# Theoretical Bases of Application of Free Software in Preparation of Pre-service Teachers of Mathematics, Physics and Computer Science

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Abstract:     Modern development of education is associated with the use of information and communication technologies. To date, there is considerable experience in the use of computer training systems. New forms and methods of teaching based on modern information and communication technologies are being developed and used, the concept of e-education has appeared. In relation to free software, the period of systematization of the accumulated experience and its theoretical substantiation of application in educational activity has come. The proposed theoretical basis provided an opportunity to develop a system of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science, which contains the conceptual, semantic, technological subsystem and subsystem of qualitative and quantitative indicators. The main purpose of the use of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science is to increase the level of formation of information competence, which can not be fully formed without free software.

## 1 INTRODUCTION

At all stages of development and functioning of the education process its formation was carried out using certain methods, techniques and tools (Semerikov et al., 2021). The peculiarity of the current stage of development of education is that in the arsenal of techniques and tools used in the preparation of pre-service specialists are both traditional (printed) and digital (electronic) materials. Ensuring open around the clock, access of students to electronic education today is one of the priorities of information science, education and culture of Ukraine. In this regard, the role and functions of teachers are significantly changing. It should be noted that a special role in this process is played by information and communication technologies (ICT) as part of information-educational environment and include digital libraries, electronic educational resources, search engines and aggregation of information, which are based on the use of free software.

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## 2 RESEARCH QUESTION

Free software is the release of ideas of open scientific achievements in the field of computer science. It is because of this that free software has been developed in direct dependence on the academic environment. Despite its origin, it is not sufficiently represented in education due to a number of factors that constrain its spread (Velychko, 2016). Outsourcing has allowed to develop not only social networks and electronic resources, but also free software. Despite the fact that free software does not have marketing support for its distribution, its occasional use raises questions about its use in educational activities.

Today, various universities around the world are conducting research on the use of free software in educational activities. The results of application studies at Chu Hai College of Higher Education (Hong Kong, China) are presented by Duan and Lee (Duan and Lee, 2020). The largest free software project in education, involving 6 million students and 200,000 teachers each year in Kerala, India, is described in a study by Thankachan and Moore (Thankachan and Moore, 2017). An interesting review of the application of free and open source software is published by Gupta and Surbhi (Gupta and Surbhi, 2018). The pa-

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per presents not only analogues of application software but also training software. The authors conducted a study among Delhi teachers. This analysis gives an idea of the low prevalence of free and open source software and its causes.

Coca Bergolla and Pérez Pino (Coca Bergolla and Pérez Pino, 2021) offer free software to study artificial intelligence. To do this, the authors have developed a model of integration of educational free software to the educational process of studying artificial intelligence. The experiment allowed to draw a conclusion about the efficiency of the proposed model and the possibility of its application to the study of other sections of computer science. A similar study is described by Horvatić et al. (Horvatić et al., 2020) on the use of free and open source software in electrical engineering education.

For most information technology users who use free and open source software, the motivations of software developers are still unclear. The answer to the question of motivation to develop free and open source software is given by Daniel et al. (Daniel et al., 2020). Examining the internal and external motivations of the authors on the developers of free and open source software, the authors found those that promote the development of free and open source software and those that hinder its development. Another problem for free and open source software developers is outlined in Lee (Lee, 2018) work. The author explores the problem of involving volunteers in open projects and their short-term participation in projects.

Summing up, we present the conclusions of UNESCO on free software – "model provides interesting tools and processes with which women and men can create, exchange, share and exploit software and knowledge efficiently and effectively. FOSS can play an important role as a practical instrument for development as its free and open aspirations make it a natural component of development efforts in the context of the Millennium Development Goals (MDGs)" (UNESCO, 2020).

## 3 RESULTS AND DISCUSSION

The content of the educational process in higher educational pedagogical institutions is determined by effective programs used to train pre-service specialists in that particular university. The content of the educational training of a university is being approved by the Council of the pedagogical university, while the choice of content, forms, means and methods of work is determined by the individual departments and teachers with consideration of specifics of each

educational direction. Software products which are used and guidelines developed by university teachers taking into account specifics of preparation of pre-service teachers create the basic component of fundamental training. In the modern paradigm of education, it is necessary to develop educational standards which provide content of training upgrade as well as education of the younger generation on the principles of humanization, differentiation and integration.

