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Information and communication technology integration and teaching mathematics in higher education

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Abstract

The purpose of the study is to develop a model for the application of information and communication technology in the teaching of higher mathematics at the level of school education. The leading method for studying this issue is testing developed by V.E. Milman "Diagnostics of motivational structure of personality", which allows studying the level and features of motivational sphere of the researched based on characteristics of their personality with prevailing emotional background of interest, which are directly connected with motivational sphere and due to which it is possible to influence the level of motivation and mastering of the material on topics of higher mathematics based on given parameters of its increase. The identified indicators enable determining the success of using information and communication technologies within the framework of the created model improving the educational process of studying elements of higher mathematics at school. This will enable students to understand how the knowledge they are learning will be put into practice in their lives in the future, allowing them to be highly motivated in their approach to learning the subject, as well as within the framework of imaginative reconstructions of mathematical figures from different angles, graphs of various parameters, imaginative explanations of formulae, theorems and mathematical rules, which will be displayed in 3D on a large screen, thus enabling students, through their visualization, to understand their essence from different perspectives, which will be reinforced by their practical application.

Keywords: Learning Environment, Mathematics Education, Motivational Sphere, School Learning, Teachers

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Modern society is currently undergoing many technological changes that reinforce different components of life. Thus, the progress of the development of many engineering tools in the field of information and communication technologies makes it possible to form a new level of educational environment increasing its cognitive and informational component. It opens new perspectives for school students, which also in the general environment has globalization trends affecting the level of efficiency and relevance of the factors that will improve the school educational environment producing more literate and intelligent graduates (Zalilova et al., 2019). Modern trends of changes timely affect the educational space of Kazakhstan, where due to the emergence of new opportunities there is the consideration and development of relevant ways that could significantly increase the effectiveness of the process of delivering the information component of

knowledge, which reflects the important strategic approaches used in the educational sphere (Anene et al., 2020). Rapidly developing information technology tools on a worldwide scale demonstrate the growing opportunities for the factor of increasing information and communication components (Saray et al., 2021; Korbozerova et al., 2022). This makes it possible to expand the boundaries of the usual understanding of the academic process and to create conditions for a more detailed, effective perception of the necessary information knowledge, which would be perceived as a necessary part of education in its area of application, which would occupy its niche with its specific properties, which significantly allow increasing the educational sphere's resources (Smagulov & Tokanov, 2020).

The pedagogical tools that exist in the traditional conventional sense to provide the necessary tools for learners at this stage are complemented by new technological developments, dictated by the information elements that have caused learning difficulties among students. The new and up-to-date trends in the application of information technology tools are used to fill in the missing components of the educational process. This will be a perfect tool of pedagogical presentation of information parameters of the discipline at its deep level in terms of its practical application, which will reflect the factor of importance in the study of topics, areas and create conditions for conscious understanding and learning of the mathematics subject at the level of sustainable development of the motivational component with the factor of activating the independent activity of students. They, in turn, will successfully implement the tasks required in the learning and educational process against the background of understanding this knowledge for their personal, future activities, which will reflect the proposed given within the framework of school education, which involves learning the basics necessary for the development of a well-being component at the personal life level (Babaev et al., 2018).

Thus, against the background of successful competitiveness, the education sector in Kazakhstan is improving school teaching and learning processes and introducing them on time at the level of school lessons of higher mathematics on the level of applying information and communication tools, which will significantly improve the qualitative performance of the learning environment (Vechkinzova et al., 2019). The introduction of information communication in the education sector will greatly expand the boundaries of students' worldviews, increase their intellectual level, and by presenting practical recommendations within the lessons considering the benefits of knowledge for all students, teach them to apply their knowledge of higher mathematics in their future lives, and it will increase their level of interest in school education (Kaurav et al., 2020). In this way, technological advances introduced into school education will enhance learning motivation and develop the necessary practical qualities in school students for their future lives within the framework of preserving the well-being of society. But the motivational sphere for students of higher mathematics with the integration of information and communication technologies has not been studied sufficiently. Therefore, it was relevant to conduct this study.

