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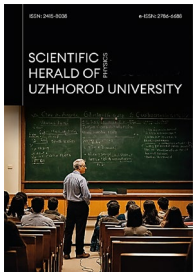

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Advantages and prospects of constructive learning of school mathematics epistemes in a pedagogical higher educational institution

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Abstract

Relevance. In the context of constant changes in the educational sphere, the introduction of constructive teaching to the epistemes of mathematics is an urgent task, the study of this topic helps to adapt teaching methods to modern requirements and effectively introduce innovations into pedagogical practice.

Purpose. The purpose of the study was to analyse the effectiveness of constructive teaching of mathematics epistemes in a pedagogical higher educational institution in order to identify and evaluate the results obtained.

Methodology. The following methods of scientific cognition were used: literary analysis, synthesis, deduction, and induction.

Results. The study identified specific epistemic competencies needed by future mathematics teachers, such as the ability to analyse mathematical concepts, identify connections between them, and develop systematic mathematical thinking. Specific elements of successful educational programmes were also highlighted, such as precisely tuned courses, systematic practical exercises, and effective feedback that contribute to the development of professional competence of future mathematics teachers. The methods contributing to the effective mastery of educational material by students and to the development of pedagogical competence in the field of mathematics education were considered. Tools and criteria were also proposed to assess the effectiveness of the implementation of constructive teaching of epistemes of mathematics, contributing to the development of systematic mathematical thinking and deep awareness of students.

Conclusions. Constructive learning based on an epistemic approach is aimed at developing students' holistic understanding of mathematics, supporting flexibility, creative problem solving and interest in the subject. The study

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proposed strategies and methods aimed at developing the professional competence of future mathematics teachers, including special educational courses, practical exercises, and feedback from experienced teachers.

Keywords: educational practice; professional competence; applied sciences; methodology; teaching; learning; abilities.

Introduction

In the modern educational context, where the requirements for the quality of mathematical education are constantly growing, the question of the effectiveness of training future mathematics teachers is becoming a topical issue. On the way to the development of students' strong mathematical competencies and epistemic beliefs, difficulties arise that require in-depth analysis and systematisation. This research is aimed at highlighting the problem of mandatory results of constructive teaching of epistemes of mathematics in a pedagogical higher educational institution. The need to investigate this topic is conditioned by the desire to ensure a high level of professionalism of future mathematics teachers. The complexity of the mathematical discipline and its key role in the development of critical thinking highlight the importance of an adequate approach to its learning. The problem lies in the lack of clear standards and mandatory results that determine effective constructive teaching of mathematics epistemes in pedagogical educational institutions. The absence of such results can lead to heterogeneity in the training of mathematics teachers and a decrease in the quality of education.

I.M. Shrestha et al. [1] claim that in their experience, most mathematics teachers struggle to improve their teaching skills in order to ensure that students receive meaningful learning. Instead of studying their "inner selves", they often look for the best pedagogical approaches. The study does not consider which specific "inner selves" of mathematics teachers might be explored in the context of improving their teaching skills. In addition, a specific methodology or strategy for exploring the "inner selves" of teachers has not been considered.

N. Madiyarov et al. [2] suggest that at the present stage, the organisation of the educational process in secondary schools according to the updated content of education in accordance with modern requirements also poses new challenges to the methodological system of school education, giving each student the necessary knowledge of geometry. They state that at the same time, attention should be focused on the content of school geometric education, the implementation of the principle of continuity of teaching the geometry course. The comprehensive development of the geometry course by students depends on the degree of geometric and methodological training of a school mathematics teacher. Thus, the university monitors the continuity of the proposed educational programmes and curricula in the training of future specialists and provides an opportunity for their professional training.

Information and communication technologies play an important role in modern education. R. Kadirbayeva et al. [3] considered the problem of developing the professional competence of future mathematics teachers through the development of an information and communication subject environment (ICSE) in a school mathematics course. The researchers note the contradiction between the pace of development of the modern education system and the low level of updating the content of education in the curricula of secondary education.

The possibilities of developing the research culture of students in the process of continuing professional pedagogical education were considered by G.B. Alimbekova and M.M. Turganova [4]. The research culture of students is the ability to constantly apply professional pedagogical knowledge and skills for certain academic circles, and a brief overview of the level of research in the field of self-development. They suggest that continuous professional pedagogical education in the process of developing a research culture of students is the basis for the training of future teachers and is important for personal development.