The main *objective* of introducing of free software in the training of pre-service teacher of Mathematics, Physics and Computer Science lays in the formation of a new citizen of the information society, who feels comfortable in society, freely operates with information through ICT, respect the opinion of others and has his own opinion and knows how to deliver it, is capable of self-education, self-analysis and has a motivation to obtain new knowledge and to self-improvement, while also understands the importance and inevitability of information education and society at large, giving preference to the latest information and educational technologies. In this case it refers to the use of free software for the transition to a new type of training of pre-service of Mathematics, Physics and Computer Science, which includes:

- creation of optimal conditions for the acquisition of general and professional competencies and actualization of the intellectual potential of pre-service teachers of Mathematics, Physics and Computer Science;

- promoting comprehensive and harmonious development of pre-service teacher of Mathematics, Physics and Computer Science as subjects of education process and information society;

- creating suitable conditions for the emotional and intellectual enrichment of pre-service teacher of Mathematics, Physics and Computer Science as the basis of development and strengthening of political, social, economic, humanitarian, cultural and informational aspects of public life in the interest of the welfare of citizens, economic efficiency and country's growth.

Strategy *aims* related to the use of free software in preparation of pre-service teacher of Mathematics, Physics and Computer Science need to be determined in accordance with the benefits that its implementation provides to the educational process, which, in our opinion, are:

- free access to software and its source code;

- safety, reliability and stability of the software;

- overcoming of the digital divide;

- open standards and independence from the developer;

- compliance with intellectual property rights, fight against piracy;

- ability to fully adapt to suit individual needs;

- unlimited number of simultaneous installations on multiple computers in educational institutions and at home;

- the ability to obtain derivative software products, use it in their own development;

- possibility of software localization.

To achieve these objectives, it is necessary to provide the following basic *measures*:

- analysis of didactic capabilities of free software through the procedure of examination and creating repositories of the recommended software provider;

- creating methodological, psychological and technological support for the use of free software in the preparation of pre-service teacher of Mathematics, Physics and Computer Science;

- analysis of readiness of subjects of the educational process for the use of free software;

- changing priorities as to the use of ICT in professional fields from studying certain software to studying technologies used to process information which in turn results in fundamentalization (see definition (Semerikov, 2009)) of the training of pre-service teacher of Mathematics, Physics and Computer Science).

Introduction of free software in the process of professional training of pre-service of Mathematics, Physics and Informatics is not an aim in itself – it is first of all a way of enhancing performance based on changing priorities of study and use of ICT in education. Currently, there is no single approach to the introduction of free software in the educational process; however, a considerable attention should be paid to implementing the following key principles.

*The principle of reforming educational processes.* The main prerequisite for the successful use of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science is the understanding that these changes are not only in the analysis of its capabilities and in creating guidelines for such a process – primarily to create a new vision and new priorities for use of ICT. The use of free software, due to its openness and accessibility, expands the possibilities of using ICT anytime and anywhere. Such opportunities make it possible to create open information systems, without which it is impossible to

obtain modern quality education and lifelong learning. The alternative of free software gives grounds to talk about its use as a means of solving problems, and not as an object of study – so the information and communication technologies, their mastery and use, and not the means of implementation come to the fore.

*The principle of motivation to use free software.* The use of free software, like any innovation, requires modern changes in the principles of learning and use of ICT in education. In order to include free software products in the list of software used in the professional training of pre-service teachers of Mathematics, Physics and Computer Science in higher pedagogical education, it is necessary to have both internal and external motivations for this process, based on the need for multifaceted and thorough training. pre-service teachers of Mathematics, Physics and Computer Science in the direction of awareness of information and communication technologies and an internal vision of their current state and the ability to analyze the constant updating of the information and communication technology industry. Motivation is the great impetus that will allow to gain direct support from the state and implement initiatives to use free software, adapting them to today's pedagogical tasks in the training of pre-service teachers of Mathematics, Physics and Computer Science.