The purpose of the study is to develop a model for the application of information and communication technology in the teaching of higher mathematics at the level of school education. To achieve the stated goal, the authors set the task of conducting diagnostic testing of students to identify the main factors influencing the motivational sphere. The developed model of applying technological capabilities in this article can be used in practice to improve the teaching of the discipline of mathematics and its important part of higher mathematics in school education.

METHODS

The study is based on a diagnostic test method for identifying the main factors influencing the motivational

sphere, developed by V.E. Milman "Diagnosis of the motivational structure of the personality", as well as method of analysis using a systematic and activity-based approach (Milman, 2014). It makes it possible to highlight the aspects related to personal motivational structures based on the influence of certain learning parameters on the emotional component, which will subsequently largely take on the motivational criteria allowing to increase the individual's interest in the learning process at the level of their active participation in the structure of topic discussion, discipline study and independent work in this area. The parameters of the selected test allow for the identification of motivational and emotional components, taking into account the changing aspects reflected in life situations depending on the selected pedagogical tool, based on the presentation of the information component and the level of the desired result, as well as on the foundations and preferences formed at the level of individual internal preconditions for different spheres of life perception, which in general will reflect personal interest based on internal aspirations showing the structure of the respondent's motivational component as a whole (Oyedokun et al., 2018).

The study of this method takes place within the framework of examining 14 parameters which have 8 different definitions each, and after examining them, the researcher evaluates them based on personal predisposition to each because of the degree of agreement with the proposed one. The parameters under consideration are defined in the sphere of personal attitudes of predominant importance at the level of maintaining the sphere of life support, status determining social belonging, communication, activity, the degree of importance of life comfort or working conditions, the creative component, the factor of the information component usefulness and its active part, as well as associative chains of interrelation with these indicators, which in their general structure will reflect the parameters of motivation of general and emotional connection. Students had to express their attitude to them for each in the affirmative or negative. After conducting the test, the results obtained were tallied, using ready-made clues and the detailing of the data obtained in determining the level of motivation both as work and life motivation. A standard method of mathematical counting and graphical representation of the findings was used to calculate the overall results of the study. The detailed analysis also made it possible to identify key elements for the formation of motivational criteria that increase interest in learning to improve successful communication during the educational process, which contributes to better knowledge assimilation. In this study, its correctness was ensured, since the characteristics and data parameters of the questionnaire and the developed criteria were comparable in the study correctly, and the analysis of its results made it possible to determine that the developed model for organizing the use of information and communication technologies allows improving the educational process of studying higher education at a qualitatively successful level.

The pedagogical experiment was conducted on the bases of Zhetysu University named after I. Zhansugurov in Taldykorgan and Sh. Ualikhanov Kokshetau University in Kokshetau, Republic of Kazakhstan. The diagnostic test was conducted among students of mathematical disciplines. The sample comprised 98 students (57 females and 21 males) of 1-4 courses aged between 17 and 25. Informed consent was obtained from all individual participants included in the study.

This problem was investigated in three stages, and the first stage was a theoretical analytical study of the available research and methodological literature on the issue under study within the framework of developing a model for applying information and communication technologies in the educational process in the study of higher mathematics. In this work, the existing problem, the main objective, the research methods, and the activity plan were determined. The second stage involved diagnostic testing of the students and the basic part of this experimental study, with a detailed analysis of the results and the

formulation of conclusions. The final third stage involved verification of the data and clarification of the conclusions, as well as the framing of the systematized results obtained.

RESULTS AND DISCUSSION

The results of the pedagogical study under consideration were processed using a systematic and activity-based approach to the processing of general and detailed results. This enabled the formation of criteria and parameters for developing a model for organizing the use of information and communication technology tools. They will successfully improve the quality of lessons in higher mathematics in school education based on an improved methodological indicator of the resource capacity of innovative technological tools significantly affecting the acquisition of the knowledge information model in the subject area in question. This in turn will increase the learning process efficiency during lessons in this context of the information component presentation in a new position of applying modern technologies, which can significantly improve the process of presenting the necessary material at the level of its deep understanding and assimilation with the criterion of enhancing the motivational component to obtain knowledge in general (Sarfo et al., 2016).

