Modern Aspects of Forming the Motivation of Learning Activities of Bachelors of Mathematics in the Process of Studying Professional Disciplines

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Abstract. The study explores the formation of motivation among mathematics undergraduates in the context of professional training. A combination of theoretical methods (analysis, synthesis, comparison, generalization), modeling, and empirical methods (surveys), as well as statistical analysis, was utilized. The research analyzes contemporary approaches to motivation and psychological-pedagogical concepts of its structure, identifying key aspects relevant to developing learning motivation in mathematics students.

The study involved 86 undergraduate students (aged 18–22, 57% female) from the Faculty of Mathematics, Physics, and Computer Science at Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University. Surveys were conducted using the "Motives for Choosing a Profession" methodology and A. Rean's "Motivation for Success and Fear of Failure" questionnaire. Ethical standards, including APA guidelines, were strictly adhered to.

The findings highlight two motivational types: positive motivation, characterized by a drive for success and self-confidence, and negative motivation, marked by anxiety and avoidance of failure. The use of modeling enabled the creation of a comprehensive approach to assess motivation through criteria, indicators, and levels of motivational development.

This research contributes to understanding how motivational factors influence the academic success of mathematics students and offers practical tools for enhancing their professional training.

1. Introduction

The formation of sustainable motivation for academic activities is a pressing challenge in modern pedagogy. This issue is particularly critical for educators in higher education institutions working with future professionals. Students' level of motivation impacts not only their academic success but also their future professional fulfillment.

Currently, the topic of motivation, both academic and general, is extensively studied. Internal and external connections between different types of motivation have been established, and numerous successful classifications of motivation types and kinds have been proposed. The structure of motivation comprises three groups of motivating factors: needs and instincts that determine individual orientation; emotions, feelings, and experiences; and attitudes that regulate

the dynamics of student behavior. Some researchers argue that influencing the professional motivational sphere of students involves restructuring it, increasing the proportion of intrinsic over extrinsic motivations through academic motives. These motives drive students to learn and include attitudes "(e.g., psychological readiness for cognitive activities), cognitive needs, and interests that shape their focus, persistence, and other volitional qualities" [1].

Vasiuk et al. [2] state that "motivation is a system of complementary motives formed and expressed in activities." Researchers have explored the specific characteristics of academic motivation among higher education students, identifying leading motives. This study refuted the hypothesis that acquiring knowledge and developing skills are the primary drivers of students' academic motivation, with obtaining a diploma being less significant. The research revealed that success is not always a determining factor in academic motivation, indicating that a student's character and personal qualities significantly influence their motivation to learn.

Klibanivska [3] highlights that optimizing a student's potential requires directing their focus toward academic activities, which serve as both a motive and a goal. The study demonstrated that dominant motivations evolve throughout the years of study. Students' priorities shift from external to intrinsic motivations, with a growing emphasis on educational and professional competitiveness based on deep knowledge acquisition. The research also found that the primary academic motivation for first-year students is professional, personal prestige for second-year students, a combination of both for third-year students, and the addition of pragmatic motives for fourth-year students. Professional and educational motives remain priorities across all years. Additionally, changes in academic activities from the third year onward reflect an increasing emphasis on cognitive achievement and competitiveness.

Despite differences in findings between studies by Vasiuk and Klibanivska, both authors emphasize that academic success influences student motivation [2] and that success strongly impacts professional and cognitive motives [3].

According to Schunk [4] and Valenzuela-Peñuñuri et al. [5], "academic motivation is referred to as the disposition that is related to academic functioning, learning, and success, as well as the effort made by students and persistence to achieve the goals they set for themselves."

Research on autonomous motivation has been conducted by Azila-Gbettor et al. [6], Jeno et al. [7], and Mouratidis et al. [8] define autonomous motivation as "behaviors students endorse out of their own will; behaviors carried out because they find them interesting, fun, or challenging (intrinsic motivation); because they consider such behaviors part of their own identity (integrated regulation); or because they view them as meaningful and personally important (identified regulation)."

On the other hand, Dutaa et al. [9] highlights that without communication, teaching and learning processes cannot occur. Communication skills and work motivation significantly influence teaching activities, as the instructor's communication style can affect student engagement and attitudes, creating an appropriate learning atmosphere.

Innovative monitoring of academic habits and motivation in learning mathematics at the undergraduate level is discussed in Szilágyi et al. [10].

Simanjuntak et al. [11] aimed to explore mathematics learning motivation in the context of blended learning based on gender. They found no significant difference in motivation levels between male and female students using blended learning models.

Self-regulation in mathematics learning during professional training is examined in Berger's research [12]. The author employs a dual-methodological approach: (1) path models to explore links between variables related to motivation and metacognition; and (2) a person-centered analysis (latent profile analysis) to identify student groups with varying competency goal configurations.

Lim et al. [13] analyze academic motivation for mathematics in adaptive learning systems using Rasch analysis. Their study aims to validate the Academic Motivation Toward

Mathematics Scale (AMTMS) based on self-determination theory, applied to secondary education levels (grades 11 and 12) in Asia.

Mayerhofer et al. [14] investigated aspects related to motivational beliefs and associated factors that are crucial for fostering a positive attitude toward lifelong learning, particularly in the context of university education. In many German universities, successfully completing introductory courses is a prerequisite for further degree progression. As a result, prospective undergraduate mathematics students face high levels of pressure and often engage in externally motivated activities [15]. Liebendörfer emphasized the significant role of the institutional environment in shaping the motivation of mathematics students.