*The principle of strategic initiative.* Taking into account the realities of austerity and taking into account the current needs of education, in particular the need to finance the training of pre-service teachers of Mathematics, Physics and Computer Science, we outline the main priority projects, which would be funded on a "protected" basis. Such projects should be characterized by a clear educational value, measured by certain criteria.

In terms of content, we are close to the position of UNESCO experts, who attributed it to strategic initiatives (UNESCO, 2014):

- introduction of information and communication technologies in the development of education, science and social knowledge (harmonization of general principles of building social knowledge; expanding learning opportunities through access to various content and delivery systems; improving research, dissemination of information and cultural exchanges; the use of ICT to build intellectual capacity, empowerment, governance and social participation);

- lifelong learning, including by means of distance education (expanding access of adults to higher education; organization of education near the place of residence; providing access to higher ed-

ucation by distance methods; reorganization of the learning process and structure of educational institutions taking into account the educational needs of adults);

• training of professional and pedagogical staff to work in a high-tech educational environment (expanding training opportunities for teachers through the use of technological means; improving the training process based on technological support in the form of appropriate programs and pilot projects that contribute to the successful implementation of educational tasks; popularization of ideas to ensure the quality of professional and pedagogical training of teachers, growth of a positive image of pedagogical professions).

*The principle of cooperation.* The need to introduce new forms of relationships both between the subjects of the educational process and in cooperation with the community of developers and users of free software. First, teachers must overcome their unwillingness to work with pre-service teachers of Mathematics, Physics and Computer Science to create and use e-learning resources based on open standards and free software. Overcoming such unpreparedness can occur through the introduction of educational disciplines in the educational process, the content of which is based on the study of the principles of development of electronic educational resources, rather than the acquisition of apathetic user skills. Second, cooperation in the development and application of free software will help the subjects of the educational process to carry out effective reforms, which will accelerate the process of practical application of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science.

*The principle of open systems.* One approach to implementing this principle is to create an information and educational environment that contains software, hard-ware, communication mechanisms, interfaces, data formats and protocols that are based on available and generally accepted standards and that provide multi-platform, interoperability and scalability of applications and shared data. Software created for use in teaching and research should be as accessible as possible to scientists and educators. Information resources that can be extremely useful in teaching and research should also be as open as possible to their use. Another approach is to use functional standardization methods – building and using a profile, i.e. a coherent set of basic standards needed to solve a specific task or a whole class of tasks. The standard system (Open System Environment Reference Model – OSE / RM), adopted in the basic document ISO/IEC 14252, is used for standardization of open systems.

The general properties of open information systems can be formulated as follows:

• interaction (ability to interact with other application systems on local and (or) remote platforms (technical means on which the information system implemented by the network is implemented);

• standardization (information systems are designed and developed on the basis of agreed international standards and recommendations, the implementation of openness is carried out on the basis of functional standards in the field of information and communication technologies);

• extensibility / scalability (the ability to move applications and data in systems and environments that have different performance characteristics and different functionality, the ability to add new features to information systems);

• mobility / porting (providing the ability to transfer applications and data in the process of upgrading or replacing hardware platforms of information systems and the ability to work with them professionals who use information and communication technologies, without their special retraining when changing information systems);

• user-friendliness (developed unified interfaces in the processes of interaction in the system "user – computer device – software", which allow the user to work without special system training).

*The principle of the rule of law, legality, equality of all subjects of the educational process before the law.* The principle of the rule of law is based on the provision that not a person is subordinate to each other, but everyone follows the rules that determine, including the form of direct interpersonal relations – through a system of status-es or agreements. Such rule of law includes degrees of freedom of free software, copyleft (an antonym for copyright), and licensing agreements under which free software is distributed.

*The principle of freedom of intellectual, creative activity.* We define creativity as the ability of an individual that can be applied in any field of activity, whether production, social communications, scientific or research activities, and so on. Mental activity and achievements of mankind are key factors in the development of society. In countries where science, culture and art are respected, the standard of living is much higher, because the achievements of intellectual activity determine the level of development of production, culture, education and so on. We are convinced that in order to increase the level of development of society, the state must be interested in the develop-

ment of science and education and, accordingly, comprehensively protect and support these areas of activity. In our opinion, such support includes direct budget financing, certain tax benefits, a system of incentives and support for investment in research and development, and so on. Note that a striking example of innovative mental activity is the development and creation of software in the case when the results of such activities are the subject of public use, have signs of openness and focus on increasing and improving the heritage of mankind. Such intellectual, creative activity meets universal needs and can be used in education.

