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GUIDELINES FOR EFFECTIVE IMPLEMENTATION OF STEM EDUCATION IN UKRAINE

Formulation and justification of the relevance of the problem. Information and technological revolution causes the emergence of new occupations in high tech area at the intersection of the most natural sciences and information technologies. The success of such future professionals mainly depends on the profound and deep knowledge in basic high school STEM disciplines, i.e. mathematics, physics, chemistry, biology, and especially informatics that form the scientific worldview of a person. No less importance has the logical and critical thinking as an apparatus which allows a person to gather the relevant and accurate information in the continuously changing world. For that reasons, the problem of implementing the STEM education is very vital for Ukrainian educational system as a part of globalization and integration of Ukraine in European educational community and global job marker.

Analysis of recent research and publications. The problem of implementation of the STEM Education is widely studied in a global scientific and pedagogical community in the works

by R. Bybee, J. Fairweather, H. Gonzalez & J. Kuenzi, H. Kanematsu & D. Barry, M. Mataric & N. Koenig, M. Sanders, P. Williams, etc. In particular, the primer of STEM Education, the practical aspects of using Hands-On Robotics, the requirements to the today technology teacher, the advantages and disadvantages of STEM education, and its perspectives of development till 2020 have been studied.

Instead, in Ukrainian scientific-pedagogical community it is sporadically discovered only by V. Sharko, thus the problem of effective implementation of STEM education in Ukraine remains unexplored, that determines the relevance of our research.

The purpose of the article is to analyze the concept of STEM education, its goal and premises, define the legal framework of STEM education in Ukraine, address the barriers and challenges that should be considered and eliminated for effective implementation, and recommend the principles for successful implementation of STEM initiative in Ukrainian educational institutions.

The main material of the study.

The theoretical background. Basically the term «STEM education» is an acronym that integrates four main approaches and disciplines to education – science, technology, engineering and mathematics. The STEM label firstly was used by National Science Foundation at the end of twentieth century as a concept that refers to any action in STEM fields (R. Bybee) [2].

STEM education is treated «an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy» (N. Tsupros, R. Kohler, & J. Hallinen) [14].

This concept also has been defined as «a standards-based, meta-discipline residing at the school level where all teachers, especially science, technology, engineering, and mathematics (STEM) teachers, teach an integrated approach to teaching and learning, where discipline-specific content is not divided, but addressed and treated as one lively, fluid study» (R. Brown, J. Brown, K. Reardon & C. Merrill) [1, p. 6].

According to H. Gonzalez and J. Kuenzi STEM education includes educational activities in classroom and afterschool programs in the whole educational system – from pre-school to post-doctorate grade levels [6].

Consequently, the main purpose of STEM education is improving the value of both undergraduate teaching and learning in these disciplines according to main challenges of information society and new economy.

The evidence and promising practices in STEM education related to faculty involved in this reform come from three major premises:

a) Better student learning outcomes in STEM area as main challenge of information society;

b) Higher pedagogical effectiveness of teaching STEM disciplines;

c) Variability of changes of instructional roles of faculty positions in STEM fields [5, p. 3–5].

Another premise is to prepare students to future employment in some high technological areas like robotics and artificial intelligence. In this context, M. Mataric, N. Koenig and D. Feil-Seifer [9] recommend robotics as a superb tool that can be implemented trough hands-on learning in any classes at elementary, middle and high school-level. The authors describe own vision of robotics application in STEM fields in K-12 schools and suggest the materials and tools as well as developed science courses that involve robotics in teaching middle school classes. The material includes lesson plans, freely distributed on the Internet, detailed workbook of robot programming exercises with illustrations and solutions, and the textbook that discovers the key concepts and principles of using robotics in the teaching subject.

However, as R. Bybee [2] has mentioned, in most cases this innovation is treated only as science and mathematics, despite the fact the influence of technology and engineering increasing day by day. Consequently today STEM education should be more oriented to developing students' knowledge, skills and abilities in engineering and using of technologies. Actual topics include: designing engineering processes; discover how it works; how to use technologies; problem solving and innovation etc.