Moreover, students often attempt to adapt learning strategies to meet course requirements [16], such as aligning their time management with mandatory course demands and seeking help from peers to complete assignments. In summary, the challenges of transitioning from secondary to higher education are multifaceted [17]. Heublein et al. identified nine categories of reasons why undergraduate students in Austria drop out of their chosen programs across all fields of study. The most critical reasons include academic performance difficulties, lack of learning motivation, and career orientation issues (e.g., a desire for practical work). Code et al. [18] examined the development of motivational indicators among first-year mathematics students and found that all indicators declined during their first year at university.

The crucial role of motivational factors in academic activities is reflected in the principle of motivational support in the learning process, which addresses contradictions between the existing and required levels of motivation; between personal and societal needs, goals, and interests; and between students' motivational attitudes and their functional capabilities. Addressing these contradictions during professional training necessitates a shared understanding among educators of motivational goals and strategies for achieving them. The authors believe that achievement motivation and self-affirmation motivation are essential for forming professional motivation among mathematics undergraduates. Academic success depends on the interplay of individual abilities, achievement motivation, and situational factors (e.g., favorable conditions). Achievement motivation encompasses both personal traits and situational factors such as perceived value, likelihood of success, and task difficulty [19].

The main aim of the study is to propose approaches and tools aimed at increasing the motivation of mathematics bachelor's students while studying professional subjects, as well as to verify the results of the educational study using statistical analysis.

The main objectives are to describe the theoretical foundations and analytical approaches to developing learning motivation among mathematics bachelor's students in the process of studying professional disciplines; to define the criteria, indicators, and levels of development of the motivational-value component of professional training; and to apply Kolb's learning cycle, interest-based motivation, and achievement value motivation in solving applied problems aimed at modeling real-world objects and phenomena.

2. Methods

The study employed various methods: theoretical (analysis, synthesis, comparison, and generalization), modeling, and empirical methods (surveys), along with statistical techniques for processing research data and calculating statistical indicators.

An analysis of scientific research and resources dedicated to contemporary approaches to studying motivation and motives was conducted. This included an examination of psychological and pedagogical concepts of motivation, its types, and its structure in the context of training mathematics undergraduates. This analysis facilitated the identification of relevant aspects of fostering learning motivation among mathematics undergraduates during the study of professional disciplines.

The analysis of materials published in philosophical, psychological-pedagogical, and

methodological periodicals formed the basis for defining the conceptual framework, systematizing and summarizing existing experiences, justifying theoretical propositions, developing and implementing original ideas, and performing statistical analyses within the selected topic.

The use of modeling methods enabled the creation of a comprehensive approach to assessing student motivation by determining criteria, indicators, and levels of formation of the motivational-value component in the professional training of mathematics undergraduates.

To explore the relationship between internal and external motivation and personal qualities, we conducted two tests among mathematics undergraduates across all four years of study. These tests included the methodology "Motives for Choosing a Profession" and A. Rean's "Motivation for Success and Fear of Failure" questionnaire [20].

The study was conducted among students of the Faculty of Mathematics, Physics, and Computer Science at Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University. The final sample included N = 86 bachelor's students from the first to fourth years (approximately 18–22 years old, 57% female).

The survey was conducted with the utmost respect for participants' privacy and confidentiality, adhering to ethical standards and the guidelines of the American Psychological Association (APA) as well as the Ethical Code of the Ukrainian Researcher. Faculty administration was informed about the study. Parental consent was not required, as all students were over 18 at the time of the survey.

Students from the first to fourth years were invited to complete a Google Form survey. The form contained tables with response options based on the "Motives for Choosing a Profession" methodology and A. Rean's "Motivation for Success and Fear of Failure" questionnaire [20].

Motivation for Success relates to positive motivation. With this type of motivation, students begin tasks with the aim of achieving something constructive and positive. Their academic activity is driven by a hope for success and a need to achieve it. Such students are typically confident, responsible, proactive, and active. They are characterized by persistence, goal orientation, and determination in achieving their objectives.

Motivation for Failure, on the other hand, is a type of negative motivation. In this case, a student's activity is driven by the need to avoid failure, criticism, punishment, or setbacks. This motivation is rooted in avoidance and negative expectations. When beginning a task, a person motivated by fear of failure anticipates possible setbacks and focuses on ways to avoid them rather than on achieving success. Individuals with this type of motivation tend to exhibit heightened anxiety and low self-confidence. They often avoid taking on significant responsibilities and may experience near-panic states when faced with highly demanding tasks. In such situations, their situational anxiety becomes extremely pronounced, although this can coexist with a relatively responsible attitude toward their work.

3. Motivation in mathematics learning: theoretical framework and analytical approaches

In this study, motivation is studied using the "expectancy-value" theory (Eccles et al. [21]), which suggests that students' perceptions of studying mathematics are influenced by four components:

1. Intrinsic value: The enjoyment or intrinsic interest in mathematics.
2. Attainment Value: The importance of achieving success in mathematics, reflecting personal identity and self-expression.
3. Utility Value: The usefulness of mathematics for achieving future goals, such as career aspirations.
4. Cost: The perceived effort, stress, or negative consequences associated with studying mathematics (Eccles et al. [21], [22]).