*The principle of social responsibility* is a social phenomenon, which is a voluntary and conscious implementation, use and observance by the subjects of social relations, regulations, social norms both to the general doctrine of educational development and to the implementation of specific steps of its implementation. This principle is directly related to the informatization of education (Fedorenko et al., 2019). The process of using free software must comply with both legal and social norms, which is of particular importance in the educational process. Responsible attitude to the results of scientific, practical, creative and intellectual activities should be an important factor in the humanization of education and upbringing of a socially responsible member of society.

Defining the role and place of free software in the process of informatization of education, we note that the use of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science at the current level of informatization of educational activities plays a special role in terms of forming a certain level of information culture and intellectual development. and in terms of forming a scientific worldview, understanding the essence of the practical orientation of computer science disciplines. At the same time, the level of such training in the future should enable pre-service teachers of Mathematics, Physics and Computer Science in the process of their professional activity to create and implement new technologies, even those whose theoretical basis may not yet be developed during training.

The main features of modern information society are: introduction of information to different spheres of life; concentration in the field of information and intellectual services of more than 40–50% of the population; development of general theory of information society; exponential growth of knowledge and accumulation of information; combining computer systems into a single information environment through means of communication; creating information in a digital code; extremely high development of produc-

tion of technology and telecommunication technologies and means of communication requires a radical change in the field of education through information and adequate response to the demands of the information society.

According to the Law of Ukraine on the National Informatization Program, informatization means a series of interrelated organizational, legal, political, socioeconomic, scientific-technical, manufacturing processes aimed at creating conditions aiming to meet the information needs of citizens and society through the creation, development and use of information systems, networks, resources and information technology that are based on the use of modern computer and communications technology (Verkhovna Rada of Ukraine, 1998).

Computerization is driven by industry trends, including the informatization of education, by definition of Bykov (Bykov, 2010), is a set of interrelated organizational, legal, socio-economic, scientific-methodological, scientific, technical, manufacturing and administrative processes aimed at meeting information, computing and telecommunication needs of subjects of the educational process. Informatization of education is associated with a wide introduction of methods and means of ICT in educational system, the creation on this basis of computer-based information and communication environment, filling this environment with electronic research, education and management of information resources enabling entities to carry out the educational process, provide access to environmental resources, to use its tools and services for solving various problems.

Let's define the role and place of free software in the informatization of education. The use of free software in preparation at the present level of informatization of educational activity plays a special role in preparation of pre-service teacher of Mathematics, Physics and Computer Science in the formation of a certain level of informative culture and intellectual development as well as in the formation of a scientific outlook, understanding the essence of practical orientation of informatics disciplines. The level of this training should equip pre-service teacher and make them to be able to create and implement new technologies theoretical framework of which might yet not be developed while they are still in their training.

One of the steps of informatization of educational process, improving the quality of training of pre-service teachers of Mathematics, Physics and Computer Science, enhancing teaching and learning and scientific and research activities, the disclosure of creative potential, the increasing role of self-education,

according to Zhaldak (Zhaldak, 2003), is the creation and widespread adoption into teaching practice of computer-oriented methodology of teaching based on the principles of progressive and not destructive embedding of ICT in active didactic systems, a harmonious combination of traditional and computer-oriented learning technologies, involving past achievements of pedagogical science of the past, improving and enhancing their achievements through the use of the achievements in development of computer technology and communications.