In the process of learning new information there has always been a place for the importance of cognition for the field of its practical application, which when covered creates a background of meaningful cognitive activity and awareness of the importance degree of the material being studied, which against the background of the general field of education takes a leading role that determines the purposefulness of selecting the cognitive part of the subject. The field of mathematics under consideration is of great importance for learning, both from the perspective of the developing intellect, the logical way of thinking, and the cognitive part of it, enabling calculations that reflect the many areas of everyday life and production that provide a high level of life sustenance (Sawant & Sankpal, 2021). School education is fundamental and, in its scope of application, has the prerequisites for the cognitive part of the basic foundational knowledge criteria that would provide its graduates with a high level of cognitive engagement in their future life activities environment. Based on considering the future professional suitability, it is precisely in school education that the level of borrowing the basics occurs, which students will later use in their future professional activities as well as the fact that each of them will choose an area of great interest, which they will study in more detail during further education at secondary and higher educational institutions (Doyle, 2019).

Schoolteachers have a responsibility to teach the young generation the fundamentals they will need for their future lives within an overall perspective of well-being, which is necessary in everyday life, cultural expression, communication relationships, while excluding the factor of future professional activity, which is superimposed on the spectrum of professional educational institutions (Kalyani, 2020). Thus, essential general school education, should provide with a quality presentation of relevant basic knowledge, including the subject of mathematics. The field of mathematics is subject to great criteria in the development of students' thinking activity, logical, imaginative thinking, who should be able to compare and master the information area of counting, solving tasks and equations at different levels. And one of the difficult objects to study is its part of higher mathematics, which together define a series of intellectual and logical chains based on knowledge of formulas, definitions, and other rules of mathematics (Alcock et al., 2020). They also include a large part of multi-complex figures and graphical calculus, which require a broadened outlook and the presence of a high factor of imaginative thinking, which combined with all the mathematical knowledge allows one to reach a logical conclusion of a

mathematical problem relating to its field of higher mathematics (Setyowati et al., 2020). The existing methodological prerequisites at the level of modern introduction of new technological means of information and communication order allow significantly improving the educational process on a competent level, and with a more high-tech approach to present the information component of teaching, where the cognitive sphere and area of its future application will be clear, which will designate the meaningful framework for this (Amua-Sekyi & Asare, 2016).

Any purposeful learning requires a practical outlet in the field of its application, for the student to understand why he or she needs to learn a particular field. Furthermore, it will enable him or her to spend his or her life at a higher quality level using the knowledge acquired from the school curriculum, which is reflected in his or her worldview, activity, independence, self-determination, which to a greater extent depends on self-confidence and knowledge, but which requires understanding how to use certain knowledge, including in mathematics and within its part of higher mathematics, in his or her life. The learning time and personal time, based on many criteria, are reflected in the framework of their harmonious distribution, which affects the development of young generation. Knowing this criterion, teachers at school level should teach only necessary knowledge according to their level of complexity and cognition within a set of all the criteria responsible for many components of the student's life (Idhalama & Ifidon, 2019). In the area under consideration, the information and communication tools can significantly improve the educational process and fulfil a number of tasks that face the practical area of school education, and directly in higher mathematics on the part of teaching the semantic part of the practical application of knowledge and the factor of clear, imaginative explanation of material at the level of its visual, cognitive, semantic part for better understanding of this, based on the implementation of the visibility possibilities through the use of modern information and communication technologies. Thus, the timeliness of their implementation will improve the quality of educational services by bringing them to a new level of knowledge delivery with the development of an active component of students' independence at the level of manifestations that improve their livelihoods (Tilak, 2019).

This criterion will also create a more interesting approach to learning higher mathematics at school, increasing the motivational factor at the level of personal interest, which is directly related to increasing the emotional background of cognitive activity in the order of the student's attendance and stay in the school learning area (Lishchynska et al., 2023). Expanding the pedagogical arsenal through information and communication tools will also improve interpersonal relationships between students and teachers. This will create a friendly area of emotional communication when teaching the subject of higher mathematics, where the complex will be presented from the perspective of the importance of its practical application and imaginative understanding of the purposeful parameter in learning to solve problems, examples, and graphs with an interesting presentation at a multi-level of study. This form of presentation will enable teachers to express their knowledge more fully and also to receive an emotional return in the form of aroused interest on the part of the learners in the topic, subject or any other thing that will allow them to expand their teaching abilities and skills, which will have a beneficial effect on students within the framework of increasing their motivational interest and emotion towards the learning process at school (Tan & Hew, 2016).