Intrinsic value pertains to the enjoyment or curiosity students experience when engaging with mathematics. This component is closely linked to intrinsic motivation, where students participate in learning activities because they find them enjoyable or fulfilling.

Example: A student who enjoys solving puzzles may find satisfaction in solving complex problems in algebra, geometry, mathematical analysis, etc. because they find them interesting or intellectually stimulating.

Applications in education: teachers can develop students' interest by incorporating fun and interactive activities such as mathematical games, real-world problem-solving scenarios, or creative projects such as creating geometric artwork, 3D modelling and 3D printing of bodies, surfaces, etc., and modelling real-world processes using numerical methods or differential equations.

Attainment value reflects how important success in mathematics is to students, as it aligns with their identity or sense of self. This value is particularly significant for students who view mathematics as a core part of their identity or as a means of expressing their abilities. Such students are more likely to invest effort in self-education.

Example: a mathematics major may strive to excel in mathematics to support this aspect of their identity, they may take pride in being considered the best in the group or in being able to explain to other students how to solve a difficult problem, design their own problem, or write an interesting research project. Students who view mathematics as a way of self-expression are more likely to invest in self-education, more likely to seek out additional materials, practice, and improve their competencies on their own.

Applications in education: Teachers can support the value of achievement by recognising and rewarding students' mathematics achievements, encouraging them to set personal goals, and viewing mathematics as a skill that reflects their intellectual growth and self-discipline.

Utility refers to the perceived practicality or relevance of mathematics in achieving personal aspirations, career goals, or everyday life tasks. Students who understand how mathematics connects to their future are more likely to remain motivated, even if they do not fully enjoy it at the moment.

An example: a student who aspires to become an engineer may not enjoy maths, but is studying hard because he knows that maths is essential for his career goals. Similarly, another student may find maths essential for managing finances or understanding data in everyday life. Future teachers who are aware of how mathematics helps in teaching and career development are more likely to show interest in their chosen profession.

Applications in education: Teachers can emphasise real-world applications of mathematics, such as its role in different professions, technology, or even everyday tasks such as budgeting and shopping. Guest lectures from professionals or project-based learning (e.g. creating a budget for a simulated business) can emphasise the practical value.

Cost refers to the potential drawbacks or sacrifices students associate with studying mathematics. These may include stress related to completing tasks, the effort required, or the fear of failure. A high perceived cost can demotivate students, even if they recognize the importance and utility of the subject.

For example, a student may feel overwhelmed by mathematics assignments, which currently take up too much of their time, leaving them less time for leisure or other favourite activities. Another student may avoid active participation in practical classes for fear of making a mistake and embarrassing themselves in front of their classmates.

Applications in education: Reducing perceived cost involves creating a supportive classroom environment where mistakes are seen as learning opportunities. Teachers can also break down complex tasks into simple steps, provide resources for additional support, and emphasise effort rather than innate ability to build students' confidence [23].

These factors influence students' decisions to engage with mathematics and their persistence

levels. Previous research highlights the importance of these elements in skill development: while interest, perceived importance, and utility enhance positive outcomes, cost-related factors can hinder progress [24], [25].

Values are subjective, as individuals assign different levels of importance to the same tasks. For instance, success in mathematics may hold significance for some students but not others [22]. Attainment value emphasizes the importance of succeeding in tasks integral to one's self-concept, such as excelling in mathematics through personal identity. Intrinsic value reflects the satisfaction derived from the task itself, encouraging deeper engagement and sustained effort. Utility value highlights how a task aligns with future goals, such as meeting academic requirements for a degree. While utility value may resemble extrinsic motivation, it often reflects meaningful personal goals, linking it to both achievement value and self-concept [21].

The **Situational Expectancy-Value Theory** (SEVT) extends traditional expectancy-value theory by focusing on how task value and success expectations shift across contexts. It emphasizes the dynamic and context-dependent nature of motivation, especially during critical educational decision-making moments [22]. SEVT suggests that students are more motivated by tasks aligned with their self-concept (achievement value) or future aspirations (utility value).

Person-Oriented Approach. The person-centered approach is often associated with the holistic-interactionist paradigm introduced by Magnusson [26] and further developed by Bergman [27]. This paradigm views the individual as an active agent within the "person-environment" system. Its key principles suggest that there is order and structure both in intra-individual consistency and change, as well as in inter-individual differences in consistency and change. This order and structure can be described as patterns of involved factors, and some patterns occur more frequently, while others occur less frequently than theoretically expected [28].

Using the person-centered approach, students can be categorized into motivational profiles based on combinations of factors (e.g., interest, achievement, utility value, and cost). This approach accounts for the complexity of individual differences in motivation, allowing researchers to examine how specific profiles are related to academic outcomes and engagement ([24]; [25]).

Identifying common motivational profiles enables tailored recommendations for educational practices. For instance, interventions can focus on enhancing the intrinsic value of mathematics for students who perceive it as overly demanding or misaligned with their goals.

This approach not only identifies individual differences but also bridges theoretical gaps by offering practical insights into the connection between motivation and learning [29].

Components of expectancy-value theory provide criteria, indicators, and levels to assess motivational and value-based aspects of professional preparation for mathematics undergraduates, offering a comprehensive approach to evaluating motivation in mathematics learning (table 1).