A.E. Abylkassymova et al. [5] suggest that the need to determine the theoretical foundations of the professional orientation of teaching mathematics, in the context of the development of a certain set of competencies among students, determines the purpose and relevance of the study. They adhere to a leading scientific approach that combines methods of systematic analysis of the basic concepts of teaching higher mathematics with the investigation of prospects for improving professional orientation in its teaching. This study did not examine in detail the specific steps or programmes proposed to build the competencies of future mathematics teachers.

According to G.B. Akhdiyeva et al. [6], one of the main difficulties of modern schools is the lack of qualified and competent teaching staff. In this regard, the paper highlights the problem of research: the training of teachers of higher educational institutions is mainly limited to the theoretical investigation of the subject area, pedagogy, and teaching methods. G.B. Akhdiyeva et al. [6] have not considered what specific methods and strategies can be used to expand education in modern schools.

Constructive learning is one of the most promising approaches in modern mathematical education. As noted by D. Belessova et al. [7], the COVID-19 pandemic accelerated the processes of digital transformation of education and revealed many problems in this area, including the lack of digital infrastructure, digital inequality, and low levels of digital literacy. In these conditions, innovative teaching methods that allow achieving educational results using digital technologies are of particular importance. A constructive approach based on the construction of knowledge by students in the process of active cognitive activity meets these requirements.

In connection with the introduction of the updated content of secondary education in schools in Kazakhstan, the issue of improving the methodological training of future mathematics teachers in higher educational institutions is relevant. G.S. Jarassova et al. [8] suggest that mathematics can make a significant contribution not only to the overall development of personality, but also to the development of character, moral traits, and contributes to the development of aesthetic perception of the world. Thus, pedagogical universities have faced a number of difficulties in teaching mathematical subjects.

The purpose of the study is to analyse the effectiveness of constructive learning based on an epistemic approach in the development of advanced epistemic competencies and a deep understanding of mathematical concepts in future mathematics teachers.

Materials and Methods

The literature review served as the foundation for the proposed solutions and included the study of modern educational requirements, emphasising the importance of deep mastering mathematical knowledge. The study also highlighted key aspects such as the development of epistemic competencies, critical thinking, and understanding of mathematical knowledge in various fields. Teaching methods, including constructive learning, were considered in the context of encouraging students to research, analyse, and create their own ideas about mathematics.

Logical analysis was used to explain in detail how constructive learning based on an epistemic approach helps to establish deep connections between various mathematical concepts. The critical analysis was aimed at identifying the advantages and disadvantages of conventional teaching methods, while highlighting the effectiveness of constructive learning in response to the current challenges of the modern educational environment.

The synthesis was used to combine the principles of constructive learning with the basics of the epistemic approach, forming an integrated method of teaching mathematics. This method provided a harmonious combination of the basic principles of constructive learning and the fundamental principles of epistemic methodology.

This method has also been used in combining various data, practical examples, and theoretical concepts. This method enabled a comprehensive understanding of the impact of constructive learning in combination with an epistemic approach on the learning processes and the development of competencies for future mathematics teachers. The application of teaching methods, including epistemic and constructive, was considered with an emphasis on specific examples, demonstrating how constructive learning contributes to the formation of holistic ideas about mathematics and develops students' skills of independent research. A data comparison method was also used to identify differences between constructive learning and the epistemic approach.

The deduction was used to formulate a general statement, such as the inconsistency of standard teaching methods with the requirements of modern education. The deduction was also used in discussing the general principles of constructive learning and the epistemic approach in education. These principles were formulated based on deductive processes, including generalisations and conclusions from previous research, the experience of teachers or the analysis of modern educational requirements.

The induction was used to provide concrete examples of the successful use of constructive learning and an epistemic approach. These examples were derived from the study of pedagogical scenarios presented in the literature and the results of previous studies. The approaches and scenarios identified through the induction method serve as illustrations of the successful implementation of constructive learning and provide a context for the effective integration of the epistemic approach into pedagogical practice, enriching understanding and providing the basis for the development and implementation of such teaching methods in the educational process.

The contextual approach revealed the requirements of modern education and the role of teachers, and also drew attention to various pedagogical methods such as group work and research projects, emphasising their importance in the context of constructive learning to form a deep understanding of the epistemes of mathematics.