Despite all these positive facts, P. Williams argues that STEM education realization and support is very difficult because school curriculum has a rigid structure resistant to change [15]. Another impediment is staffing implications in secondary and high schools, where each teacher teaches one discipline not as in primary school, where one teacher teaches all subjects to one class, which cause a necessity to provide team teaching in secondary and high schools which requires teacher's training to implement this approach. One more problem is how the STEM subjects could relate to each other in the curriculum and to justify their places [15]. For those reasons, «a focus on STEM integration will not overcome the barriers, and may result in the decimation of technology as a distinct component of the school core curriculum. A STEM orientation, therefore, must be approached with caution» [15, p. 33].

Therefore STEM education can be treated as a presumptive reform model based primarily on in-classroom innovation and the teaching-learning

process in STEM fields as challenges of the 21st century.

The legal framework of STEM education in Ukraine. The legislative basis of STEM education in Ukraine is formed by three main documents: The Law of Ukraine «About the Innovation Activities2 (2002) [8], The Decree of the of Minister of Education and Science of Ukraine «About the Approval of the Procedure of realization of innovative educational activities» (2000) [11], and The Decree of the Minister of Education and Science of Ukraine «About the creation of a working group on implementation of STEM-education in Ukraine» (2016) [10].

The first document defines the legal, economic and organizational principles of state regulation of innovative activities in Ukraine, establishes state forms of incentives and innovative processes aims to support the development of innovative of Ukrainian economy. According to this law the innovations are newly formed (applied) and (or) improved competitive technologies, products or services, and organizational and technical solutions for industrial, administrative, commercial or otherwise, which significantly improves the structure and the quality of production and (or) social services; the innovation activities are the activities aimed at use and commercialization of research results and development and causes the release of new competitive goods and services [8].

The second document determines the procedure of innovative educational activities in the education system. Respectively, the educational innovation is considered as first created, improved education, training, educational, managerial systems, their components, with results significantly improve educational activities. The innovative educational activities are carried out at the national, regional levels and the level of the educational institution. At the national level innovative educational activities involve the following areas: education, training, educational, administrative systems; a basic component of preschool education, invariant component of general secondary education, national component content of vocational education, adult education content, regulatory content of higher (including postgraduate) education; the experimental curricula, textbooks, manuals, developed in the course of the experiment and results to improve education; educational technologies, forms, methods and resources of training, education and education management; scientific and methodical, personnel, logistical and financial support of the educational process in educational institutions; systems, technologies, forms and methods of leadership training, teaching and teaching staff [11].

In accordance to the Decree of the Minister of Education and Science of Ukraine (2016) [10], for the purpose of innovation development of disciplines of natural and mathematical cycle, the research in education, implementation and development of STEM education in Ukraine was created a working group composed by scientific and teaching staff of the Institute of modernization of the content of education, regional In-Service teacher training Institutions, methodical staff of district instructional Institution, and teachers. The main objective of this group is to develop an action plan for implementing STEM agenda in Ukraine.

The barriers and challenges to successful implementation of STEM education in Ukraine.

As every innovation, the implementation of STEM agenda in Ukraine comes across a variety of barriers and challenges.

J. Ejiwale [4] identified ten barriers to successful implementation of STEM initiative in USA that are completely applicable for Ukrainian education system:

1. Poor preparation and shortage in supply of qualified STEM teachers.
2. Lack of investment in teachers professional development.
3. Poor preparation and inspiration of students.
4. Lack of connection with individual learners in a wide variety of ways.
5. Lack of support from the school system.
6. Lack of research collaboration across STEM fields.
7. Poor Content preparation.
8. Poor Content delivery and method of assessment.
9. Poor Condition of laboratory facilities and instructional media.
10. Lack of hands-on training for students [4].

These barriers call a range of challenges to Ukrainian educational system in *methodological*, *management*, and *performers'* aspects. The following describes some of the identified challenges to successful implementation STEM education in Ukraine in relevant aspects.

The ***methodological challenges*** of STEM education implementation consist of:

– The requirement to make explicit the nature of STEM education, its realization and outcomes.

– The request to develop a concept consensus and define strategies to implement STEM reform in Ukrainian education.

– The demand to develop the model of implementation of STEM education that defines the learning objectives, performers roles, curriculum content, traditional and innovative instructional techniques, classroom instruction, student and teacher activities in a classroom or laboratory, resources and results.

– The necessity to elaborate an educational technology for effective realization of STEM

education in Ukraine that will implement the relevant model.