This organization of knowledge presentation with the help of information and communication technology will be created based on the amount of completeness and depth of information of higher mathematics and its gradual assimilation with the accompanying active participation of students in various classes in different disciplines, which with the creation of a motivating atmosphere with positive cognitive and engaging elements will create conditions for them to show an increased active and cognitive interest

in learning and to express themselves at the activity level with the activation of the thought process, and taking into account effective methodological preconditions, with a level of understanding and awareness of the importance of the knowledge model being taught, including for their professional advancement (Lishchynska et al., 2023). Such learning in the form presented, considering the deep personal positive perception that will be created as a result of the conditions described above, will enable school pupils, students and future teachers to acquire practical skills in the subject with a focus on its application in practice. Thus, this structure has the need to initially teach students in such a way that they develop a competent and practical understanding of applying the knowledge of higher mathematics in various fields and disciplines (Chandra & Murugan, 2017).

Consequently, the above described components, when considered in combination, reveal the organization of the formation process of the information and communication technologies application organization model within the teaching process of studying the higher mathematics subject at school practical education level, including the methodological features for organizing successful development of the individual with the acquisition of practical skills and knowledge of applying its scope of knowledge and skills in different areas of life activities, as well as imaginative representation of many components constituting the subject definition of higher mathematics, which will also be taken, as a result of the functioning of the study based on the developed model of applying information and communication technology tools. The result of this research work in the form of a developed model for the use of information and communication technologies in the study of higher mathematics was implemented in the educational process in several stages, which included the identification of personal characteristics affecting the motivation for learning the subject, which was reflected during a detailed analysis of testing data, as well as educational observation and complete statistical processing of the data on the direction of results analysis. The next stage involved the development and implementation of the above-described model for the study of higher mathematics using information and communication tools, where modern technologies are introduced into the teaching process of practical mathematics lessons, improving the learning process at a high level for its subsequent and successful implementation in the field of practical education.

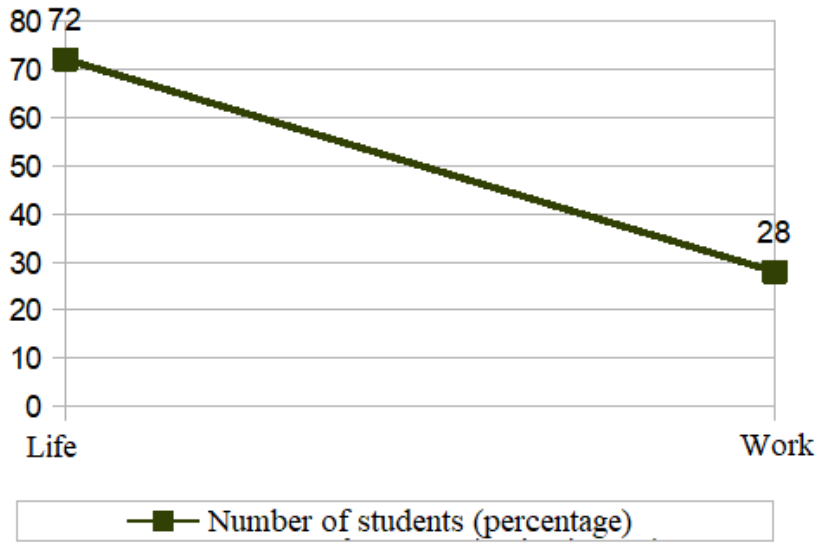

Figure 1. The level of orientation of the personality motivation component among those surveyed within the framework of their attitudes towards future work

A total of 98 students were surveyed, and the results showed that most of them have personality factors that reflect their focus on improving their life situation (72%), which indicates their low interest in showing quality in their future work at the activity level (28%), which was definitely in the minority according to the diagnostic test (Figure 1).