When looking at the methodological training system of A. M. Pyshkalo using a systematic approach to the understanding of teaching methods, where all components of the educational process form a single system with defined internal connections, who defined methodical system of education as a set of five hierarchically related components: learning objectives, contents, methods, tools and organizational learning, which form a single integrated functional structure focused on achieving the learning objectives (Zhaldak, 2003). The described methodical system is a condition for sustainable development, stability and control of the educational process, which is impossible for teaching disciplines of informatics cycle and in view of the role and place of self-education in the educational process (Ponomareva, 2021). Similar arguments are used by Morze (Morze, 2003). Considering the combination of methods, tools and organizational forms of traditional methodical teaching system all if which answer the question "how to teach?", Chernykh (Chernykh, 1995) that this is the formation of a unified system of subsystems, called technology of education. Based on this structure of subsystem, they determine target, contents and technological components of methodical system of training (Semerikov et al., 2021).

Society shapes the social demand to preparation of pre-service teacher and defines objectives of any educational discipline. Thus, the modern information society is characterized by high development and use of information technology and advanced technologies which guarantee the production of information resources and access to these, processes of automatization of all sectors of production and management. While formulating the learning objectives of any disciplines, particularly fundamental, characteristics and requirements of the information society must be taken into account. Learning objectives, according to Tryus (Tryus, 2010), is the initial condition for the creation of methodical system as the most specific and well-defined element of the system, that is, any modification of methodical system should, according to Morze (Morze, 2003), relate to the learning objectives which

describes the basic principle of improvement of methodical system – commitment.

The implementation of the principle of purposefulness is possible only by defining and developing the specific content of the components of the methodological system, and vice versa, the development of content will make it possible to determine the purposefulness of the methodological system. When designing a methodological system in which free software is used as a learning tool, the main principles and main trends in the development of higher education should be taken into account. Such a system should become a basis for overcoming the shortcomings of the higher education system and promote the implementation of ways to overcome them, to meet the new educational paradigm in terms of using ICT to intensify the learning process. The system of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science should be based on the modular principle of building curricula and programs of disciplines, apply innovative pedagogical learning technologies, widely use ICT, contain self-educational and research activities, use various methods and technologies training, apply effective organizational and pedagogical forms of training. The result of the development of the methodological system should be a methodological complex suitable for use in any form of education, as well as be a component of the information and educational environment of higher education.

The main tasks of using free software in the training of pre-service teachers of Mathematics, Physics and Computer Science are:

- demonstration of the essence of the scientific approach to the study of information processes and phenomena, the role of information and communication technologies in the development of scientific research and technical progress;

- mastering by pre-service teachers of mathematics, physics and informatics of methods of using information and communication technologies in professional activity, methods of selection and analysis of software capabilities;

- formation of skills of harmonious use of ICT in education and skills of independent processing of information and choice of appropriate technologies and means.

The use of free software in the preparation of pre-service teacher of Mathematics, Physics and Computer Science should ensure formation of individuality of pre-service teachers, develop their intellectual abilities, analytical and synthetic thinking, information culture, mastering information technologies nec-

essary for professional basic training and professional work, mastering techniques of information technology based on free software necessary to analyze social, economic, technical, manufacturing and information systems, search for optimal solutions to improve the efficiency of the systems, ability to choose the best ways to implement these solutions, processing and analysis of experimental results.

The results of the introduction of free software in the process of professional training of pre-service teacher of Mathematics, Physics and Computer Science, in our view are:

- development of information culture of a person, computer literacy (due to a change in priorities from studying of certain software to studying information technologies and their implementation);

- development of content, methods and means of education to international standards (due to lack of legal and financial restrictions on access to sophisticated achievements in information technology field);

- reducing the term and improving the quality of education at all levels of training of personnel (through enabling the use of information technologies anywhere and at a convenient time);

- integration of academic, research and production activities (through access to the source code of software and means to change it according to individual needs);

- improving the management of education activities (through the use of open standards for interoperability) ;

- opportunity to intensify the training of pre-service teachers of Mathematics, Physics and Computer Science (through fundamentalization of professional training).

An important factor of the concept of implementation of free software in the professional training of pre-service teacher of Mathematics, Physics and Computer Science is compliance with international and national standards. In view of this, special attention should be paid to standards of electronic documents that must conform to the principles of openness and accessibility. These standards include international standards for open file formats, such as OASIS Open Document Format ODF 1.0 (ISO/IEC 26300) and Office Open XML (ISO/IEC 29500). Unfortunately, the national standard DSTU in this field does not exist, though, in our opinion, the existence of a national standard is needed to provide a framework of using open file formats.