– The need to design an assessment technique and tools that determine student outcomes and perceptions according to defined learning objectives, especially with more complex ones, such as the retention of knowledge over time, the application of knowledge to solve unfamiliar problems, and commitment to lifelong learning.

The ***management challenges*** of STEM education implementation are:

– The demand to develop a detailed instruction plan in single settings, for a course, department, institution, and location. This plan should also include the timing of implementation of all activities and responsible persons.

– The need to operate the STEM pipeline and instruction at each Ukrainian school level – from primary to high school with focus on interaction and interrelation of teaching subjects within and across departments.

– The necessity to elaborate a mechanism of motivation in teaching and learning STEM subjects. This mechanism could increase the interest and self confidence of students in field of study, and attracting them to STEM majors in college or university.

– The requirement to make a regular monitoring to determine the current state of STEM initiative implementation results and possible problems. In case of problems appearance, the relevant activities could make to solve them.

– The request for substantial external funding to develop methodological materials, manage and assess student learning outcomes of STEM education implementation.

The ***performers' challenges*** of STEM education implementation include:

– The requirement to increase public awareness about STEM education could improve the level of understanding of effectiveness and necessity of this innovation in classroom or laboratory.

– The necessity to prepare performers who have not enough necessary knowledge and skills to effective teach STEM subjects.

– The demand to adequate performer compensation to attract and retain high-quality teachers in STEM pipeline.

– The need to encourage STEM performers to provide sufficient information about the course taught, materials, and resources required for its successful implementation. Also they could detail the relevance of STEM initiative to their own professional and classroom activities.

The principles of effective implementation of STEM education in Ukraine. The principles we understand as certain outgoing regulatory requirements for the organization of the educational process which ensure its efficiency and success. They define the content, direction and main output of this process. Therefore principles are defined through the specifically targeted rules, regulations and recommendations. It also should be mentioned that principles are interrelated and determine each other [3, p. 168-170].

Based on this theoretical position, indentified barriers and challenges, our experience, and depending on the key components and stages of the educational process, we recommend *twelve principles* of effective implementation of STEM education in Ukraine:

– The goal and objectives (Practical Purpose and Clarity);

– Student involvement (Personalization, Interaction, and Bottom Line);

– Content forming (Interrelation, Integrity, and Modularity);

– Organization (Hands-on learning, Technologization, Continuity, and Adaptability).

For example, a STEM education program supposed to include as much as possible practical objectives that aim at the development of a students' computer and information technology literacy (*Practical Purpose*), which should be clear and understandable for every student, teacher, and instructor involved in this process (*Clarity*). During classroom and laboratory sessions each student should be involved in a STEM study according to his own needs and abilities (*Personalization*). The students could interact in various forms of activities, from individual to the whole group of students (*Interaction*). Not all of students could achieve the highest level of STEM education and not all of them will be engineers, mathematicians or programmers, but each student should get the minimal knowledge and skills, necessary for a successful professional activities and life in the information society (*Bottom Line*). The content of STEM course should be related with main study disciplines at each school level (*Interrelation*), and could contain integrated (*Integrity*) and self-contained separate independent educational topics (*Modularity*). The STEM education organization could use more practice in learning (*Hands-on Learning*) and relevant education technology (*Technologization*). This process should continue from elementary schools to pre-university colleges (*Continuity*) and could tolerate to changes in education and society (*Adaptability*).

The given principles in a certain way guarantee the successful implementation of STEM initiative and will improve the effectiveness of the whole educational system of Ukraine.

Conclusions and prospects for further research. The STEM education is an interdisciplinary approach that aims at integrated teaching and learning of science, technology, engineering, and mathematics on one live and fluid process to compete education the new economy

reality. The main premise of STEM education is that it is a presumptive reform model that responds to mail challenges of the 21st century and information society.

The legislative framework in the field of STEM education in Ukraine is formed at the primary level and could be developed to many perspective directions.

The successful implementation of STEM initiative in Ukraine encounters several barriers and challenges. To achieve STEM education goal and objectives, we identified and described some methodological, management, and performers' challenges.

