Studies of impact of specialized STEM training on choice further education

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Abstract. The specialized training influence to the choice of further direction of study is considered in the work. The assumption that early involvement of students in the study of natural and mathematical disciplines, in particular mathematics is given. It will stimulate young people to get STEM education in future. The essential element in future professional choice, development and formation is the issue of motivation for learning. It is important that modern students are gradually losing their incentive to study. Almost a third of those who choose the appropriate study profile have contradictions between professional self-determination and the availability of the necessary knowledge for the profession, between choosing a higher education institution and being able to enter in it. The contradiction requires purposeful formation of a conscious choice of future activities. The conducted research has shown that the basis of the motivational component of the choice of STEM-learning is studying of natural and mathematical disciplines by modern teaching technologies and organizing of additional lessons system based on the projected teaching methods. It satisfies the growing needs for intelligence, knowledge, motivational beliefs to understand the specifics of the future profession.

1 Introduction

At every stage of its development, society presents to the education system certain requirements that meet the scientific and technological achievements of the time. In the reform of general and higher education, the problems of scientific substantiation, content development and teaching methods, as well as pedagogical diagnostics of learning outcomes are very relevant in improving of the teaching and educational process. The main purpose of the reform is to move from a school, knowledge is only given to a school of competencies necessary for life [1, p. 9]. The research of the relationship between the competencies of students, their intellectual abilities and their vision of further education, the use of active learning strategies for profession choice has shown the usefulness of motivational beliefs in understanding the choices of this future. Supporting such beliefs depends on a system of motivational influences in formal, non-formal and informal education.

In Ukraine there has developed the system of work with intellectually talented children in the natural-mathematical and technological disciplines: intellectual competitions; a network of specialized lyceums, the graduates demonstrate high results in STEM disciplines (Science, Technology, Engineering and Mathematics); system of extracurricular education. These are the measures on the basis of which, it is necessary to build a system of science-oriented education, to introduce the principles of scientific and engineering methods in the education. Today, STEM approaches are being implemented in many Ukrainian schools and other educational and extracurricular institutions. Non-formal STEM education in the country is Olympiads, activities of the Junior Academy of Sciences (JAS), other extracurricular institutions, various competitions and events: Intel Techno Ukraine; Intel Eco Ukraine; Sikorsky Challenge Science Festival; STEM competitions; scientific picnics, hackathons etc. [2]. At the same time, there is a shortage of specialists in engineering and sciences. Today in Ukraine these subjects do not occupy the top places in the popularity rating among young people [3]. According to the survey, the basic sciences occupy only the 10th place. STEM education, which has been actively developing in Ukraine in recent years and has been identified as a priority area for the development of education for 2020, is intended to promote the exact sciences and increase the interest of young people in scientific activities.

Education should meet the needs of society in the fields of natural and mathematical and technological fields, capable of developing innovations in bio-, nano-technologies, technologies of artificial intelligence, robotics, etc. Therefore, an important task of training should be to develop student’s motivation to study natural sciences. It is important to train teachers capable of supporting such motivation and making the conditions for further interest in the sciences.

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2 Related works

Researches present the achievements in the mathematical sciences are unique, they serve as a source of the basic knowledge required by every specialist in the STEM [4]. There is the problem of learning the exact and technical disciplines, as students find them “difficult to study” [5]. According to PISA (Programme for International Student Assessment) in 2015, there was almost half of students from 12 million researches from different countries were unable to complete the simplest tasks in reading, math, science, and a number of innovative industries during world testing [1, p.15]. In the future, it may lead to the loss of interest to obtain STEM specialties.

Numerous studies of connections between competencies and academic achievement in higher education students [6, 7, 8] and others) have found the students in junior, secondary or senior school age have additionally acquired knowledge of the natural sciences (e.g. chemistry), physics, maths) have achieved higher educational attainment than the other students [9]. In addition, studies were conducted in different age groups on the ability of early intelligence, the reasons for its formation, not only because of the influence of parents, but also due to the goal, self-regulation, students’ efforts. But there are few researches on the connection between motivation and achievement in engineering, technical, technological contexts, including STEM activities.