The analysis of the results of selecting necessary parameters through testing made it possible to identify the degree of personal reflection required for personal perception within the examined tendencies of professional expression, which were mostly found in the parameters of comfort (94%), status (100%), life support (82%), and important manifestations for future teachers such as communication (36%), activity (41%), on which the level of interest and determination of the cognitive component in class and communication ability depend, as well as the usefulness ratio of information taught (38%), creative component (32%) were identified in the predominant minority, as reflected in Figure 2.

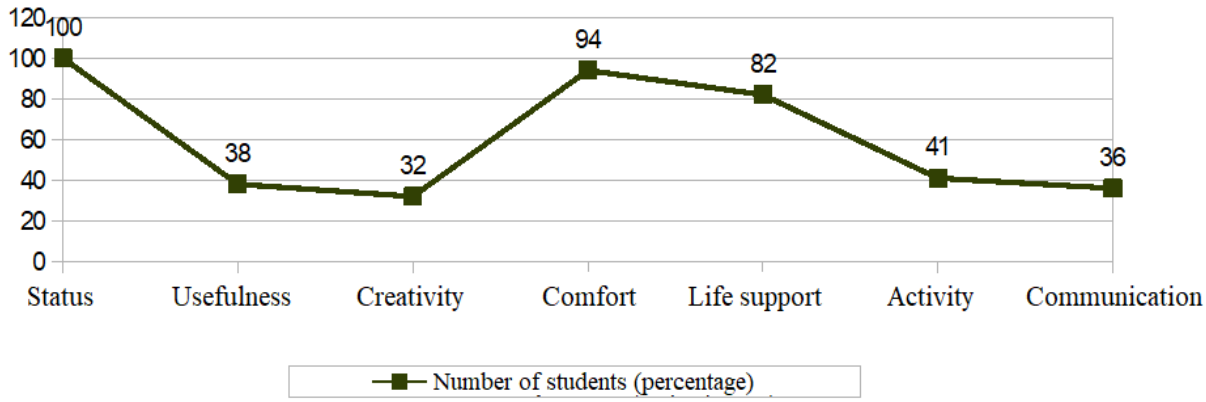

Figure 2. Degree of expression of the personality motivational orientation parameters among those surveyed

The evaluation of the data obtained from the test results based on the definition of personality type at the motivational sphere level is shown in Figure 3.

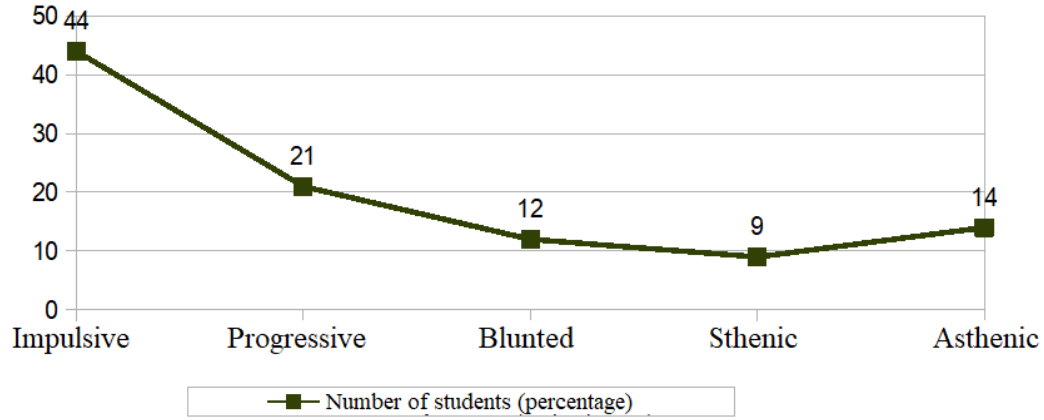

Figure 3. Identified personality type of those surveyed according to test data at the beginning of the pedagogical experiment

Thus, the survey data revealed that only a fifth of the respondents (21%) displayed the full aspect of the qualities required at this level of motivational component within the framework of the available

methodological features of the mathematics discipline learning process. Most future teachers (44%) have the characteristics of an impulsive character with their typical mood swings with changes in their line of behavior that depend on their emotional state and personal attitude towards students, and which lack the parameters of thoughtfulness and analysis of possible situations. The remainder of those surveyed expressed a neutral attitude towards what is happening (12%) or a position of poorly managed personal emotions (14%) and strong personal feelings at the neurotic level (9%), which would not be good for the behavioral reactions factor with a possible degree of exaggeration of what is happening. The processing of the information obtained makes it possible to say that it is necessary to introduce into the practical education system the factors that would satisfy the needs of the students when conducting mathematics classes, even if the teacher has little interest in the cognitive and educational part of them.

