Determining the Level of Readiness of Teachers to Implementation of STEM-Education in Ukraine

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Abstract. Research of existing models of professional development of future teachers of natural and mathematical disciplines and professional teacher has shown that the creation of an educational environment for STEM-oriented learning affects the formation and further improvement of the system of their values. In this paper, the concept of STEM-education in terms of inter-discipline is considered. An attempt was also made to identify the factors that influence the readiness of teachers to support STEM-education and implement it in educational institutions. This study is concerned with determining the level of formation of teachers' readiness for the implementation of STEM-education in Ukraine. Here we propose a methodology and a model for determining the level of readiness through surveys and analysis of results. On the basis of the obtained results, further prospects of the research are proposed and recommendations for involving young people in scientific activities, which may improve learning of Science, Technology, Engineering, Mathematics (STEM).

Keywords: cooperation, exchange of experience, integration, collaboration, STEM, survey, questionnaire, education.

1 Introduction

One of the promising areas that address the issues of providing queries in the labor market, education in science, technology, engineering and mathematics (STEM-education): creation of conditions for a balanced harmonious formation of science-oriented education on the basis of modernization of the mathematical and naturalistic and humanitarian education profiles. Interest in STEM is growing worldwide. This is indicated by the number of publications and studies in different countries. For example, in a review [1] examines 44 published articles on the topic of STEAM (Science, Technology, Engineering, Arts, Mathematics) education from 2007-2018 was made. Interesting information about statistics that Google leads on request. In the world,

there has been an increase in interest in STEM education in the last five years (Figure1).

In this case, searches in most cases relate to STEM-education tools, as well as degrees and levels of education, education departments, stages.

Fig. 1. Relative number of queries statistics on the theme of STEM in the world over the past five years

In Ukraine, STEM-education began to be interested relatively recently: the first queries appeared in 2007 year. The leaders in these queries are Kirovograd region (Figure 2). Mostly looking in the context of such phrases as: toolkit, summer camp, topic, tournament.

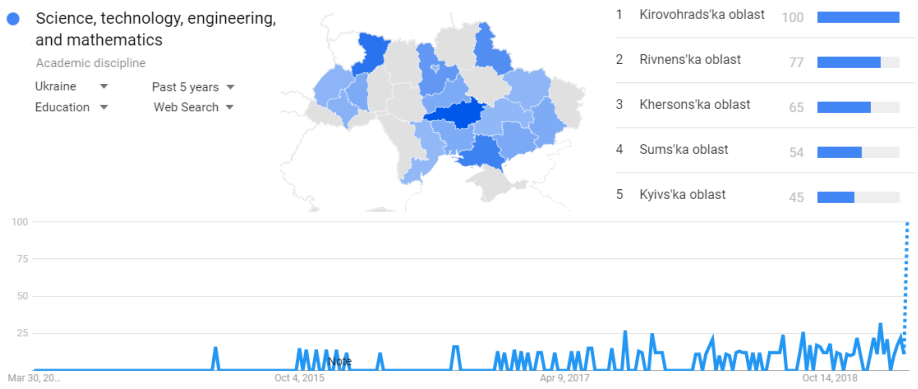

Fig. 2. Relative number of queries statistics on the theme of STEM in Ukraine over the past five years

Development and implementation of education programs in the field of science, engineering, engineering and mathematics (STEM) in the educational process is able

to provide the needs of the labor market by highly skilled professionals. Accordingly, there is a need for trained teachers, teaching methods and upgraded training programs.

"The quality of an education system cannot exceed the quality of its teachers and school leaders – and the quality of teachers and school leaders cannot exceed the quality of work organization, professional development and support provided by and to schools and local communities" [2]. Therefore, the problem of determining factors influencing the construction of a model for the professional development of future teachers in the STEM education is actual.

The purpose of the article is to study the level of formation of participants' readiness for the implement of STEM-education in Ukraine and identify of factors influencing the professional development of the future teacher of natural and mathematical disciplines.