In [10] it is noted that «a shift in the focus of the classroom activities from teaching to learning» is fundamental value shift as a result of collective work on the concept of “science for all”. The basis for this was:

- changing interactions between teachers, academic institutions, research centers;
- professional development of teachers of all levels, including the primary professional education of graduate students, postdoctoral fellows and entering faculty, and reeducation for midcareer faculty;
- change of teaching and learning resources from “passive” learning to “active” classroom strategies that complemented the inquiry-centered approach of modules.

Among the factors that contribute to the attraction of studying STEM-subjects occupies a special place:

- creating an appropriate support environment and an enhanced sense of community / feeling of belonging;
- enhanced accessibility for youth and their caregivers to STEM education through science clubs;
- creating long-term STEM training programs

A relatively small amount of research is devoted to examining how students studying science, technology, engineering and mathematics, developing these skills and aptitudes and what learning tools are used by teachers to contribute to this development in the STEM learning context.

Psychologists point out that young people’s beliefs about their knowledge, competences often change with reference to their views and efforts to study, have such basic psychological properties as new communication opportunities, beliefs about their successes and/or failures, contribute to the development of cognitive processes etc [11]. It will help strengthen cognitive, emotional, and social skills. Important knowledge and knowledge of specialized skills in a particular field are important [12]. Do not forget about the impact of awareness of the students of their intellect on the learning purpose, efforts, strategies, academic success. Therefore, it is important to study students’ assessments of their cognitive, social and other motivations, based on their own actions in the environment.

3 Research background

In the scientific field there is no single approach to the interpretation of the concept of “STEM technology”. This definition is interpreted as a type of learning, a method of teaching, a technology of learning. In our point of view, it is a didactic technology allows changing by intensification of educational process in its procedural and productive aspects. In the process of realization in the conditions of general / higher vocational education, the named technology acquires pedagogical content, combining methods, techniques, teaching aids, as well as various forms of subject-subject interactions. They make the great opportunities for developing student’s independence, critical thinking, mastering of cognitive and social skills in the complex [13]. The main features of STEM learning technology are:

- positive relationship: the success of each person depends on the integrity of the other members of the group; mutual responsibility and teamwork;
- direct support: young people exchange opinions, resources and materials, evaluate the execution of each team member in order to get an overall result;
- personal responsibility: everyone is responsible for the results of group activities and for their share of work, since the success of the team depends on the individual work of each of its members;
- social competence: participants learn mutual trust and respect for each other, they develop skills to manage the actions of others (leadership), to make decisions, to communicate and to overcome conflicts;
- self-assessment: students learn how to evaluate their contribution to the success of group work, as well as evaluate the group's collaborative work from the point of view of the appropriateness of the methods chosen and identify the causes of the failures;
- one of the main functions of specialized training in STEM education is to unite: uniting of disciplines, people, and forces.

The teacher acts as a conductor, facilitator, assistant, equal member of the group, who ensures necessary skills formation for the cooperation of the applicants, such as: coordinate their activities with the activities of partners; to stand in the position of others and change your own; to assist and benefit from their partners; reflect their actions and those of other group members; respect everyone’s opinion; to give high priority to the achievement of the collective goal; to prevent conflicts. The teacher’s main task is to instill faith in the possibility of successful achievement of the goal and to encourage students to independently search. The key competences of a teacher are in world standards. To meet the demands of the digital society, in 2018

International Society for Technology in Education (ISTE) has approved standards for ISTE teachers to improve the learning impact for all students using technologies [14].

The analysis of their work presents the insufficient theoretical and methodical level, weak subject base of pupils. Sometimes, clubs are turned into extra classes to repeat the classrooms topics. So, a lot of pupils refuse to attend clubs' activities because of their lack of interest and pattern, similarity to the ordinary lesson. However, the analysis of STEM education clubs showed that all STEM technologies lessons are interesting for the participants. They are aimed at developing logical thinking and imagination, teaching teamwork, responsibility for the results not only of group activity, but also for personal part of work, etc.