Analyzing the conclusions of numerous researchers alongside our long-term observations of the psychological characteristics of the academic and cognitive development of mathematics undergraduates, we can identify three stages in the evolution of their motivations: learning motives (Stage I), a combination of learning motives and future professional motives (Stage II), and professional motives (Stage III).

Stage I (1st–3rd semesters): characterized by relatively high levels of learning motivation.

Stage II (4th–6th semesters): focuses on the development of the motivational sphere by combining learning and future professional motives, forming the foundation for professional motivation.

Stage III (7th–8th semesters of undergraduate studies and 1st–3rd semesters of master's studies): marked by greater awareness and integration of various forms of learning motives. During this period, students study professional and practical disciplines, making it the critical phase for the formation of professional motivation.

Table 1. Criteria, indicators and levels of formation of the motivational and value component of professional training of bachelor of mathematics.

Indicators of maturity	Levels of formation			
	initial	average	sufficient	high
Intrinsic Value (interest in learning and academic discipline)	lack of interest in the discipline and learning activities, situational interest in certain topics, fear of failure	interest in learning activities appears, all positive motives are associated only with the result, a certain tendency of motivation to fail	stable orientation of cognitive motives and interest in learning in general and mathematics in particular, a certain tendency of motivation to success	deep awareness of cognitive motives, general goal-orientedness, success-oriented
Attainment value (ability to self-education)	no ability to self-education, tendency to fulfil the minimum requirements for graduation	self-education skills are partially developed, there is no initiative in acquiring new knowledge	the desire for self-education and self-development is developed, but not sufficiently manifested	systematic and conscious self-education activities aimed at increasing key competences of the individual
Utility value (interest in the chosen profession)	lack of motivation and interest in the future profession, random choice of speciality; material, prestigious and utilitarian motives prevail	formal interest in the profession of mathematics teacher, studying is a condition for obtaining a diploma; synergistic combination of moral and aesthetic motives with material, utilitarian and aesthetic motives	conscious choice of the future profession, learning activities consciously aimed at acquiring professional competence; synergistic combination of cognitive and professional motives with moral, aesthetic, material, utilitarian and aesthetic motives	awareness of personal and social significance of the profession of mathematics teacher'; synergistic combination of social and creative motives with cognitive, professional, moral, aesthetic, material, utilitarian and aesthetic motives
Cost (reflection, self-analysis)	the ability to introspect is not formed	there are skills of self-analysis, the formation of which occurs mainly under the influence of external factors	ability to carry out adequate self-assessment, ability to organise personal, educational, professional activities	awareness and understanding of the results and prospects of their own activities; ability to overcome obstacles and achieve success

According to Podolyak and Yurchenko, learning motives are not only prerequisites for successful professional education but also its outcomes. Motives are formed through activity,

which the teacher organizes, while students' attitudes toward this activity develop within it [1].

Notably, as motivation increases, so does the quality of students' academic activities and achievements. Teachers must identify the optimal motivation level at which this activity is most effective. Psychologists have demonstrated that excessive motivation in some individuals can lead to heightened activity and tension, resulting in disruptions in performance and behavior. Over-intense external stimulation (e.g., threats) and high motivation levels can provoke undesirable emotional reactions such as stress and anxiety, impairing performance [19].

Experimental studies have shown that both low and excessively high levels of motivation result in reduced performance. This phenomenon is encapsulated in the Yerkes-Dodson law: as motivation intensity increases, performance quality initially improves, reaches an optimal point, and then declines [19].

4. Formation of student motivation in the cyclic model of experiential learning

Some universities in Ukraine, under the conditions of martial law, have been forced to operate in remote and blended learning formats. In such circumstances, it is crucial to sustain students' motivation to study mathematical disciplines. Frequent air raid alerts and power outages make it difficult for instructors to focus students' attention on learning materials, leading to a backlog of unresolved educational tasks and, at times, an inability to conduct classes. The acquisition of professional competencies by mathematics undergraduates under such challenging educational conditions largely depends on their motivation.

At the first and second stages of the formation of learning motives and the combination of learning and future professional motives in mathematics undergraduates, David Kolb's experiential learning cycle model [30] can be effectively employed. This model implements the expectancy-value theory of motivation by Eccles et al. [21].

Kolb is renowned for his work on experiential learning and contributions to organizational behavior studies. His research focuses on individual and social change, learning through experience, career development, and professional education [30].

Kolb's model proposes a learning cycle consisting of four sequential stages: "Concrete Experience" – "Reflective Observation" – "Abstract Conceptualization" – "Active Experimentation." The model presents two dialectically connected processes of understanding experience (concrete experience and abstract conceptualization) and two modes of transforming experience (reflection and active experimentation).

This process integrates the following elements:

- knowledge – comprising concepts, facts, and information obtained through formal education and past experience.
- activity – the application of knowledge in real-world situations.
- reflection – analysis and synthesis of knowledge and activities to generate new insights.

Kolb emphasize that the learning cycle can start at any of the four stages and should be viewed as a continuous, sequential spiral [30].

Application in Mathematics Education

1. Abstract Conceptualization. Learning begins when a student encounters a new and intriguing mathematical problem or situation, which sparks their intrinsic motivation. This stage aligns with the expectancy-value theory by Eccles et al., as it highlights the value of student interest in learning mathematics.
   Theoretical lessons can incorporate simulations such as role-playing, debates, or brainstorming to encourage active discussion and idea exchange. Teachers utilize digital interactive platforms and tools to engage all students, showcasing applied problems and mathematical modeling of real-world systems or processes to stimulate cognitive motivation.