These methods were used to identify the effectiveness of constructive learning based on an epistemic approach in the development of advanced epistemic competencies and a deep understanding of mathematical concepts in future mathematics teachers.

Results

Modern education, faced with the challenges of a changing information and socio-cultural context, calls for the search for innovative methods of teaching mathematics in pedagogical educational institutions. This is conditioned not only by the need for a deep theoretical understanding of mathematical concepts, but also to the desire to train future teachers with developed epistemic competencies – the ability to think critically, analyse and understand mathematical knowledge in their broad context.

In the light of the new requirements of modern education, standard methods of teaching mathematics no longer always meet the needs of students and the requirements of the school curriculum [9]. Constructive learning, which focuses on the active interaction of students with the material and the collective building of knowledge, is an effective response to these challenges. The epistemic approach in teaching mathematics implies not only the transfer of facts, but also the development of students' belief systems and approaches to understanding mathematical phenomena [10]. It goes beyond the superficial assimilation of the material, encouraging students to explore, analyse, and build their own understanding.

Constructive learning should contribute to the development of holistic and integrated ideas about mathematics in future teachers of mathematics, rather than just fragmented knowledge. This includes the ability to see the relationships between different topics and concepts. Students who have completed constructive training should be able to actively interact with the material, ask questions, conduct research and take part in a dialogue [11]. This contributes not only to the assimilation of facts, but also to the development of critical thinking. They are able to analyse information, identify contradictions, and make reasoned decisions. Constructive learning develops students' independence in the search for knowledge. They find satisfactory answers to their questions, stimulate their learning interest, and interpret the information on their own.

Students trained in a constructive epistemic approach demonstrate the ability to creatively apply their mathematical knowledge in solving real problems and situations. The next important aspect of constructive

learning is to promote the application of mathematical concepts in various contexts. Students should be able to see how mathematics is applied in real-world situations and what conclusions they can draw based on their knowledge. This develops their skills of analysing and solving problems in various areas of life.

Constructive learning should develop the ability of future mathematics teachers to independent research. This includes the ability to formulate and solve mathematical problems, analyse new materials and, apply them in practical scenarios. The application of various pedagogical methods, such as the use of contextualised examples, group work, research projects and practical tasks, becomes an integral part of constructive learning aimed at developing a deep understanding of the epistemes of mathematics. In addition, epistemically trained students should successfully interact with colleagues and students, express their thoughts clearly, discuss mathematical ideas, and argue their conclusions. The epistemic approach in teaching mathematics is not limited to the superficial assimilation of facts, but sets itself the task of developing a deep understanding [12]. In addition, it is designed to help students understand not only individual mathematical terms, but also to build relationships between them. This means that students should not only memorise isolated concepts, but also see them in the context of the general structure of mathematical knowledge.

In the modern educational environment, not only the transfer of mathematical knowledge is required, but also their deep and systematic development. Combining constructive learning and epistemic approach becomes a key factor in the development of students' not only technical competence, but also the ability to see mathematics as a holistic system of interrelated knowledge [13]. Modern education is responsible for developing not only technical skills, but also a deep, meaningful understanding of subjects, especially in the context of mathematics. The epistemic approach, aimed at forming a system of beliefs and understanding, becomes a key tool, and its combination with constructive learning acts as a response to the challenges of the modern educational environment. When an epistemic approach is combined with constructive learning, students not only learn mathematical facts, but also develop a deep understanding that allows them to apply knowledge in new contexts and critically evaluate information. They not only memorise algorithms, but also understand the logic and structure of mathematical concepts. Constructive learning, combined with an epistemic approach, should direct efforts to clarify the meaning of mathematical concepts.

Students should be aware not only of the procedures and rules, but also have a deeper understanding of why these concepts exist and how they interact with each other. This allows students to develop not only a superficial knowledge, but also a deep mathematical intuition. Students who have completed constructive training based on the epistemic approach are distinguished not only by their technical competence, but also by the ability to see mathematics as an integral system [14]. They are better suited to solving complex problems, critically analysing information, and applying mathematical concepts in real-world scenarios (Table 1).