The existing possibilities of the modern world based on its technological developments enable the creation of a successful cognitive sphere that would satisfy both teacher and student and provide a high level of knowledge, creating a creative motivational background to enhance lessons in the reflection of all its participants at the level of developing the intellectual, cognitive factor allowing to expand the students' horizons, conducting discussion sessions with students, telling and answering their questions on various topics within the framework of using mathematical knowledge in the life sphere. Considering that the factor of pedagogical discussion is an important component in ensuring a competent, welcoming learning environment that creates close communication links on a positive emotional note that increases interest in the learning process is important for the educational process. Thus, the considered model of applying information technology should improve the fundamental parameters of conducting lessons in mathematics, so that the lessons arouse students' interest, increase their motivation to learn, understand the meaningful form of the data studied within the considered higher mathematics to increase the factor of self-realization and manifestation of students' knowledge at the level of their practical application. This will also strengthen the informative part of cognition with indicators of increasing practical extensive knowledge, which will also enable the formation of practical skills within the mathematical discipline (Maruthavanan, 2020).

The learning process can be presented in different forms, based on the possibilities of the modern world, and in this case, it is the outcome considered from the educational work of the younger generation that matters, to shape them into worthy members of society with a high level of knowledge of the subject, including in the field of its practical application. And from this position the necessity of improving the methodological foundations of conducting lessons using technological means of information and communication technologies, which will allow to understand, study, and comprehend the phenomena, laws of mathematics within the lessons at school education at a deep level, which will increase the importance of these lessons for students and their interest to obtain various knowledge in the considered area of higher mathematics, is highlighted. Thus, the identified data show the need for creating a model based on the development of modern technologies within the framework of applying information and communication tools in the study of higher mathematics, which was carried out based on a detailed productive methodological analysis and in the totality of a holistic analysis. This made it possible to identify its main parameters, which, on the basis of a generalized approach based on the creation and retention of the well-being component in the learning and cognitive part and various necessary types of life support on the background of the creative process of personal development within the discipline of mathematics, allowed to form at a high level the motivational cognitive creative environment for quality improvement of education in the area of its practical application in lessons of higher mathematics at school (Lishchynska et al., 2023).

Based on the position under consideration, a model for organizing the use of information and communication technology in the study of higher mathematics in school education has been developed, which includes cognitive review of practical program with discussions at the level of knowledge practical application. These will be explored in a topic based on the school curriculum, with a visual range of applications of the mathematical calculations themselves and an overview of the resulting components based on performance in practical life within both the future professions and the training stage. This is to enable students to apply the knowledge they acquire in their everyday lives, by extending their practical skills and the boundaries of learning at school to provide the knowledge for improving the area of their life activities. Moreover, such an excursus of cognitive and practical application should be presented before the study of each topic in mathematics, especially its part of higher mathematics, which has several difficulties in the depth of its study, allowing students to become more familiar with the importance of learning in this area and greatly increasing the motivational component in its study.

The developed model also provides an important part of visualization of various geometrical figures, formulas, theorems, graphs at the level of its volumetric perception with detailing in different parameters and spheres of planes within the framework of possibility of performing motion in its various possible forms and directions as necessary for studying and imaginative understanding of what is studied at mathematics lessons, in fact in representing dynamic 3D reproduction of studied subject in mathematics lessons. Then, in the control stage of the study, the data were identified within the dynamics framework, considering the results obtained in the re-testing and pedagogical refinement after testing this model of the organization of learning in practice. This revealed its success, as implementing its professional duties in the presented form of methodological improvement of the mathematical discipline's teaching material allows the educational process to be improved at a qualitative level by arousing professional interest in it. This is demonstrated in Figure 4, which shows that the professional element of the motivational component was increased to 84%.