Presentation tools like Canva or PowerPoint, along with mathematical visualization software such as GeoGebra or Desmos, help convey complex theoretical material. The use of interactive resources like quizzes, competitions, or creative projects further enhances interest and engagement. For example, the Quizizz platform enables quizzes in team or individual formats, providing a leaderboard at the end to highlight top performers.

2. Active Experimentation. At this stage, students apply fundamental mathematical knowledge to solve practical problems. They actively engage by asking themselves: "What needs to be done? How can this be solved? What steps should I take?"
   Practical tasks combine motivation through interest - students derive satisfaction from solving complex problems - and achievement, as they realize their capabilities. This dual-component approach integrates theoretical knowledge with its practical application, as posited by the expectancy-value theory.
   Group activities such as data collection, discussion of problem-solving methods, and idea sharing foster collaboration. For example, the "jigsaw" method allows group members to examine problems from different perspectives.
   Students are encouraged to develop projects, participate in competitions, and explore creative solutions, which not only deepen their theoretical understanding but also cultivate essential practical skills for future professional environments.
3. Concrete Experience. This stage involves analyzing data and developing theoretical frameworks to enhance understanding. Students assess the utility of their mathematical knowledge for various professions. They reflect on the significance of their prior achievements and evaluate how the acquired knowledge benefits their future careers.
   Activities include independent research, group discussions, role-playing, critical thinking exercises, forecasting, modeling, and analyzing conclusions. Educators may also encourage students to prepare academic projects [31], [32], scientific papers, or participate in innovative competitions.
4. Reflective Observation. Reflective observation involves critically assessing the experiential learning process, identifying strengths and weaknesses, and determining areas for professional growth. Students analyze alternative solutions, compare methods, and evaluate their outcomes.
   Formative assessment techniques such as "know – learned – want to learn," open-ended questions, or one-minute essays help students reflect on what they have learned, how it relates to their future profession, and how theoretical knowledge translates into practical use. Interactive tools like digital boards or structured group activities foster engagement and critical evaluation.
   Maintaining motivation requires fostering both interest and achievement. Feedback tools such as messengers, social networks, and Google Classroom comments enable instructors to respond quickly to student queries and support practical tasks.

Students' efforts are further characterized by their level of digital competence, which influences their activity, engagement, and speed of completing assignments in remote or blended formats. Proficiency in programming languages and computational tools empowers students to automate routine calculations, create algorithms, and solve complex problems, preparing them for success in modern academic and professional settings.

Kolb's experiential learning model provides an effective framework for fostering student motivation through a balanced integration of theoretical knowledge and practical application. By encouraging reflection, active participation, and digital competency, educators can create a dynamic and engaging learning environment even in challenging conditions (figure 1).

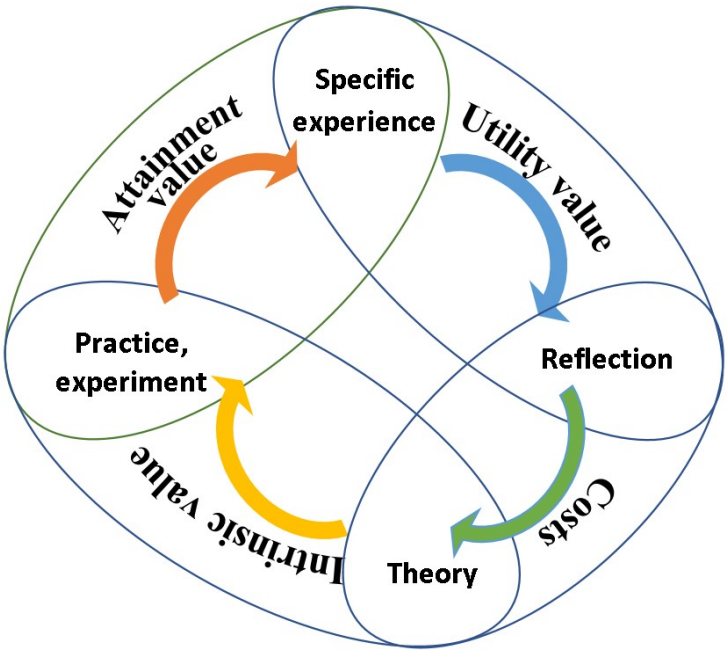


Figure 1. Motivation of students through experiential learning according to the cycle of Kolb (author's development).

4.1. Structure of a Lesson Based on Kolb's Experiential Learning Cycle

Starting the learning process by demonstrating an applied problem of modeling real-world objects and phenomena, the instructor implements the "practice, experiment, testing" stage of Kolb's experiential learning cycle, simultaneously addressing value motivation through intrinsic and attainment as per Eccles et al.'s theory. For example, students may be tasked with determining the time it takes for a projectile fired from a cannon under specified initial conditions to hit the ground [[33] ((figure 2).