Table 1. Comparison of epistemic and constructive teaching methods

Characteristics	Epistemic teaching method	Constructive teaching method
Main focus	On the transfer of ready-made knowledge and facts	On the active interaction of students and the joint building of knowledge
Role of the teacher	Source of information and an expert in the subject area	Mentor, training organiser, stimulating students' thinking and research approach
Role of the student	Passive reception of information, memorisation	Active participation, research, critical thinking, independent problem solving
Teaching process	Unidirectional, from teacher to student	Interaction and exchange of opinions, discussions, learning through experience
Basic methods	Lectures, demonstrations, information reproduction	Group projects, discussions, practical exercises, problem-oriented tasks
Approach to errors	Avoiding mistakes, focusing on correct answers	Perception of mistakes as part of the learning process, their analysis and correction
Purpose of training	Transfer of basic knowledge and skills, readiness for testing	Development of critical thinking, problem-solving skills, and academic independence
Evaluation forms	Tests and exams, grades for correct answers	Assessment of activity, participation in discussions, project activities, development of competencies
Applicability	It is effective for transferring basic knowledge, structured topics	It is effective for the development of critical thinking, the ability to apply knowledge in new contexts
View on the learning environment	Teacher-oriented, control-oriented	Student-oriented, supports creative thinking and self-regulation
Examples of learning tools	Textbooks, lectures, tests, standardised assignments	Projects, group discussions, problem situations, real cases

Constructive learning based on an epistemic approach should actively assist students in building connections between various mathematical concepts. This includes not only a cursory knowledge of individual terms, but also the ability to see them in the context of the general landscape of mathematics. Students should be aware of how different concepts interact and how they can be applied in different scenarios [15]. The purpose of constructive learning should be to develop students' holistic understanding of the subject. They should see mathematics not as a set of isolated topics, but as a system in which different concepts interact and complement each other. This allows students to build deeper and more structured knowledge that remains stable in various situations. Such a vision contributes to a deeper understanding of the mathematical world and stimulates creative thinking [16]. Constructive learning, focused on epistemic principles, seeks to form not only superficial competence, but also deep awareness of students. This means that future mathematics teachers will not only have the necessary knowledge and skills (abilities), but also an understanding of the fundamental principles underlying mathematical concepts.

Constructive learning should strengthen students' skills in flexible and creative solving of mathematical problems [17]. This is achieved not only by memorising algorithms, but also through active participation in building their own solutions, research and analysis of various approaches to solving problems. Such skills are key when encountering new mathematical problems in school practice. The development of systematic mathematical thinking is also important to maintain interest in mathematics among future teachers.

Students who have the ability to see the big picture and apply knowledge in different contexts are more likely to overcome difficulties and study with pleasure, which significantly increases their professional effectiveness. This approach to teaching mathematics in pedagogical educational institutions not only provides future teachers with the necessary theoretical knowledge, but also develops in them the abilities necessary for successful teaching, including the ability to effectively communicate mathematical ideas and stimulate interest in the subject among students. For the effective development of systematic mathematical thinking, it is necessary to use a variety of teaching methods. This includes tasks that facilitate analysis and discussion, group projects, research assignments, and the application of new technologies in learning.

An important tool for forming connections and systemic understanding in mathematics is the use of visualisation and examples. Constructive learning should include methods that facilitate the visualisation of mathematical concepts and provide students with specific scenarios where these concepts can be applied. This helps students to better see the relationships and build their own understandings. Constructive learning, based on the epistemic approach, should also set itself the task of ensuring the practical application of mathematical knowledge in real situations. Students should be given opportunities to apply their knowledge in various contexts, which contributes to a deep understanding and vision of mathematics as a tool for solving real problems. Students trained in constructive teaching of epistemes of mathematics should successfully apply their systemic mathematical abilities in educational activities. This includes developing lessons, adapting learning materials, applying interactive teaching methods, and providing flexibility in teaching different students.

The modern school environment requires teachers who are able to implement innovative teaching methods. Deep knowledge in the field of mathematics, developed through constructive teaching of epistemes, prepares future teachers for active participation in the process of educational innovation. They become not only the executors of the programme, but also the initiators of positive changes [18-20]. Teachers who have received constructive training in epistemes have the skills to effectively adapt to a rapidly changing educational environment. This includes the ability to quickly master new teaching methods, adapt lessons to different types of students, and successfully innovate in their teaching practice. Teaching mathematics epistemes in pedagogical universities should lead to practical results in the school educational environment. Teachers trained in this way are able to create stimulating learning environments where mathematics is presented not only as a compulsory subject, but also as a fascinating and interesting study. The study of the mandatory results of constructive teaching of epistemes of mathematics contributes to the creation of a new generation of teachers. These teachers will not only impart knowledge but also inspire students with a deep interest in maths, building not only technical competence but also a love of the subject.