2 Related Work

Today in the world there are more than a dozen analogs of interdisciplinary integration: STREAM, STEMLE, iSTEM, eSTEM, METALS, MINT, GEMS, etc. This is a combination of basic disciplines (Science, Technology, Engineering, Mathematics) with logic, law, robotics, gender issues, ecology, etc. The leading principle of STEM-education is project activity. It has characteristics such as: interdisciplinarity (integrated learning), collaboration (active communication and teamwork), availability of results (application of scientific and technical knowledge in real life), preparation of children for technological innovation of life. Technology itself cannot create an environment for sharing knowledge, although it is a very important element of a knowledge management system. The use of modern digital technologies should support the necessary elements of interpersonal communication, because they make the process of sharing knowledge more intense. In this regard, it is necessary to pay attention not only to the material and technical part, but also to the organization of training activities.

Students cannot fully benefit from interdisciplinary studies until they acquire a solid grounding in the various disciplines that interdisciplinarity attempts to bridge [3]. Therefore, sufficient attention should be given to the basic subjects in the training of future teachers. Also, the key to learning is the support of STEM teachers by the institution of education in this direction.

The issue of STEM support by the institution of education in scientific works is called the school STEM culture. A survey carried out in [4] revealed that the issue of school STEM culture formation is an important factor in the professional activity of teachers. The main issues of the formation of school STEM culture that have expressed the focus groups of the survey can be divided into three categories: cooperation, exchange of experience, integration (Figure 3).

Cooperation	between lecturers and administration
	between teachers and parents
	in professional communities
Exchange of experience	professional development training, workshops
	in professional communities
Integration	in the curriculum of science add mathematics and technology
	Have PD specifically in STEM and technology to help illustrate discipline in-tegration

Fig. 3. Components of school STEM culture for [4].

In 2010, an attempt was made to compare educational curricula for teacher education in a European project SITEP [5]. The purpose of this study was to obtain information on the content of curricula for future teachers, as well as the identification of competences and skills that are important for the formation of professionals.. As a result of this study, some suggestions were made to improve the practice of pedagogical education at different stages of learning from various parameters:

- Knowledge of the subject area is the main criterion for evaluating the learning activity of a future teacher and teacher with teaching experience.
- Self-assessment and independent professional development are sufficient for an experienced teacher, but for a future teacher it will be more expedient to manage self-esteem.
- Own learning experience is often transformed into transferring it into professional activity. Therefore, the use of teaching different practices and approaches will have a positive effect both in teaching and in the professional activity of teachers.
- Collaboration with colleagues (future colleagues) will provide an incentive for professional growth.
- Involving teachers with teaching experience in developing and implementing a rating system will enable the formation of professional standards that will affect the quality of future teachers' training.

Qualifications for teachers who are already working should be supported by short-term courses. Adult education, associated with active cognitive activity and research, creates a positive experience of using technology. It helps not only to quickly perceive information, but also to apply it in its practice and create new knowledge. [6].

According to the study [7], teachers teach how they studied themselves. Therefore, the initial training of teachers for teaching STEM, as well as advanced training, requires appropriate changes in the orientation of values, as well as in the form of training [8, 9].

Among the organizational forms of teaching, today the most common frontal (lecture), group, individual activity (Figure 4).

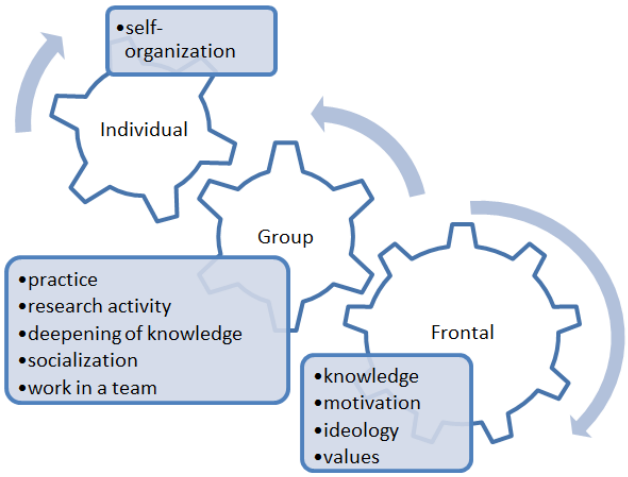

Fig. 4. Organizational forms of education, and the emerging qualities

Each of these forms affects the development and formation of a certain group of qualities. In particular, for all forms of learning, the development of cognitive skills is inherent due to the combination of theoretical knowledge and practical activity. The use of these forms in STEM-education has modern types of cognitive activity that provide the formation of such qualities (Figure 5).