We recommend twelve principles of effective implementation of STEM education in Ukraine, depending on the key components and stages of the educational process: The goal and objectives (Practical Purpose and Clarity); Student involvement (Personalization, Interaction, and Bottom Line); Content forming (Interrelation, Integrity, and Modularity); Organization (Hands-on learning, Technologization, Continuity, and Adaptability).

Future possible research will be devoted to describing the above mentioned twelve principles of effective implementation of STEM education in Ukraine and given practical examples for their using in the classroom and online learning.

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ОСНОВНІ ВИДИ МОВЛЕННЄВОЇ ДІЯЛЬНОСТІ ЯК СТРУКТУРНІ СКЛАДНИКИ ІНТЕГРАЦІЇ НАВЧАЛЬНО-ПІЗНАВАЛЬНОЇ ТА САМООСВІТНЬОЇ ДІЯЛЬНОСТІ СТУДЕНТІВ ВИЩОГО ПЕДАГОГІЧНОГО НАВЧАЛЬНОГО ЗАКЛАДУ

Постановка та обґрунтування актуальності проблеми. Основні види мовленнєвої діяльності (говоріння, письмо, аудіювання, читання) як структурні складники інтеграції навчально-пізнавальної та самоосвітньої двяльності студентів вищого педагогічного навчального закладу є основним підґрунтям підготовки до професійної діяльності майбутніх учителів іноземної мови, підвищення якості якої, в свою чергу, є пріоритетним напрямом розвитку освітньої галузі України в цілому.

Розвиток мовленнєвої компетентності майбутніх учителів іноземних мов з психологічної точки зору ґрунтується на теорії мовленнєвої діяльності.

Аналіз останніх досліджень і публікацій. Вивчення процесів мовлення як діяльності дають змогу визначити шляхи та закономірності розвитку мовленнєвих умінь і навичок. Мовленнєву діяльність у психології розглядають Л. Виготський, І. Гальперін, О. Гойхман, М. Жинкін, І. Зимня, О. Леонтьєв, А. Лурія, А. Маркова, І. Синиця, О. Шахнарович та інші. Мовленнєва діяльність – це процес використання мови для спілкування під час будь-якої іншої діяльності [4]; мовленнєва діяльність являє собою процес активного, цілеспрямованого, опосередкованого мовою та обумовленого ситуацією спілкування і взаємодії людей між собою [5].

Мета статті – обґрунтування основних видів мовленнєвої діяльності як структурних складників інтеграції навчально-пізнавальної та самоосвітньої діяльності студентів вищого педагогічного навчального закладу.

Виклад основного матеріалу дослідження. О. Леонтьєв, порівнюючи мовленнєву діяльність людини з будь-якою іншою діяльністю, визначає такі її риси: 1) потреба, мотив, мета, задум, знання; 2) усебічний аналіз ситуації, у якій має відбутися й відбувається діяльність; 3) прийняття рішення виконувати чи не виконувати діяльність та вибір оптимальних для певної ситуації засобів реалізації діяльності; 4) планування діяльності та передбачення можливого результату; 5) виконання певних дій та операцій; 6) контроль над реалізацією діяльності та її корекція; 7) порівняння результату діяльності з поставленою метою [6]. Таким чином, мовленнєва діяльність являє собою комунікативну сферу життєдіяльності людини. Знання її специфіки, законів, етапів перебігу забезпечують формування та вдосконалення вмінь спілкуватися відповідно до ситуації, поставлених цілей та завдань, що виникають у процесі комунікативних потреб.

І. Зимня [5] визначає низку загальних характеристик мовленнєвої діяльності та всіх її видів: 1) структурна організація, що включає фазову будову й операційну структуру; 2) предметний (психологічний) зміст; 3) єдність внутрішнього та зовнішнього боків; 4) єдність змісту та форми його реалізації; 5) зумовленість мовленнєвої діяльності людини функціонуванням психічних процесів сприймання, уваги, пам’яті, мислення, уяви.

Видами мовленнєвої діяльності визначено говоріння, письмо, аудіювання, читання та розподілено їх на ті, що забезпечують процес продукування (говоріння, письмо), та ті, що забезпечують процес сприймання (слухання, читання) мовленнєвого висловлення. З цих позицій нами виокремлено в структурі мовленнєвої діяльності студентів сформованість чотирьох її видів та віднесено говоріння й письмо до процесу породження мовленнєвого