One of the key strategies is the creation of specialised educational courses covering modern methods of teaching mathematics, educational psychology, learning technologies and the effective use of educational resources. The courses should be filled with relevant material that contributes to the development of students' pedagogical abilities. The organisation of practical classes is an important component of the development of professional competence of future mathematics teachers. Students should be able to apply theoretical knowledge in real educational scenarios.

Practical classes may include modelling lessons, working with real students, and analysing and discussing pedagogical situations. In addition, effective feedback from experienced teachers plays a key role in the development of students' professional competence. Mentoring, review and analysis of lessons, and regular discussions help future teachers to see their progress and receive valuable advice and recommendations to improve their teaching activities.

Discussion

The study of the mandatory results of constructive teaching of mathematics epistemes in a pedagogical higher educational institution is an important area in the development of education. It justifies not only the need to introduce constructive methods, but also highlights the key characteristics that future mathematics teachers should have in order to successfully resist the challenges of modern education.

In their latest study, E. Löfström and T. Pursiainen [21] focus on the epistemological beliefs of future teachers of mathematics in the context of mathematics and education. The main purpose of their study is to gain an understanding of the difficulties faced by students in the process of acquiring knowledge in two disciplines. The research methodology uses mathematical and pedagogical tasks, interviews and stimulation of memories with the participation of three future mathematics teachers. The results of the study show that students' epistemologies depend on the subject area, and problems arise when consolidating mathematical and pedagogical knowledge.

The researcher identified several aspects that may hinder the consolidation of knowledge. For example, the fact that students believe that pedagogical knowledge is very relative, which can create difficulties in integrating it into the general context. Students consider theoretical pedagogical knowledge as unrelated to real practice, which may make it difficult to apply them in the educational process. Students also adhere to formal ideas about mathematics, which may interfere with understanding its applied and contextual nature. According to the researcher, students prefer to rely on authority rather than evidence to justify their mathematical knowledge, which can reduce their critical thinking.

Both studies focus on epistemological aspects of education, placing students' beliefs in the context of their subject (mathematics) and the learning process. Both studies use a variety of research methods, such as the analysis of mathematical and pedagogical problems, and the involvement of students in reflective processes. A key aspect of both studies is the identification of difficulties faced by students in the process of mastering mathematical and pedagogical knowledge. This includes difficulties in integrating pedagogical and mathematical knowledge, and some shortcomings in students' epistemological beliefs. The above study focuses on constructive teaching of mathematics epistemes in the context of pedagogical universities, while the study by E. Löfström and T. Pursiainen [21] is more focused on the epistemological beliefs of students in the general context of mathematics and education. Research by the researchers highlights the problems of integrating pedagogical and mathematical knowledge, and emphasises formal ideas about mathematics and students' preference for authority.

While this study is more focused on constructive learning and developing the competence of future mathematics teachers. The research described above focuses on constructive learning and the development of strategies to develop a deep understanding of the epistemes of mathematics, while the researchers focus on identifying complexities and contradictions in students' beliefs. Both papers provide valuable insights into problems related to understanding mathematics and shaping the professional competencies of future teachers. By analysing these studies together, it is possible to enrich the understanding of the complex aspects of the teaching and training of mathematics teachers.

The study by A. Raoul and C. Philemon [22] is an attempt to identify binary oppositions in the discourse of mathematical education and offers a binary-epistemic model for the (re)conceptualisation of these oppositions and related epistemic-pedagogical problems. The study argues that there are binary oppositions in mathematics education, such as traditional/progressive, student/teacher oriented, discovery/transmission, constructivist/behaviourist. The researcher suggests that these oppositions may present epistemic and pedagogical problems. The study introduces a binary-epistemic model that considers the contextual relationships between different binary options. It seeks to cover both pedagogically significant binary options (related to teaching methods) and epistemically significant binary options (related to ways of knowing mathematics).