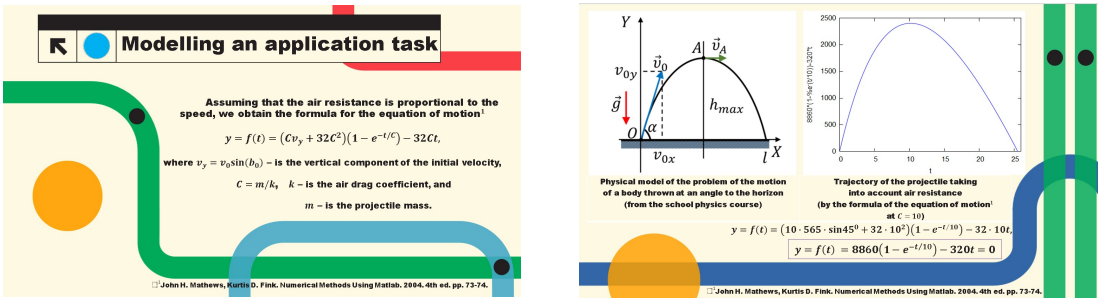


Figure 2. Information model of a real physical problem (interest value) (author's development).

The instructor then demonstrates various methods for solving this problem, employing both mathematical and computational modeling approaches. Students learn to analyze a real-world physical problem by constructing its mathematical model and applying numerical methods such as the Bisection Method (or Bolzano Method), Newton-Raphson Method, False Position (or Regula Falsi) Method, Secant Method, Combined Method, and Fixed-Point Iteration Method [33].

Students gain practical experience and understand that the problem can be solved using

various numerical methods, both manually and with the help of applied mathematical software. This corresponds to Kolb's "concrete experience" stage and reinforces the value of attainment and utility in Eccles et al.'s theory (figure 3).

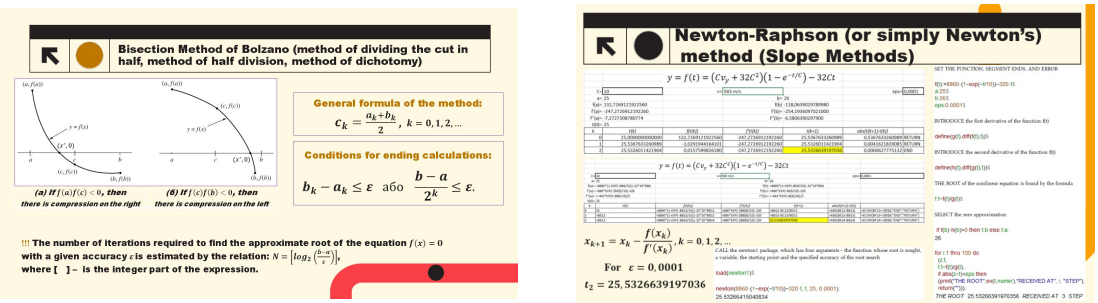


Figure 3. Fragment of mathematical and computer modelling of a problem (value of achievements) (author's development).

The analysis, observation, comparison, and critical evaluation of the obtained experience (results of calculations using different methods) lead to a deeper understanding of the outcomes. Students select the optimal method for solving the problem by weighing the advantages and disadvantages of each considered method. This corresponds to Kolb's "reflection and analysis" stage and the value of utility in Eccles et al.'s theory (figure 4).

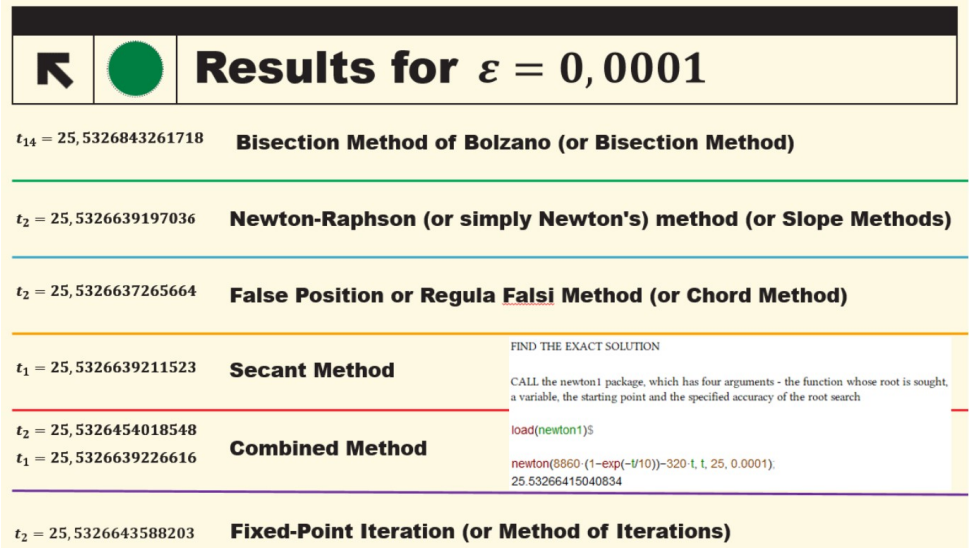


Figure 4. Practical experience: comparison of results obtained by different numerical methods (cost) (author's development).

The final stage of the first cycle involves understanding the theoretical and fundamental principles behind applying mathematical and computational modeling methods to solve applied problems. This aligns with Kolb's "conceptualization of knowledge and theory" stage and the cost in Eccles et al.'s theory (figure 5).