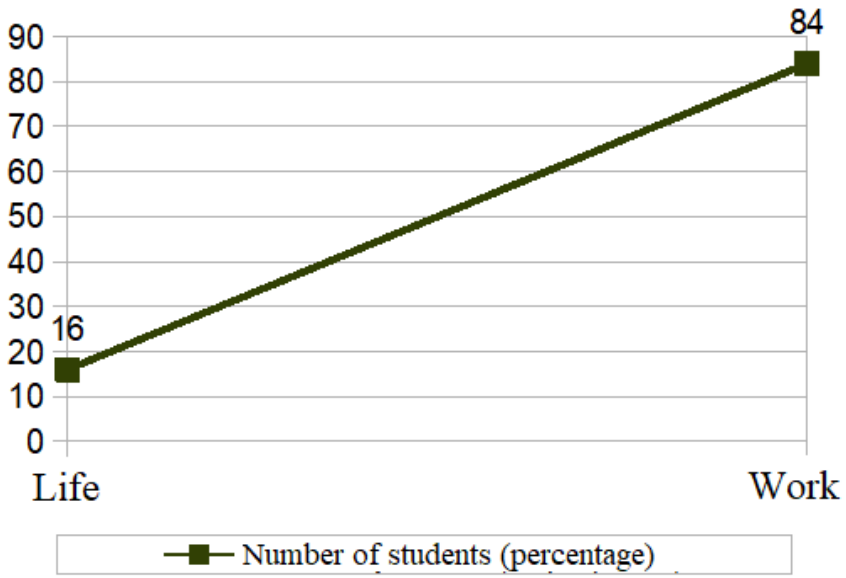

Figure 4. The level of orientation of the personality motivation component among those surveyed within the framework of their attitudes towards future work at the control stage of the study

A detailed analysis of the results concerning the important parameters responsible for the success of the teaching-learning process has revealed a significant increase in the main criteria for the

implementation at a qualitative level. Thus, the important aspects regarding the implementation of lessons by future teachers within the framework of this study were identified at the level of the increase of such components as the enhancing capacity of the function of creative communicativeness (96%), the overall activity of conducting lessons and explaining new topics (89%), the coefficient of usefulness of the information presented (89%) and the creative component of the learning process of self-expression (91%), as shown in Figure 5.

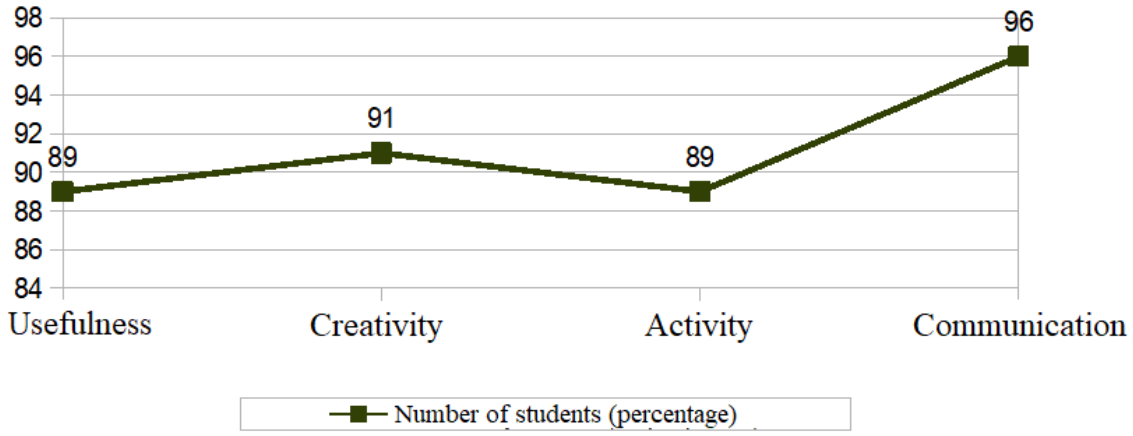

Figure 5. Degree of personality motivational orientation parameters expression among those surveyed at the control stage of the experiment