The premise of the research is that the ways of learning mathematics (epistemology) influence the methods of teaching mathematics (pedagogy) and vice versa. This highlights the importance of the relationship between how mathematics is understood and how it is taught. The study provides examples of epistemically differentiated measurement teaching methods in the 5th grade mathematics classroom in the context of the new Australian curriculum. The study offers a new perspective on the discourse of mathematical education, emphasising the importance of considering epistemic and pedagogical aspects, and contextual connections between them. The introduction of a parapositional approach can contribute to a more flexible and comprehensive understanding of issues related to methods of teaching mathematics.

Both studies focus on the epistemological and pedagogical aspects of mathematics education. Both authors recognise that the ways of knowing mathematics (epistemology) and the methods of teaching it (pedagogy) are interrelated and can influence each other. Research suggests models that allow considering the contextual relationships between different binary oppositions. This study highlights the importance of constructive learning and its impact on epistemic beliefs, whereas the study by A. Raoul and C. Philemon [22] introduces a binary epistemic model for the (re)conceptualisation of these oppositions and their connection with epistemic and pedagogical problems.

The above study focuses on constructive teaching of mathematics epistemes in the context of pedagogical universities, whereas the study by the researchers is focused on identifying and (re)conceptualising binary oppositions in the discourse of mathematical education in general. The research methods that were used above may include constructive educational approaches, while research by the researchers used binary opposition analysis in the context of the curriculum. The study described above focuses on the impact of constructive learning on epistemic beliefs, while the study by the researchers seeks to (re)conceptualise binary oppositions and related epistemic and pedagogical problems. Both studies are important for understanding complex issues related to mathematics education and can complement each other by providing a comprehensive view of the issue.

The research by B. Hudson [23] contributes to the debate about progressive approaches to the curriculum in mathematics and focuses on the question of what knowledge students should be provided in school mathematics. The study begins by recognising the progressive arguments in favour of the curriculum being linked to the liberating ambitions of education. This creates a context for considering the concept of "powerful

knowledge" and its epistemic quality. The researcher uses the concept of "powerful knowledge" as a starting point, it is considered in the context of epistemic quality. They distinguish between mathematical fallibilism and mathematical fundamentalism, which helps to understand what attitude to knowledge should be maintained in educational programmes.

The relationship between powerful knowledge and epistemic quality is analysed within the framework of the sociological theory of knowledge. This clarification helps to understand how sociocultural factors can influence the development of knowledge and its quality in a school context. The study provides examples of high and low epistemic quality in school mathematics. The first example is taken from the project "Development of mathematical thinking in primary school", while the second example is related to the Core Knowledge Foundation introduced in English schools. The paper points to the role of teachers as curriculum developers, emphasising the relationship between the curriculum and pedagogy at the classroom level. Both studies focus on the question of what knowledge should be provided in school mathematics. Both studies use the concept of "powerful knowledge" as a starting point. This concept serves as a basis for considering which knowledge is important and how it relates to epistemic quality. The research draws attention to the socio-cultural factors influencing the development of knowledge and its quality in the school context.

The study by K. Ruthven et al. [24], conducted within the framework of the project "[epiSTEMe]", aimed at improving education in the field of STEM (science, technology, engineering, and mathematics) in primary and secondary schools. The purpose of the project was to increase student engagement and learning in physics and mathematics using principles recognised in the literature as effective. An important feature was the introduction of the dialogic learning component into the [epiSTEMe] pedagogical approach. The programme was developed for the first year of secondary education in English schools (ages 11-12) and consisted of an introductory module and thematic modules, including two academic topics in each science and mathematics. A significant feature was the inclusion of a dialogic learning component in the programme.

At the intervention stage, it was revealed in the observation of lessons that the level of dialogic learning was different for different thematic modules. At the first implementation of the [epiSTEMe] project, the learning outcomes did not demonstrate significant positive effects in general. The effects ranged from small negative to small positive. No significant differences were found between the intervention and control groups, either in students' opinions about their classroom experience or in changes in their attitudes towards subjects.

This study provides information about the attempt to introduce a new pedagogical approach in the field of STEM, but despite its innovativeness, it faces challenges and has not yet demonstrated significant success in comparison with conventional methods.