After completing all four stages of empirical learning according to Kolb's cycle, when the general principle is understood, the next step is to complete the second cycle in new, supplemented, more complex mathematical problems based on the specific experience gained

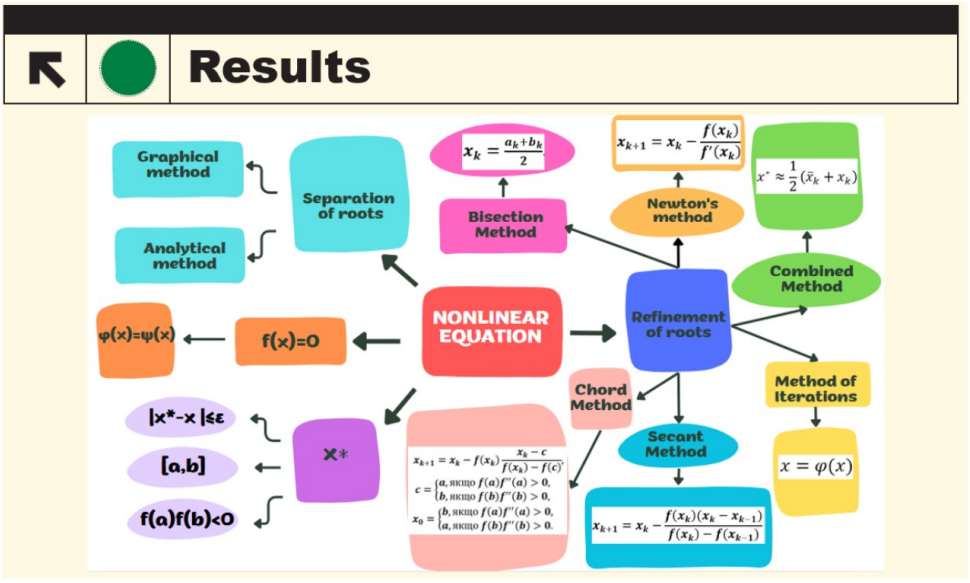


Figure 5. Theoretical foundations: summarising the material with the help of a knowledge map (usefulness) (author's development).

in the previous cycles of learning. In this way, a complex empirical spiral of learning through Kolb's cycles is built.

5. Discussion

The authors of the article offered the 1st-4th year students of the Faculty of Mathematics, Physics and Computer Science of VSPU to take a survey in Google form in the form of a table with answer options according to the methodology "Motives for choosing a profession" and A. Rean's questionnaire "Motivation for Success and Anxiety of Failure" [20].

To establish a statistical relationship between the motives for choosing a profession by bachelors of mathematics of 1-2 years (49 people) and bachelors of mathematics of 3-4 years (37 people), the Spearman's rank correlation coefficient rs was used. The ranks are not repeated, so the empirical value of Spearman's r_s correlation coefficient will be determined by the general formula: $r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$, where n is the number of features, d_i – is the difference in ranks: $d_i = R_{X_i} - R_{Y_i}$; d_i^2 is the square of the rank difference [34]. The coefficient r_s takes values in the range from - 1 to + 1.

The primary data of the results of the survey of bachelors of mathematics of 1-2 courses (X) and bachelors of mathematics of 3-4 courses (Y) by the methodology "Motives for choosing a profession" are presented in the order scale (table 2).

We set the probability level of the first kind of error and formulate the null and alternative hypotheses for $\alpha = 0.01$:

H_0: there is no statistically significant correlation between the motives for choosing a profession by bachelors of mathematics in the 1-2 year of study (X) and bachelors of mathematics in the 3-4 year of study (Y) $(r_s = 0)$;

H_1 : there is a statistically significant correlation between the motives for choosing a profession by 1-2 year mathematics bachelors (X) and 3-4 year mathematics bachelors (Y) $(r_s \neq 0)$.

The empirical value of Spearman's rank correlation coefficient r_s:

Table 2. Primary data and intermediate calculations based on the results of the survey of bachelors of mathematics 1-2 years (X) and bachelors of mathematics 3-4 years (Y).

№	Groups of motivations	X	Y	d_i	d_i^2
1	Social	5	5	0	0
2	Moral	4	3	1	1
3	Aesthetic	7	6	1	1
4	Cognitive	1	1	0	0
5	Creative	3	2	1	1
6	Related to the content of work in the chosen profession	6	7	-1	1
7	Material	9	9	0	0
8	Prestigious	8	8	0	0
9	Utilitarian	2	4	-2	4
			Sums	0	8

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)} = 1 - \frac{6 \cdot 8}{9 \cdot (9^2-1)} = 0.93.$$

For a degree of freedom $df = n = 9$ and a given $\alpha = 0.01$, according to the table of critical values of Spearman's rs correlation coefficient, $r_{crit} = 0.798$ [34]. Since $r_{emp} > r_{crit}(0.93 > 0.798)$, hypothesis H_0 is rejected. The size of the standardised effect according to J. Cohen's classification is large ($r_s = 0.93$). Therefore, there is a statistically significant direct correlation between the indicators of the importance of the motives for choosing a profession by bachelors of mathematics of 1-2 years (X) and bachelors of mathematics of 3-4 years (Y) (figure 6).

According to the statistics of the Spearman's r_s criterion ($r_s = 0.93$; $p > 0.01$; $n = 9$), there are no grounds for accepting the null hypothesis. The results of statistical research are debatable, so it is worth increasing its statistical power by studying the motivation of mathematics bachelors' learning activities, in particular in different educational institutions by increasing the size of respondents' samples and using various methods of organising a pedagogical experiment. The results of the survey "Motivation for Success and Anxiety of Failure" according to A. Rean's methodology are ranked and presented in table 3.