The revealed data of dynamics received during research allow speaking about efficiency of the created pedagogical model of conducting mathematics lessons, as well as its part of higher mathematics at a level of school education in consideration of its success in pedagogical sphere with improvement of methodical preconditions improving informational, cognitive, semantic, practical, figurative, communication components of the educational process of studying the discipline. It is also worth noting that this form is useful at the practical level of learning the parameters that students can use in their everyday life at the level of relevance of the school curriculum information component in the consideration of the higher mathematics subject (Scherer et al., 2019). In this study its correctness was ensured, as the characteristics and data parameters of the questionnaire and the developed criteria were compared correctly during the study, and the analysis of its results made it possible to determine that the developed model of organizing the application of information and communication technologies allows for a qualitatively successful improvement of the learning process of higher mathematics in the field of school practical education. Considering the technological development of the modern world and the innovative achievements of technological progress, it is necessary to use new engineering advances in the framework of increasing the opportunities to improve the educational process in the sphere of its practical application at its high level, which allows significantly enhancing the cognitive, informational, semantic part of education, increasing its relevance and the degree of importance (Gok et al., 2020; Pentang, 2021).

The developed model helps to form motivation at a high level among both students and teachers, due to the emergence of their personal interest in the subjects taught to them in improving its methodological part of the above-described type, which in essence reflects in aggregate both personal interest and the practical sphere of application extending the boundaries of professional knowledge and

life skills. This is also reflected in the increase of self-esteem, the realization of personal skills and abilities in the field of practical application of the studied mathematical regularities and phenomena. Besides, modern aspects of implementing the model create conditions for conducting interesting classes transforming areas of mathematical knowledge and from the theoretical point of view and visual learning, which increases interest in them (Nygren et al., 2019). The implementation of the developed model for organizing the use of information and communication technologies provides an experiential and practical analysis with the factors of broadening the outlook and thinking activity in mathematics education, which will improve its structure of teaching at all levels and have practical significance for the whole area of educational environment, especially its school area (Fabian et al., 2018; Gavrilova et al., 2020; Seitova et al., 2018; Abylkassymova et al., 2020).

CONCLUSION

In this study, the authors conducted a diagnostic test of the orientation of the personality motivation component in the framework of their attitude to future work. Based on the test results, they concluded that only a fifth of the respondents demonstrated the entire aspect of the qualities required at this level of the motivational component as part of the educational process for studying the discipline of mathematics. The revealed data indicated the need to create a model based on the developments of modern technologies in the study of higher mathematics.

The developed model includes the implementation of mathematics lessons with the help of information and communication tools in the field of practical application of the studied mathematical calculations, solutions, formulas and much more, as well as with 3D visualization of all components of the tasks in the form of geometric shapes, graphs, theorems, rules, problems. These tasks can be presented for the study in different directions, planes depending on the conditions of the tasks. This complex of components will allow to understand the features of the given at a deep semantic and cognitive levels and to study the necessary in interesting conditions of lesson presentation of information. This will lead to an increase in interest in the study of the discipline of mathematics, will create favorable conditions for constructive communications, the creative component and the implementation of self-knowledge as part of the activity in the lesson with the active part of the study, both the practical application of the discipline of higher mathematics, and the semantic understanding of its constituent elements, due to the full figurative visualization within the framework of 3D information and communication technologies. The developed model will allow to enrich the educational process in a figurative and information-practical way, create conditions for interest in studying the proposed topics of higher mathematics, raising the general interest of students in the educational process, which dictates its practical relevance for the sphere of education and society.

Thus, the developed model for applying technological capabilities within the framework of the developed innovative means of information and communication technology has shown itself to be effective and can be used in practice to improve teaching in the discipline of mathematics and its important part higher mathematics in school education, which will activate the students' independent activity and create conditions for them to acquire practical skills within the discipline, which is important for the whole field of education and the well-being of life. In the modern world, innovative technologies are rapidly changing and improving. This work can be used as a basis for future research in the field of studying the motivational component of future mathematics teachers.

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Declarations

Author Contribution	:	MT: Conceptualization, Writing - Original Draft, Editing; SD: Writing - Review & Editing, Formal analysis, and Methodology; SK: Validation and Supervision; GA: Methodology, Review, and Visualization; YS: Editing, Formal Analysis, and Supervision
Funding Statement	:	This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
Conflict of Interest	:	The authors declare no conflict of interest.

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