The next step of standardization for Ukraine should be the definition of free software. This kind of standard was adopted in the Russian Federation (GOST R 54593-2011), which contains general provisions for free software and is based on international standard classification software (ISO/IEC TR 12182-2004) and processes life cycle software (ISO/IEC 12207:2016). Classification meets the standard of the types of programs and policy documents (GOST 19.101-77 operates in Ukraine) and the general requirements for policy documents (GOST 19.105-78 operates in Ukraine).

Describing the purpose, objectives, classification and criteria of free software, we note that free software is created and used to form a market where any information service, such as copying, duplication, modification, error correction, functionality, etc. can be sold and bought on a competitive market by free contract of two parties (supplier and buyer of the service) without appeal to a third party. This wording defines the general provisions of the licensed purity of free software in accordance with certain degrees of freedom. The specific tasks of free software include:

- ensuring import substitution of proprietary components of information systems, reducing dependence on monopolists, and, consequently, freedom of action in the Ukrainian information space;

- stimulating the development of the domestic industry of software development for computer systems;

- expanding the possibility of participation of domestic developers in the performance of works and provision of services for state, municipal needs and the needs of the private business sector;

- providing additional investment in the development of domestic producers;

- ensuring a high level of technological independence;

- reducing the number of violations related to the legal protection of software products for computer systems.

Based on the general criteria of freedom, which must meet the free software, we note that free software in the training of pre-service teachers of Mathematics, Physics and Computer Science should correlate with:

- the ability to freely use the software for any purposes not prohibited by applicable law;

- studying how the software product works and rework it for their own goals and needs;

- free distribution of copies of both original software products and modified versions;

- dissemination of own property and research results.

Drawing from these tasks, we believe that infrastructure of development and use of free software should include:

- isolated environment of software packages (means of obtaining the source code of software binary files are directly loaded onto computer systems) and other means of collective development;

- single repository of software for computer systems and source code for various hardware and software platforms including ready distributions of basic software application and standard software solutions;

- control system of software for computer systems, providing records and the right to use and reuse of software and their components;

- infrastructure support for users and developers;

- infrastructure implementation (application) of open standards and specifications, including automation assess of compliance with standards (specifications).

Expected outcomes of introduction of free software are, above all, in the transformation of educational technology, due to:

- transition from delivering already formed knowledge and its memorization to independent information search and constructing their own knowledge;

- joint training activities of pre-service teacher in different educational situations and simulating future professional situations;

- providing educational material in a nonlinear format;

- opportunity to study independently according to individual path and in his optimum pace;

- modeling of world processes and events during educational activities;

- revitalization of intellectual and emotional processes of perception, understanding, comprehension and interpretation of educational material through the integration of verbal, graphic and audiovisual information;

- satisfactory qualification of teachers and pre-service teachers in the field of information and communication technology (equal to the level of International / European Computer Driving License);

- satisfactory qualification of graduated in the field of information and communication technology;

- quality access for teachers and students to their own internal and external e-learning and teaching resources;

- quality access for teachers and senior students to scientific electronic resources;

- automated control of their own activities for teachers and students;

- use of wholly licensed software.

The result of preparing of pre-service teacher of Mathematics, Physics and Computer Science to be able to use free software in their own training will serve as their willingness to use free software in their own teaching careers.

The considered scientific and methodological approaches allowed us to develop a system of free software in the training of pre-service teachers of Mathematics, Physics and Computer Science (see figure 1).

We will describe the components of the created system of using free software in the training of pre-service teachers of Mathematics, Physics and Computer Science. The purpose, tasks, approaches and principles of functioning of the system of application of free software in preparation of pre-service teachers of Mathematics, Physics and Computer Science which make a conceptual subsystem of system are described. Therefore, we provide a detailed description of the components of the content subsystem.

The computer competence of pre-service teachers of Mathematics, Physics and Computer Science determines the content line of application of the free software system in their preparation and forms, accordingly, the content subsystem.