Conclusions

Modern challenges in education require effective methods that form not only technical competence, but also a deep understanding of the subject. Combining the epistemic approach and constructive learning in pedagogical educational institutions is becoming a strategically important step in ensuring high-quality mathematical education for future generations of teachers. The combination of constructive learning and an epistemic approach in pedagogical educational institutions not only enriches students' knowledge, but also establishes a stable foundation for their successful teaching and understanding of mathematics in the context of the school educational environment. These skills not only prepare future teachers for successful teaching of mathematics, but also create the basis for continuous professional development and adaptation to a dynamic educational environment.

The study of the results of constructive teaching of mathematics epistemes in a pedagogical higher education institution is a strategically important approach aimed at the training of teachers. These results contribute to improving the level of mathematical education and preparing teachers for the role of leaders in the educational field. Modern teachers should be not only the executors of educational programmes, but also the initiators of educational innovations. Deep mastery of mathematics through constructive epistemological learning gives future teachers the necessary skills to actively participate in the process of updating education.

Teachers, having been trained in the epistemes of mathematics, have the flexibility and ability to quickly adapt to a rapidly changing educational environment. Teaching mathematics epistemes in pedagogical universities should bring practical results. Teachers trained in this way are able to create stimulating learning environments, inspiring students to take a deep interest in mathematics and forming in them not only technical competence, but also a love for the subject. The creation of specialised educational courses covering modern methods of teaching mathematics, educational psychology, learning technologies and the effective use of educational resources is a key strategy. Effective feedback, mentoring, review and analysis of lessons, and regular discussions play a key role in developing the professional competence of student teachers.

Based on the conducted research, it is possible to conduct a number of additional studies for further in-depth understanding and effective implementation of constructive learning based on an epistemic approach. These studies may include an analysis of the impact of modern technologies on the effectiveness of constructive mathematics teaching and a comparison of student learning outcomes in educational institutions using various techniques.

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Conflict of Interest

None.

References

[1] Shrestha IM, Luitel BC, Pant BP. Exploring transformative pedagogy in teaching mathematics. *Math Educ For Chitw.* 2020;5(5):9-17.

[2] Madiyarov N, Tursynkulova EA, Kokesh AN. Training of the content of geometric construction calculations in school and university in the process of training future mathematics teachers. *Ped Psych.* 2023;54(1):21-34.

[3] Kadirbayeva R, Amirbekuly A, Jamankarayeva B, Issabek B, Ibashova A. The development of the informational and communication subject environment for the future mathematics teacher. *Opc Rev Cienc Human Soc.* 2019;35(23):1023-1042.

[4] Alimbekova GB, Turganova MM. Formation of research culture of students in the teaching of physics in higher education. *Bull Phys Math Sci.* 2021;73(1):76-81.

[5] Abylkassymova AE, Kalybekova ZhA, Zhadrayeva LU. Some aspects of professional orientation of teaching mathematics course in higher educational institutions. *Bull Phys Math Sci.* 2022;77(1):165-171.

[6] Akhdiyeva GB, Seitova SM, Egemberdieva SSh. Formation of students' functional literacy is one way to increase professional competence. *Bull Phys Math Sci.* 2022;80(2):71-79.

[7] Belessova D, Ibashova A, Bosova L, Shaimerdenova G. Digital learning ecosystem: Current state, prospects, and hurdles. *Open Educ Stud.* 2023;5(1):20220179.

[8] Jarassova GS, Seitkhanova AK, Tokzhigitova AN. The influence of university mathematics teacher training programs on the quality of teaching in schools. *Bull Ser Ped Sci.* 2021;72(4):133-142.

[9] Fowler S, Leonard SN, Gabriel F. Empowering mathematics teachers to meet evolving educational goals: The role of "epistemic objects" in developing actionable practice knowledge in tumultuous times. *Asia-Pacif J Teach Educ.* 2023;51(1):45-57.

[10] Thacker I, Rasiej R. Mathematics teachers' epistemic dispositions and their relationship with teacher instruction and student learning: A systematic research synthesis; 2020. http://www.ianthacker.com/PMENA_EC%20PAPER_2020.pdf

[11] Castillo MJ, Burgos M, Godino JD. Prospective high school mathematics teachers' assessment of the epistemic suitability of a proportionality textbook lesson. *Acta Sci.* 2021;23(4):169-206.

[12] Fowler S, Gabriel F, Leonard SN. Exploring the effect of teacher ontological and epistemic cognition on engagement with professional development. *Prof Dev Educ*. 2022;1–17.