STEM education introduction in the educational process will allow students to form the most important characteristics that determine a competent specialist:

• the ability to see the problem and identify in it as many parties and connections as possible, the ability to formulate a research problem and determine the ways to solve it;

• flexibility as the ability to apply knowledge in different situations, to understand the possibility of other points of view on solving problems and stability in defending one's position;

• originality in solving problems, the ability to abstract and to concretize, to analyze and synthesize, to feel the harmony in organizing an idea.

In many countries (Canada, Finland, Singapore, and others), a variety of strategies are being used to identify, at school age, the students' ability to learn and, where appropriate, provide them with comprehensive support.

In the middle and senior classes of many secondary schools in Ukraine there is a division of classes in the following areas: mathematical classes, science classes, computer science, philological classes and others - the so-called specialized training. There are different points of view: positive and negative points. One of the motives is the idea that it leads to the formation of homogeneous classes, teaching becomes more directed.

Specialized training differs from general education with more specific professionally oriented characteristics of motives, goals, means and results of educational, productive, creative activity, which act in relation to the student in the form of certain requirements. Students should move from a general to more specific activity training. It involves a specific specialization, specifying training activities around a particular group of professions. Over time, this orientation will be narrowed down and specified in vocational training in secondary specialized or higher education institutions.

Some schools have their own focus, specialization. This specialization increases the number of lessons spent studying the subject and organizes additional activities. Based on the students' cognitive interests in the relevant profession, it is possible to orient them to a definite study profile, and vice versa, knowing the abilities and interests of students in some subjects of the educational cycle, you can offer the appropriate profile, and later the profession itself.

4 Experimental results of research

In order to study the attitude of teachers of natural sciences to innovative teaching methods use, in particular, STEM technologies, non-traditional, integrated lessons and its introduction into the educational process and cross-curricular connections, a questionnaire of teachers was conducted:

1. Is it necessary to formulate basic concepts about STEM education in students?
2. Is it possible to form an understanding of independent search in solving tasks by students in the traditional system of education?
3. Does the method of teaching in the natural sciences affect students' formation of imagination, attention, memory?
4. Does the use of STEM technologies develop students' personal responsibility, social competence?
5. Do you need a methodology for the formation and development of vocational training opportunities in basic / secondary or higher education?
6. What slows down the process of formation and development of STEM-competence of students?

The results of the answers of the five questions (Fig. 1) indicated that the interviewed teachers considered such lessons are important and necessary, but they are not always ready to use them. Teachers point out that in the traditional educational system without proper methodological support the study of STEM-disciplines is not complete. Students should be encouraged to make scientific activities, to direct and control of learning process. Otherwise scientific competences formation, understanding of natural processes will be minimal.

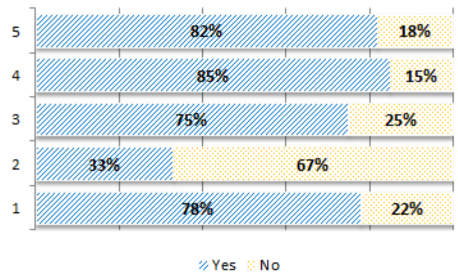

Fig. 1. Questionnaire distribution of answers.

Therefore, use of STEM technologies and innovative methods in the learning process is possible, provided the appropriate methodological support and teachers' training. It will help to develop understanding and perception of achievements in natural, technical, technological fields and contribute additional intrinsic motivation.

The sixth question has the answers:

• Lack of interest, conscious attitude, students' motivation to study.
• Low level of basic school training of students.
• Insufficient amount of methodological support.
• The topic of the subject is studied at the low level.

Researches confirmed [15, 16] that the shortcomings highlighted by teachers can be decided as follows:

• Ensuring the study of natural disciplines by systems of practical problems with STEM technologies.
• Modern methodology development of the educational process organizing in natural sciences study.
• Material base strengthening with instruments for conducting / demonstrating experiments, researches, and ICT tools.
• Improving the activities of various math, science, engineering, and modeling clubs is the foundation of STEM competencies.

As mentioned above, additional intrinsic motivation contributes to the choice of the direction of further study.

One of the experiment's stages was the study of the motivation of professional self-determination of high school students. Choosing a profession is one of the major life choices a person makes. It is important to the individual and society. Choosing a profession is a prerequisite for future successful professional activity, essentially choosing a life path, one's place in life.