Given the activity nature of teaching, we have identified such components of information competence of preservice teachers of Mathematics, Physics and Computer Science, as:

- motivational and value (identification, understanding and updating of goals and objectives of their own educational activities; awareness of the importance of knowledge, skills and abilities in the use of free software in educational activities; focus on professional and pedagogical development and self-development);

- cognitive (possession of the content of theoretical, psychological and pedagogical, professional and methodological knowledge of the process of using free software in educational activities);
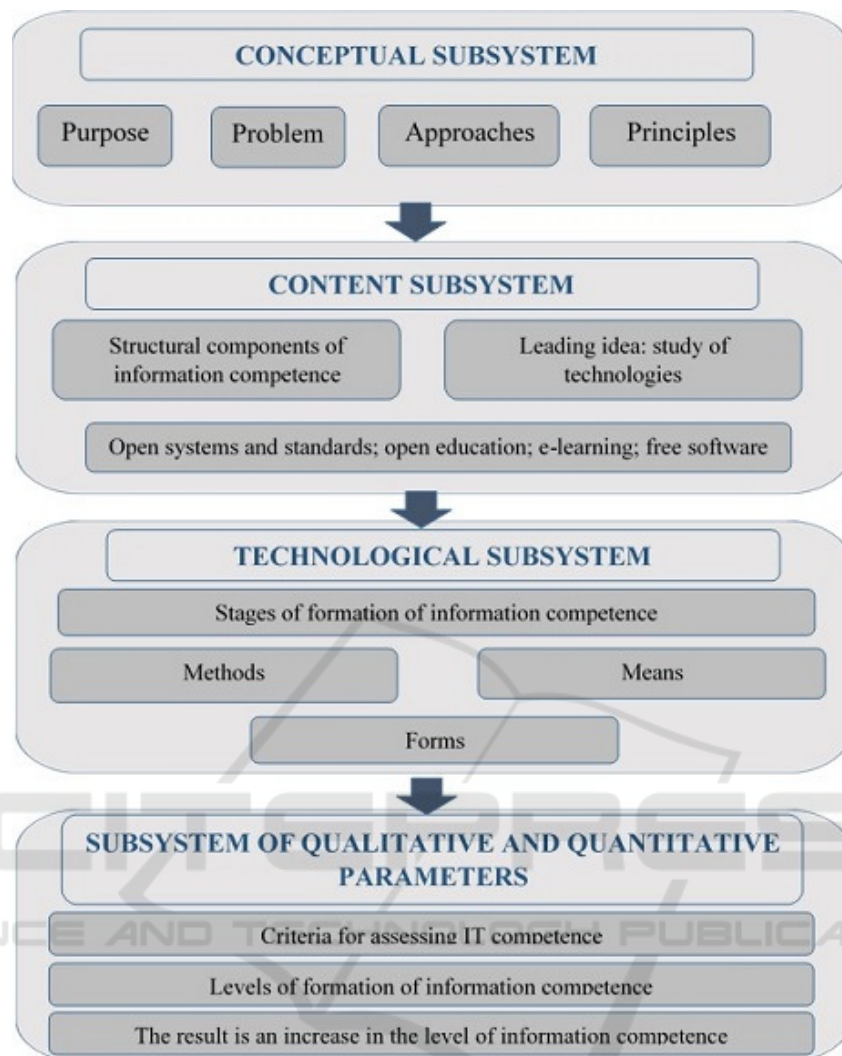
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Figure 1: The system of using free software in the training of future teachers of Mathematics, Physics and Computer Science.

- activity (use of knowledge, skills and abilities in the process of studying both psychological and pedagogical and professional disciplines, and educational disciplines of the information cycle; choice of technologies, forms, methods, teaching aids, planning of educational tasks and their implementation);
- organizational and communicative (creation of own information and educational environment by means of free software; use of information and educational environment for professional communication, dissemination of pedagogical experience, professional activity);
- reflexive (control, self-control, evaluation, self-evaluation).

