapid development of information technologies, robotics, and nanotechnologies causes the need for specialists in high-tech industries able for complex scientific engineering activities. Therefore, the creation of conditions for training of specialists in these fields is an urgent issue today. To achieve this goal, changes to the system of training teaching staff for educational institutions of engineering and technological profiles should be made. Vocational education should be anticipatory, follow the tends of the society development in the future. That is why the development and implementation of innovative approaches, technologies and methods of professional training is paid special attention today. One of the promising ways in this direction is the development and introduction of STEM education elements at all stages of youth education - from elementary to higher[1].

Currently, in many countries, the educational policy is aimed at increasing of students' interest to STEM professions and involving them in building a career in the related fields, which is ensured by means of implementing the integration of several educational disciplines in the educational process[2].

Undoubtedly, significant transformations are also taking place in the field of national education of Ukraine, which is now confidently changing its format from traditional to innovative, introducing information, communication and digital technologies into educational process, which is the key to building a new reality, the basis of the life of the society in the future. Modern trends in educational reform and active process of its digitalization cause the newest forms of future specialists training in the conditions of higher educational institution for introducing innovations in practical pedagogical activity[3].

This, in turn, leads to the formation of STEM education paradigm, which is aimed at personality developing by means of natural sciences, fostering life values using transdisciplinary approach to teaching, based on the practical application of scientific, mathematical, technical and engineering knowledge, solving practical tasks[4].

As experience shows, using the leading principle of STEM education which is the integration of knowledge from various fields, makes it possible to modernize the methodological foundations, content, volume of educational material of the subjects of natural and mathematical cycle as well as to technologize teaching and form students' skills that will help them to become competitive in the labor market. In addition, students develop such research skills as conducting scientific research, proposing, substantiating and testing a hypothesis, experimenting, analyzing data and preparing

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conclusions that confirm, refute or modify a hypothesis, as well as skills for observing, measuring, forecasting, using spacial and time connections, data interpreting, etc.
In many countries, the main policy is aimed at increasing the students' interest to STEM disciplines and involving them in career building in the related fields, which is ensured by implementing the integration of disciplines[5].

2. ORGANIZATION OF STEM EDUCATION

The development of STEM education in educational institutions is provided at four levels[6] (Fig. 1).

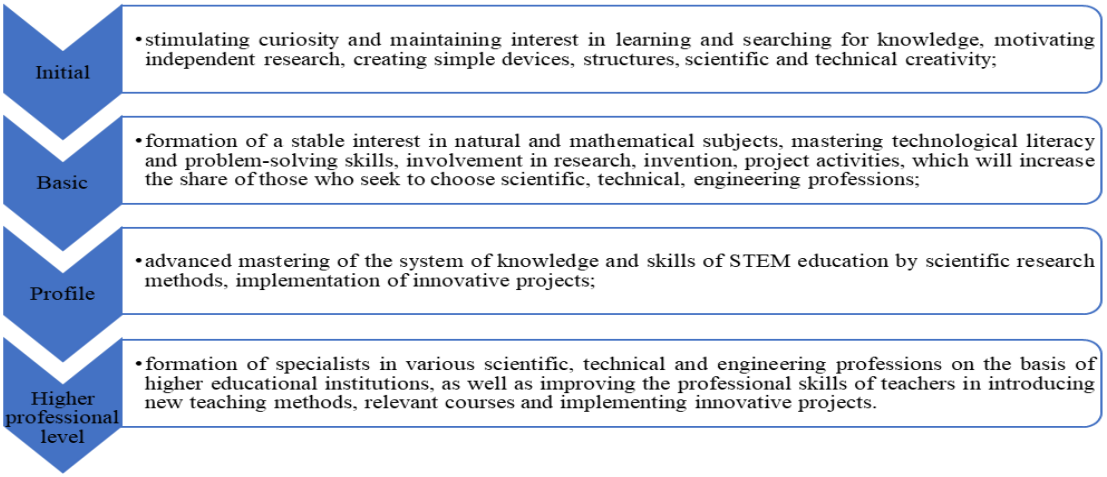


Figure 1. Levels of STEM education development

Modern trends in the development of society determine the need to improve the professional education system of Ukraine, which involves the introduction of new educational standards that will contribute to its integration into the European educational space. The key features of modern European education are its focus on the personality able to become the citizen of the globalized post-industrial information society.
The main task of STEM education development is to create a suitable environment in the educational institution. The STEM educational environment combines intellectual and material conditions for implementing the results of researches, technologies, engineering, and integrated knowledge, which ensure the self-development of a free and active personality, and realization of his/her creative potential.
The directions of STEM education in training future specialists of engineering and pedagogical professions can be: programming, artificial intelligence, electronics, mechatronics, bionics, additive technologies, numerical software control, computer modeling, milling and laser technologies, climatic, astronomical, biological observations and processing of their results, robotics, engineering, rocket modeling, aerospace technologies, radio electronics, car, aircraft, ship modeling, three-dimensional modeling; chemical-biological and agroecological technologies; designing; web design, basics of video technology, digital art, etc.
Organizing training based on the principles of STEM education requires a constant search and updating of knowledge and its use to gain new experience, emphasizing the technological approach, as well as the development of cognitive skills, awareness of the process of processing information presented in various formats[7-15].