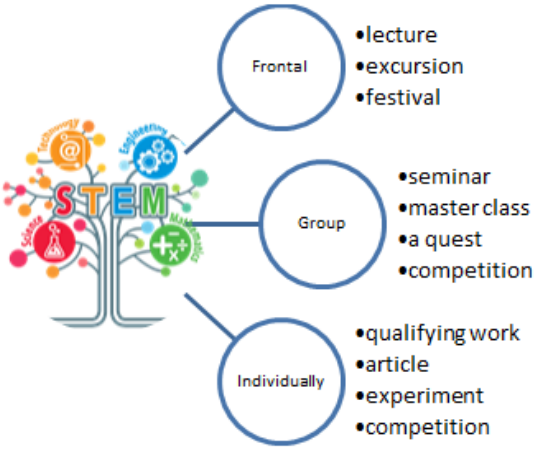

Fig. 5. Types of cognitive activity for various organizational forms of learning

The studies analyzed in [10] document that active learning leads to increases in examination performance that would raise average grades by a half, and that failure rates under traditional lecturing increase over the rates observed under active learning. Therefore, the usual types of cognitive activity for various organizational forms of learning should be characterized primarily by the activity of students and involve them in active discussion and problem solving.

There are different types of interaction between participants in the framework of interdisciplinary work. In work [11], interdisciplinary activities are presented as social interaction. According to the authors, interdisciplinary research is team research entailing social interaction among the research team in order that the disciplinary perspectives may interact. Therefore, for the process of actually achieving integration involves both social and cognitive elements. This work was presented four ideal types of socio-cognitive frameworks group learning:

- Common group learning - The result of the group's work is the collective intellectual property of the group. In such a group it is not possible to identify specific specialists - the expert is group.
- Modeling – is a structure that is need not be constructed by the entire research team. It may be imported intact from outside sources. Takes into account the individual contribution of each in the formation of a new intellectual result.
- Negotiation among experts – unlike common group learning, negotiation does not render team members expert in every aspect of the project. Negotiation among experts is not the dominant framework for integration. Effective integration requires to substantively reflect the inclusion of the findings of the all expert analyses of team members.
- Integration by leader – it involves a communication pattern in which the problem is divided by the leader on the basis of team members expertise. This type of interaction is more suitable for multidisciplinary.

Thus, social interaction and interaction in the professional environment are necessary and useful in terms of personal and professional growth [12].

3 Experimental Settings

In order to identify teachers' readiness for the support and implementation of STEM-education in Ukraine, we conducted a survey among 144 teachers of natural and mathematical disciplines. The survey was attended by teachers from different schools and different specialties.

Almost a third of the respondents were teachers of natural sciences (chemistry, biology, etc.). Among respondents 83% were teachers. Teachers of the directions "Mathematics" (34.8%), "Physics" (19.6%), "Informatics" (17.4%) turned out to be the most.

The questionnaire contained three types of questions: assume one-choice answers, assessment on a scale from 0 to 5 and free-answers. Were asked teachers to rate their knowledge and skills on a five-point Laickert scale.

4 Experimental Results

The survey consisted of 10 questions on awareness of STEM education issues and 4 questions on the educational activity of teachers.

The question about the level of awareness in STEM education was asked to answer in scores from zero ("I hear about it for the first time") to five points ("Actively use STEM-technologies").