Modern students of the 1st-4th years of study are primarily focused on motivation to succeed or demonstrate a tendency to succeed. This may be due to the fact that the choice of profession is more often made at the stage of master's studies rather than during bachelor's studies. At the bachelor's level of education, students mostly focus on acquiring general knowledge and skills that open up wide opportunities for future professional fulfilment. At the same time, the motivation to succeed at this stage is formed as a desire for academic excellence, which allows students to create a basis for further specialised study and career development.

6. Conclusions

The article describes the theoretical foundations and analytical approaches to developing learning motivation among mathematics bachelor's students in the process of studying professional disciplines, based on the expectancy-value theory (Eccles et al., 1983; Eccles Wigfield, 2000), which suggests that students' perception of learning mathematics is shaped by four components of task value: interest value, attainment value, utility value, and cost. The

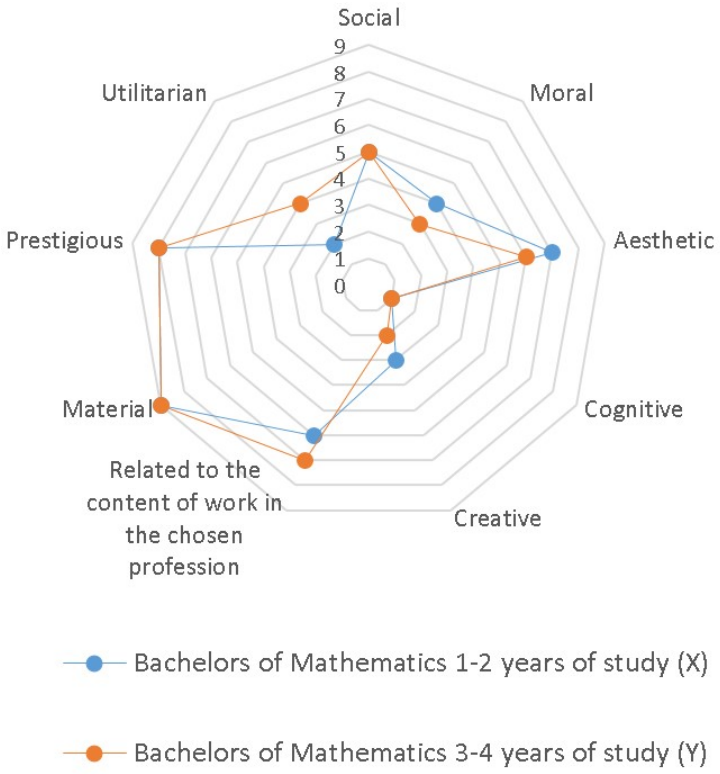


Figure 6. Groups of motives 1-9 according to the "Motives for Choosing a Profession" methodology (table 2) and its significance for bachelors of mathematics at Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University.

Table 3. The results of the survey of bachelors of mathematics of 1-2 courses (X) and bachelors of mathematics of 3-4 courses (Y).

№	Groups of motivations	X	percentage of students	Y	percentage of students
1	Motivation to anxiety	4	2.1	4	8.1
2	A certain tendency of motivation to anxiety	3	10.2	3	13.5
3	A certain tendency of motivation for success	2	36.7	2	27.0
4	Motivation to succeed (hope for success)	1	51.0	1	51.4

authors demonstrate that these components can be operationalized using criteria, indicators, and levels of motivation-value formation in the professional training of mathematics bachelor's students, providing a comprehensive approach to assessing motivation in mathematics education.

The study reveals that analyzing students' learning motivation helps to identify the driving factors that determine individual activity. Since success in any activity depends not only on

abilities and knowledge but also on motivation, the transformation of external motives into internal ones stimulates students to higher levels of activity aimed at achieving success. It has been confirmed that applying the author's methodology throughout all stages of professional training-specifically, a lesson design based on Kolb's learning cycle and the motivation components of interest value and attainment value, which simulates stimulating situations-creates conditions for the intensive development of achievement motives. These motives later transform into professional ones, positively influencing students' satisfaction with their career choice, as well as their activity and independence in mastering elements of professional practice.

Three stages in the development of mathematics bachelor's students' motives have been identified:

1. Learning motives (Stage I).
2. Combination of learning and future professional activity motives (Stage II).
3. Professional activity motives (Stage III).

It is recommended to apply David Kolb's experiential learning model across all three stages. This model incorporates the value components of Eccles et al.'s theory, contributing to students' motivation to study mathematics. The authors have developed educational and research tasks for modeling real-world objects and phenomena.

To explore the relationships between intrinsic and extrinsic motivation as well as personal qualities, two tests were conducted among first- through fourth-year mathematics bachelor's students from the Faculty of Mathematics, Physics, and Computer Science at VSPU: "Professional Motivation of Students" and A. Rean's "Test-Questionnaire on Motivation for Success and Fear of Failure." Statistical analysis was performed using Spearman's rank correlation coefficient (r_s). It was proven that a statistically significant direct correlation exists between the importance of professional choice motives for first- and second-year mathematics students and those of third- and fourth-year students at VSPU. According to J. Cohen's classification, the standardized effect size is high.

The research results can be utilized by university instructors during mathematics courses to enhance students' motivation for learning.

Future research should focus on exploring the continuity of learning motives across secondary specialized education, pre-university, and higher mathematics education levels.

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