[13] Bayyat A. *Ethnographically informed action research: Exploring the extent to which an art/craft-based mathematics resource and inclusive pedagogy facilitate equitable teaching and learning at upper KS2*. Sheffield: University of Sheffield; 2022.

[14] Sager MT, Wieselmann JR. Analyzing epistemic frames during STEM instructional coaching meetings: A quantitative ethnography approach. *Int J Ment Coach Educ*. 2023;13(1):1-16.

[15] Gurer MD, Akkaya R. The influence of pedagogical beliefs on technology acceptance: A structural equation modeling study of pre-service mathematics teachers. *J Math Teach Educ.* 2022;25:479-495.

[16] Lee YH, Hong HY. Preservice teachers' intention for constructivist ICT integration: Implications from their Internet epistemic beliefs and internet-based learning self-efficacy. *Inter Learn Env.* 2022;32(1):102-114.

[17] Gandhi H. Thirty-one teachers' epistemic beliefs as they worked with random generators: An explorative study. *Canad J Sci Math Tech Educ.* 2022;22:645-658.

[18] Boon M, Orozco M, Sivakumar K. Epistemological and educational issues in teaching practice-oriented scientific research: Roles for philosophers of science. *Eur J Philos Sci.* 2022;12:16.

[19] Cantoral R. Socioepistemology in mathematics education. In: *Encyclopedia of Mathematics Education* (pp. 790-797). Cham: Springer; 2020.

[20] Bielaczyc K, Kapur M. Playing epistemic games in science and mathematics classrooms. *Educ Tech.* 2010;50(5):19-25.

[21] Löfström E, Pursiainen T. Knowledge and knowing in mathematics and pedagogy: A case study of mathematics student teachers' epistemological beliefs. *Teach Teach.* 2019;21(5):527-542.

[22] Raoul A, Philemon C. Beyond the binary: Dexterous teaching and knowing in mathematics education. *Math Teac Educ Dev.* 2020;16(2):108-125.

[23] Hudson B. Powerful knowledge and epistemic quality in school mathematics. *Lond Rev Educ.* 2020;16(3):384-397.

[24] Ruthven K, Mercer N, Taber KS, Guardia P, Hofmann R, Ilie S, Luthman S, Riga F. A research-informed dialogic-teaching approach to early secondary school mathematics and science: The pedagogical design and field trial of the epiSTEMe intervention. *Res Pap Educ.* 2017;32(1):18-40.

Переваги та перспективи конструктивного навчання шкільних математичних епістем у педагогічному вищому навчальному закладі

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Анотація

Актуальність. В умовах постійних змін в освітній сфері впровадження конструктивного навчання до епістем математики є актуальним завданням, вивчення цієї теми допомагає адаптувати методи навчання до сучасних вимог та ефективно впроваджувати інновації в педагогічну практику.

Мета. Метою дослідження було проаналізувати ефективність конструктивного навчання математичних епістем у педагогічному вищому навчальному закладі, виявити та оцінити отримані результати.

Методологія. Використано такі методи наукового пізнання: літературний аналіз, синтез, дедукція та індукція.

Результати. Дослідження визначило конкретні епістемічні компетентності, необхідні майбутнім учителям математики, такі як здатність аналізувати математичні поняття, виявляти зв'язки між ними та розвивати системне математичне мислення. Також були виділені конкретні елементи успішних освітніх програм, такі як точно налаштовані курси, систематичні практичні вправи та ефективний зворотний зв'язок, які сприяють розвитку професійної компетентності майбутніх вчителів математики. Розглянуто методи, що сприяють ефективному засвоєнню студентами навчального матеріалу та розвитку педагогічної компетентності в галузі математичної освіти. Запропоновано інструменти та критерії оцінювання ефективності впровадження конструктивного навчання епістем математики, що сприяють розвитку системного математичного мислення та глибокої обізнаності студентів.

Висновки. Конструктивне навчання на основі епістемічного підходу спрямоване на розвиток у студентів цілісного розуміння математики, підтримку гнучкості, творчого вирішення проблем та інтересу до предмета. У дослідженні запропоновано стратегії та методи, спрямовані на розвиток професійної компетентності майбутніх учителів математики, включаючи спеціальні освітні курси, практичні вправи та зворотній зв'язок з досвідченими вчителями.

Ключові слова: освітня практика; професійна компетентність; прикладні науки; методологія; викладання; навчання; здібності.