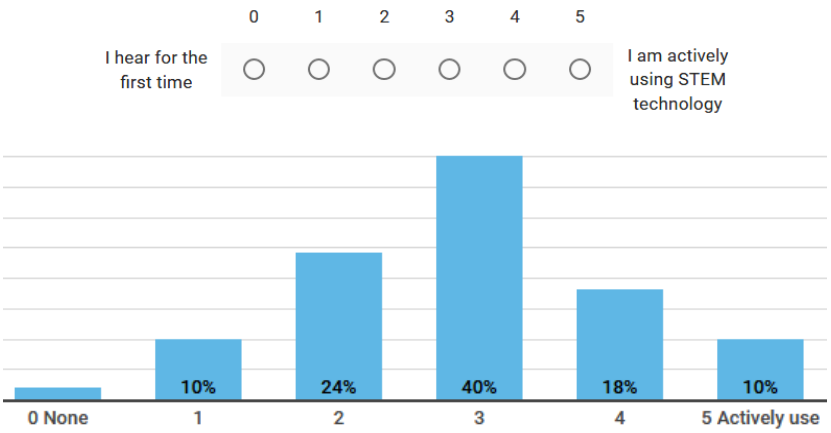

Fig. 6. Questions and answers about the level of awareness in STEM education

A sufficiently large number of teachers have an understanding of STEM-education, as were show answers presented in Figure 6. Against the background of previous results, the share of teachers who are not familiar with the concept of STEM education has decreased (previously it was 43%) [13]. Conducting on-line courses, webinars, popularization of festivals, as well as the work of the community of active teachers led to a better awareness of STEM-education. Some respondents answered negatively to this question. In the future, their answers were excluded from the analysis.

In the question of the combination of which subjects are best suited for STEM education, teachers could choose no more than four subjects.

Preference received such disciplines as computer science (21.2%), mathematics (19.7%), physics (19.2%) and technology (15.2%). All other disciplines in the nature-mathematical cycle received less than fifty percent. Some of the polled indicated philology. Such a division is due primarily to the specialization of the teachers themselves and the possible prediction of the use of STEM-education in their work. Such results can be considered a reflection.

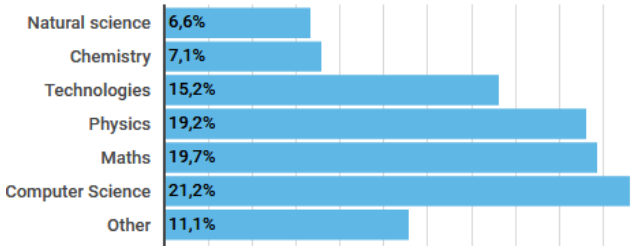

Fig. 7. Answers to the question of the best combination subjects for STEM education

The question "Which of the statements is true for STEM-education?" The respondents were asked to select several allegations from the proposed.

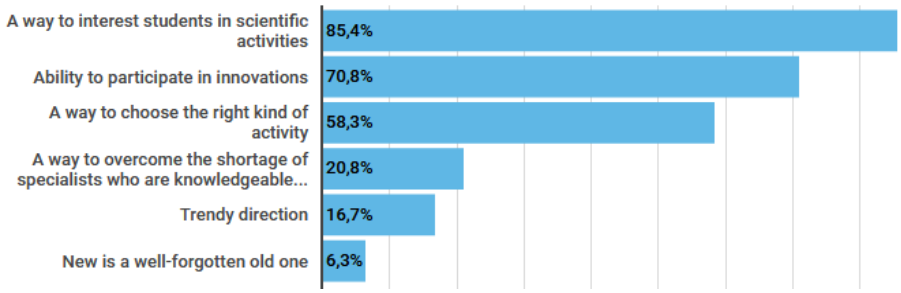

Fig. 8. Answers-statements about STEM-education

STEM education is associated with a promising area that will help students engage in research in the world (85.4%) believe the majority of teachers. as well as the ability to be involved in innovation (70.8%). Some teachers expressed doubts about STEM education (16,7%).

On the question "How are the properties of STEM education best described it?" Several variants of options could be made in order to determine the association's educational technologies with this area of activity.