3. IMPLEMENTATION OF THE STEM PROJECT "SPECTROSCOPE"

Currently, the problem of attracting future teachers to participate in the development and implementation of STEM projects, which is a powerful tool for forming the ability to think creatively and create educational innovations, is gaining particular relevance[16].
The project "Spectroscope" implemented by students is an example of using STEM education tools. The innovative way of studying the phenomenon of light dispersion by means of robotics was tested in the course of its implementation. In particular, the spectral composition of various light sources of artificial and natural origin was studied as well as the structure of modern displays and the principle of pixels and subpixels operating were considered.

As an artificial light source with an adjustable spectrum, a robotic set based on an Arduino UNO microcontroller with a three-color RGB LED was used. The intensity of each color (subpixel) was adjusted using a hardware 8-bit digital-to-analog converter and three potentiometers, the voltage of which was read by a 10-bit hardware analog-to-digital converter of the microcontroller; the circuit was powered from the USB port of the computer. Adjustment of the scales of the input and output signals was done by programming. An example of connecting elements is shown in Figure 2.

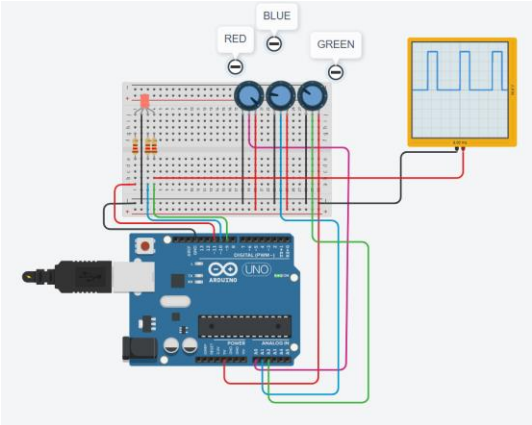


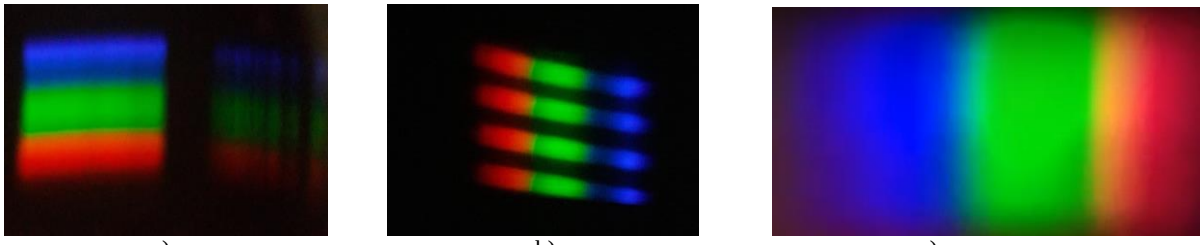
Figure 2. Schematic image of connecting elements

As a tool for studying the spectrum of various sources, a self-made diffraction spectroscope was used, the body of which is made of thick cardboard, and the dispersion element is a diffraction grating which is the part of an optical CD-disk. Instructions for making a spectroscope are freely available at the link https://storage.googleapis.com/publiclab-production/public/sites/default/files/minispec3-8.pdf.

Studying the phenomenon of dispersion lasted for 4 academic hours and included the following steps:

- assembling the electrical circuit from a robotic set;
- programming and debugging of the project, constructing the spectroscope;
- simulating the color gamut of the RGB palette, studying the pixel structure of smartphone displays, using a microscope;
- studying the spectra of artificial and natural light sources using a spectroscope, photographing and comparing the spectra.

As a result of practical work, images of spectra of various sources were obtained (Fig. 3).



a) b) c)

Figure 3. Snapshots of spectra of various sources: a) the spectrum of the LED lamp; b) RGB LED spectrum; c) spectrum of a lamp with an incandescent filament

Thus, during the implementation of the project, all its participants became familiar with the phenomenon of diffraction or deepened their knowledge of Physical optics which is the nature and regularities of diffraction spectra forming, acquired skills in programming and working with ADC and DAC modules of a microcontroller, learned to read and assemble electrical circuits, improved technical modeling and design skills. At the same time, they received practical confirmation of the nature of the complex structure of light, its differences in the case of light from different sources, got acquainted with the principle of operation of displays and light sources, understood the important role of Optics in the development of modern technologies.