The data of three schools with advanced study in mathematical, philological and non-core subjects were analyzed in the study (Fig. 2). The data of graduates' entrance from these schools in the specialty in universities / colleges for the last five years have been analyzed. We were interested in further training of these graduates. The list of branch of knowledge and specialties was taken in accordance with [17].

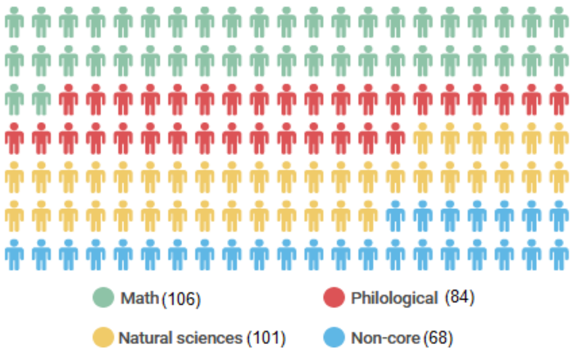

Fig. 2. Students' ratio in the study.

Some branches of knowledge have similar subject areas. For example, the branch "01 Education / Pedagogy" has a specialty "014 Secondary education (by subject specialties)". The specialty, in turn, has 16 specializations, among them "014.04 Secondary education (mathematics)", "014.05 Secondary education (biology)", "014.08 Secondary education (physics)" and others. There are also some branches such as "09 Biology", "11 Mathematics and Statistics", "14 Electrical Engineering" and others. We group the number of graduates. The results are presented in table 1.

Based on empirical research, it has been determined the graduates studied in the specialized class with advanced study of mathematics, the most popular are the specialties of branches of Tech knowledge: Information Technology, Transport.

Among the classes with a natural specialized training, more of graduates chose the branch of knowledge of Social and Behavioral sciences, Natural sciences in a second position. Among the graduates of the Philology training, the most selected are: the Humanities, Management and Administration. The branches of knowledge of Management and Administration, Health care, Law are in demand approximately equally for the three groups, both in absolute and relative terms (in the range of 8,5-13,1%), as well as "their" specialized for the appropriate group (from 15,8 to 20,8%).

Table 1. Graduates' distribution table by directions.

Branch of knowledge	**Math, %**	**Philology, %**	**Sciences, %**	**Non-core, %**	**All Num**
Transport	19,8	8,3	3	22,1	46
Information technology	20,8	4,8	7,9	1,5	35
Electronics and communications	0	0	4	7,4	9
Natural sciences, biotechnology	6,6	3,6	15,8	2,9	28
Production and technology	2,8	0	10,9	0	14
Agrarian sciences and food	2,8	1,2	5	16,2	20
Mechanical engineering	2,8	0	0	5,9	7
Automation and instrumentation	1,9	0	0	0	2
Architecture and construction	2,8	0	2	0	5
Management and administration	11,3	13,1	4	7,4	32
Health care	9,4	13,1	9,9	4,4	34
Law	8,5	11,9	12,9	1,5	33
Humanities	0,9	29,8	3	2,9	31
Culture and art	1,9	7,1	3	7,4	16
Service sector	1,9	2,4	0	4,4	7
International relations	1,9	1,2	1	0	4
Social and behavioral sciences	2,8	1,2	17,8	10,3	29
Education / pedagogy	0,9	2,4	0	0	3
Military activity, security	0	0	0	5,9	4
The overall result					359

The summary table 2 presented the highest number of people (%) chose specialized training closely connected to the future profession. Graduates who did not have specialized training, there is the choice for the considered directions averages 26,9% (almost a third) of considered categories of destinations.

Table 2. Table of distribution by training.

%	**Tech**	**Science**	**Philology**	**Other**
Math	51,0	21,7	2,8	24,5
Sciences	27,7	48,5	4,0	19,8
Philology	13,1	19,0	31,0	36,9
Non-core	36,8	33,8	2,9	26,5

Studies of motivation in learning have shown that "although there is not a perfect relationship between motivation and learning, there is a tendency to align attitudes, which are predispositions to behaviour, with behaviour itself. This means that initial or pre-training motivation promotes a predisposition to learn and to learning itself. At later stages, it also promotes a predisposition to transfer and make use of the learning outcomes in other contexts" [18].