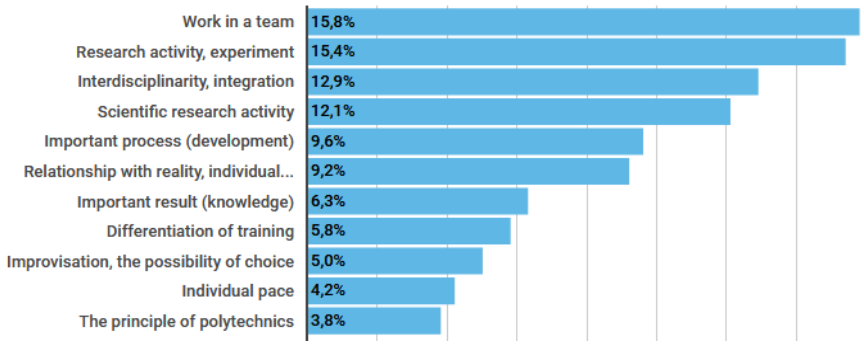

Fig. 9. Responses to the characteristics of STEM education

According to most teachers, the most characteristic of STEM education is team work (79.2%), research activities and the ability to experiment (77.1%). Scientific research activities (60.4%), as well as interdisciplinarity and integration (64.6%) are also important. These results are in good agreement with the results of work [4]. For the teachers is main interaction, integration, and exchange of experience, as described above.

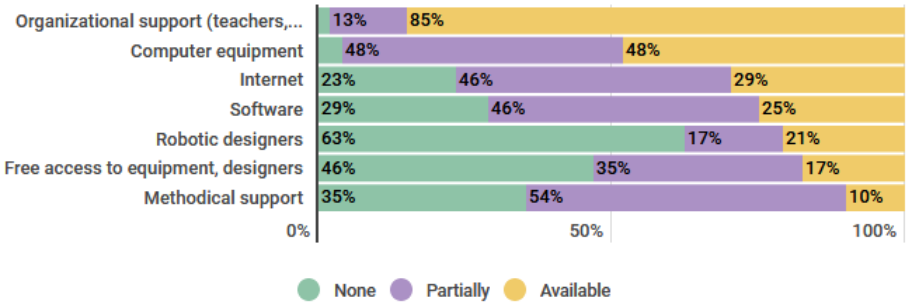

Fig. 10. Available resources for STEM training

Figure 10 shows the responses of respondents about the provision of schools to support STEM education. As can be seen from the answers, there is a lack of material and technical basis, an indirect evaluation of organizational support and methodological materials.

In the next question, the teachers could express their wishes "What is to be done to the educational establishment for the introduction of STEM-education?" (Figure 11).

Fig. 11. The most popular answers to the question of teachers' needs for the implementation of STEM-education

Most of the teachers called for the restoration of the material and technical base and funding for this direction. But some teachers still need methodological and organizational support. It should be noted that one of the answers was "Time".

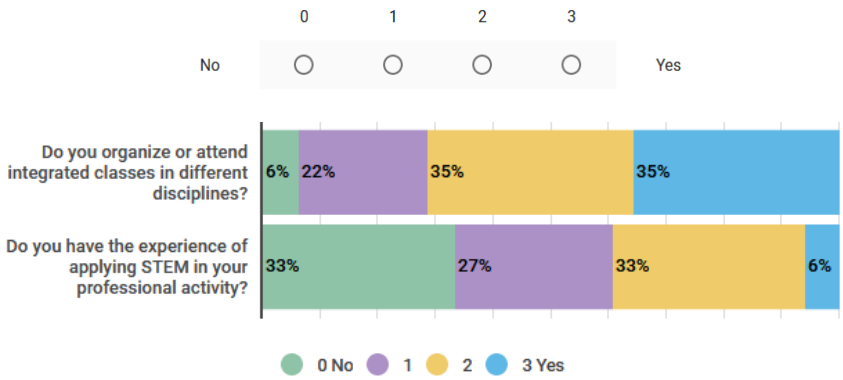

Fig. 12. Questions and answers about carrying out of integrated classes

The following two questions related to the activity of the teachers themselves: "Do you organize or attend integrated classes in different disciplines?" and "Do you have the experience of applying STEM in your professional activity?". Answers should have been indicated in scores from zero (option "No") to three points (the answer "Yes"). As can be seen from Figure 13, most of the teachers conduct integrated classes in their disciplines. At the same time, on the other question the majority answered was "no".