4. SUMMARY

STEM education contributes to forming of students' critical thinking, creativity, research skills, engineering thinking, skills of design and invention. The development of STEM education takes place in levels: primary, basic, profile, higher/professional. It is important to create an appropriate educational environment at each stage of training students of engineering and pedagogical and technological specialties. For this purpose, it is important to widely use project technologies with elements of STEM education, which contributes to the creation of the necessary conditions for intensifying cognitive activity, developing skills for searching effective ways to solve problems and the ability to work with information. As the STEM does not offer concrete answers - they must be sought independently. This enables students to formulate substantiated conclusions based on their own experience, apply the acquired knowledge in practice, and offer their own or group view of the problem.

REFERENCES

[1] Tytler, R. "STEM Educational for the Twenty-First Century," [Integrated Approaches to STEM Education], 21-43 (2020).

[2] Merchant, S., Morimoto, Emiko T. A. and Khanbilvardi, R. "An Integrated STEM Learning Model for High School in Engineering Education," Integrated Stem Education Conference (ISEC), Princeton, NJ, 4-9, (2014).

[3] Kovalchuk, V., Androsenko, A., Boiko, A., Tomash, V., and Derevyanchuk, O. "Development of Pedagogical Skills of Future Teachers of Labor Education and Technology by means of Digital Technologies," International Journal of Computer Science and Information Security, 22(9), 551-560 (2022).

[4] Concept of implementation the state policy in Professional Education "Modern Professional (Professional and Technical) Education", period until 2027 (19 May 2022). https://zakon.rada.gov.ua/laws/show/419-2019-p.

[5] Merchant, S., Morimoto, Emiko T. A. and Khanbilvardi, R. "An Integrated STEM Learning Model for High School in Engineering Education," Integrated Stem Education Conference (ISEC), Princeton, NJ, 8 March 2014, 4-9, (2014).

[6] STEM education. Institute for Modernization of Educational Content. (19 May 2022). https://imzo.gov.ua/stem-osvita/

[7] Voitovych, I., Pavlova, N., Voitovych, O., Horbatiuk, R., Kovalchuk, V, And Prylepa, I. "Training of teachers STEM disciplines to work with students in distance education, Inequality, Informational Warfare, Fakes and Self-Regulation in Education and Upbringing of Youth," Youth Voice Journal Vol. I, 103-112, (2023).

[8] Balovsyak, S.V., Derevyanchuk, O.V., Kravchenko, H.O., Kroitor, O.P. and Tomash, V.V., "Computer system for increasing the local contrast of railway transport images," Proc. SPIE 12126, 121261E1-7 (2021).

[9] Balovsyak, S., Derevyanchuk, O., Fodchuk, I., Kroitor, O., Odaiska, Kh., Pshenychnyi, O., Kotyra, A. and Abisheva, A., "Adaptive oriented filtration of digital images in the spatial domain," Proc. SPIE 11176, 111761A1-6 (2019).

[10] Balovsyak, S.V., Derevyanchuk, O.V. and Fodchuk, I.M. "Method of calculation of averaged digital image profiles by envelopes as the conic sections," Advances in Intelligent Systems and Computing, Springer International Publishing, 754, 204–212 (2019).

[11] Angelsky, O. V., Bekshaev, A. Y., Dragan, G. S., Maksimyak, P. P., Zenkova, C. Y., Zheng, J.б "Structured light control and diagnostics using optical crystals," Frontiers in Physics 9, 715045 (2021).

[12] Angelsky, O.V., Maksimyak, P.P., "Polarization-interference measurement of phase-inhomogeneous objects," Appl. Opt. 31 (22), 4417-4419 (1992).

[13] Angelsky, O. V., Maksymyak, P. P., Zenkova, C. Y., Maksymyak, A. P., Hanson, S. G., & Ivanskyi, D. D., "Peculiarities of control of erythrocytes moving in an evanescent field," Journal of Biomedical Optics 24(5), 055002 (2019).

[14] Angelsky, O. V., Zenkova, C. Y., Maksymyak, P. P., Maksymyak, A. P., Ivanskyi, D. I., & Tkachuk, V. M., "Peculiarities of energy circulation in evanescent field. Application for red blood cells," Optical Memory and Neural Networks 28(1), 11-20 (2019).

[15] Angelsky, O. V., Maksimyak, P. P., Maksimyak, A. P., Negrych, A. L., & Hanson, S. G., "Experimental demonstration of singular-optical colouring of regularly scattered white light," Journal of the European Optical Society - Rapid Publications 3, 8029 (2008).

[16] Valko, N.V. and Osadchyi, V.V. "Teaching robotics to future teachers as part of education activities," Journal of Physics: Conference Series, V. 1946, 012016 (2021).