The survey "Motives for choosing a profession" was conducted [19]. This technique allows determining the leading type of motivation at choosing a profession. The questionnaire consists of twenty test questions that characterize any profession. The study used the "Motives for choosing a profession" the method of K. Zamfir in the modification of A. O. Rean [20]. This test allows to determine the relevance of the following types of motivation: 1) material remuneration; 2) the pursuit of career advancement; 3) the desire not to be criticized by the manager and colleagues; 4) the desire to avoid possible punishment or trouble; 5) orientation to prestige and respect from others; 6) satisfaction with a job well done; 7) public utility of labor.

On the basis of empirical data, motivational complexes of the following types are obtained: at ISM > EPM > ENM or ISM = EPM > ENM is the optimal one in which the ISM (internal significant motives) are high; and it is sufficiently high in the case of EPM (external positive motivation) equal to or lower than ISM; it is low – if ENM is very low and close to unity.

We conducted a diagnostic survey (assessment of the level of formation of the motivational level) of choosing a specialized study of students of the Faculty (123 respondents), we obtained the following results (table 3).

Table 3. Survey's results.

	Number of respondents
Internal individually significant motives (ISM)	25
Internal socially significant motives (ISSM)	34
External positive motives (EPM)	44
External negative motives (ENM)	20

Students were asked to complete questionnaires. The results of the answers were evaluated on a 5-point scale: 1 point – "very small", 2 points – "to a very small degree", 3 points – "not to a large extent, but not to a small extent", 4 points – "in large enough, 5 points – "very large".

Students needed to evaluate the extent to which each of them influenced their choice of profession. The technique can be used to identify the predominant type of motivation (internal individually significant motives, internal socially significant motives, external positive motives and external negative motives).

Research's results presented EPM > ISSM > ISM > ENM, it is considered that the studied motivational complex is optimal. The high weight of (ISM + EPM) and the low weight of ENM (16%) directly correlate the students' satisfaction by the chosen profession.

The high level of ISM indicates the educational activities of students for the sake of knowledge, education, culture, and not for receiving rewards, praise, etc. Students with a sufficiently high motivation complex are interested in the chosen profession, but there is also a desire to receive external rewards, it is partly a means to personal gain. The presence of low indicators of the motivational complex (16% of ENM) implies indifferently, and even negative attitude to the learning process and choosing the profession as a whole.

Thus, descriptive statistics have shown that the findings of this study are consistent with our assumption that motivational beliefs are important and necessary for shaping the professional orientation of students of different degrees.

5 Conclusions and future work

The research presented the early attracting of students in advanced study of disciplines and STEM activities influence the choice of future profession. But it does not solve all the problems of professional self-determination formation in high school students. There are manifestations of self-selection of professional, life platform and goals. The research also presented the choice of the specialized training of students is influenced by the motivation for specialized-based learning. On the basis of differentiation of interests of students due to the specialized training, as well as the integration of academic subjects, students develop an individual style of mental activity, focus on deepening knowledge in the chosen field of activity, and improve mental and special abilities in the orientation to future profession. Thus, we found that the next choice of future profession is influenced by early attracting in advanced study of disciplines. Students who study mathematics, physics, and computer science more often choose a profession related to engineering, technology, or science, and have a career in STEM.

Thus, motivational beliefs are important and necessary for the formation of the professional orientation of applicants for education at various levels. Creating an academic climate emphasizes the importance of learning, mastering and improving mathematical and scientific competencies. This contributes to both productivity and perseverance in these subjects through a positive impact on students' beliefs.

So, we found the next choice of future profession is influenced by early involvement in advanced study of disciplines. Pupils who study mathematics, physics and computer science more often choose a profession related to engineering, technology or the exact sciences.

The research presented if the special attention is given to conduct STEM activities of school / student youth, to improve abilities, learning strategies, motivation of the chosen activity I educational environment. It leads to the understanding that the efforts will lead to success. The purposeful development of STEM education should be the basis for the further formation of all special competencies and students' professional training.

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