Such various answers say that there is still no full awareness in society and in the professional community that is STEM education and STEM technology. This concept is quite new and more attention needs to be paid to the formalization of the concepts of this direction and to familiarize the general public with its main concepts. It is also possible not to realize the value of their own activities and to compare it with existing practices.

The answers to the question "Who is the participant / organizer of which STEM events you are?" Most had negative responses. Teachers were able to determine the extent of their engagement to active engagement, as well as indicate which activities they are organizing. In the end, the answers to this question are in good agreement with the results of the previous question (Figure 13).

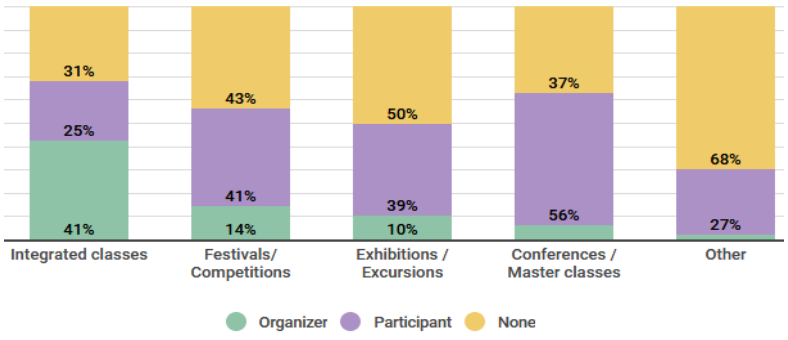

Fig. 13. Answers to questions about attending and organizing events by teachers

The relative number of negative responses was almost half of the total (47%). Other teachers are ready to participate with their students in events. At the same time, a significant number (38%) of active teachers perform passive participation as a participant, not an organizer (15%).

Relatively large activity in the integrated lessons is due to the fact that most of these lessons are conducted as Parallel Discipline Designs or Interdisciplinary Units / Courses according to the above classification [14]. That is, short-term projects that can be implemented within school activities. Among the responses to the forms of activity were basically case studies, workshops, seminars and web conferences.

5 Conclusions and Future Work

It is obvious that the main advantage of STEM-education is the formation of a community of specialists with a scientific outlook, ready to use technologies in their professional activities. However, this requires an appropriate organization of learning activities and other approaches to the formation of a community of teachers who are ready to support and implement this learning technology.

However, after undergoing training according to their specialty without using modern forms and methods of teaching, teachers give preference to those forms that they are known or need to be passively involved.

Using STEM-education as one of the learning technologies requires teachers and future teachers to be ready to change the educational environment and communicate in professional communities.

The survey conducted allows us to draw the following conclusions:

- Knowledge on STEM education is growing, but the general level of understanding of its basic principles as a technology and remains relatively low at this time.
- Given the recognition of the leading role of cooperation in STEM-education, part of teachers are ready to independently organize interaction in the educational activities of students. But most teachers are ready to passive participate in activities that focus on STEM education.
- Collaboration, integration and the exchange of experience play an important role in shaping the active community of STEM teachers. Therefore, in order to attract future teachers to the professional community, it is necessary to use such forms that give motivation for further improvement and influence the formation of a system of their values. To change the situation, it is necessary to include in the course of raising the skills of teachers, such activities as excursions, master classes, to engage in festivals and competitions.

The analysis of the results gives an opportunity to formulate prospects for further research. A promising direction is the development of programs of training modules for formal and non-formal education of future teachers of natural and mathematical disciplines. The influence of interdisciplinary programs on the readiness of teachers to support and introduce STEM-learning in the educational process has been proved. That is why it is necessary to create in the educational institution an educational envi-

ronment for STEM-oriented learning, which will ensure cooperation, integration and exchange of experience among all participants in the training.

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