The content of the motivational and value component of information competence of pre-service teach-

ers of Mathematics, Physics and Computer Science is their ability to solve issues related to the use of free software in professional activities. Motivational and value component is characterized by the formed need for systematic teaching and research activities, developed cognitive and exploratory motives, goal-setting skills, conscious desire and direction for intellectual self-development, readiness to meet educational needs, use of new methods and planning of self-educational activities. The effectiveness of training pre-service teachers of Mathematics, Physics and Computer Science to use free software in professional activities is impossible without a clear understanding of the need to take into account the didactic advantages and disadvantages of free software, creating favorable conditions for using free software to meet their educational needs in harmony with other teach-

ing aids.

The cognitive component involves the presence of pre-service teachers of Mathematics, Physics and Computer Science knowledge about the nature and features of free software in their professional teaching activities, possible options for using free software in the classroom system, self-education, research activities; features of methods of teaching profile disciplines and involvement of information and communication technologies in educational activities; deep awareness of the importance of such functions as knowledge, skills, abilities and their improvement; ability to search and analyze the possibilities of free software in terms of its didactic direction; ability to learn and receive information; information and communication skills (planned and effective use of ICT tools for search and analysis); ability and willingness to work with free software.

The presence of pre-service teachers of Mathematics, Physics and Computer Science skills to use free software in professional activities and mastery of methods of organizing educational and cognitive activities determine the content of the activity component of training pre-service teachers of Mathematics, Physics and Computer Science to use free software. The presence of such a component in the structure of information competence allows to increase the professional potential of pre-service teachers of Mathematics, Physics and Computer Science, as the necessary skills and abilities to use free software can more effectively solve the problems of teaching, education and development.

In the context of our study, the activity component acts as a system of clear, understandable, purposeful actions of pre-service teachers of Mathematics, Physics and Computer Science, related to the planning and construction of educational activities and the organization of self-education.

The organizational and communicative component determines the ability of pre-service teachers of Mathematics, Physics and Computer Science to create their own information and educational environment by means of free software. The environment is created to meet personal needs for learning, training, aggregation of new knowledge, structuring existing knowledge. The created information and educational environment can be used in further professional activity after graduation from higher pedagogical education. The obtained structured and aggregated educational materials by means of information and communication technologies are distributed among those wishing to study with the purpose of their further use in future professional activity.

The reflexive component is a component that presupposes the presence of self-analysis and self-assessment skills; self-control and self-regulation; reflection skills (analysis of professional results, task planning to improve self-education); reflecting the attitude of students to the process and results of professional activity; ability to review and analyze one's own professional activity, distinguishing positive and negative components; compare the results with the planned tasks and consider ways to improve and verify them.

Thus, the information competence of pre-service teachers of Mathematics, Physics and Computer Science formed through the use of free software necessary for their own professional activities is the result of special training, which is a fundamental education of pre-service teachers of Mathematics, Physics and Computer Science, professional knowledge, skills, pedagogical experience and reflection; meets the requirements for professional pedagogical activity. The integrity of this education is determined by the full development of motivational-value, cognitive, activity, organizational-communicative and reflective components, the core of which is the conscious actions of pre-service teachers of Mathematics, Physics and Computer Science with mandatory use of free software in their professional activities.

## 4 CONCLUSIONS

The proposed conceptual basis is an open system enabled by its interaction with the environment (social order, standard of professional education, etc.) and integration of knowledge of pre-service teacher of Mathematics, Physics and Computer Science in such scientific fields as philosophy, psychology, pedagogy, theory and methods of teaching mathematics, theory and methods of teaching physics; theory and methods of teaching information technology as well as fundamental disciplines in the field of preparation of Mathematics, Physics and Computer Science. Conceptual framework can be supplemented and extended depending on the conditions and characteristics of the operation and can be used in the preparation of pre-service teachers to design the educational process from various disciplines based on their specifics.

The proposed conceptual basis is an integrated system. Each structural element of the proposed principles of the system is its subsystem. This concept of integrity is ensured through:

- the presence of such properties and qualities which are not inherent in its structural elements;
- coherence and mutual dependence of all structural

elements of conceptual principles as structural and logical and functional links between them.

Structural and logical connection provided by relationships and relationships of structural elements with each other and with over-system (social demand, state educational standard of higher education in "Pedagogical Education"). Functional connections of structural elements are defined by concept of efficacy provide by the aggregate of the basic principles and conceptual provisions.

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