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DEVELOPING STUDENTS' ALGORITHMIC THINKING IN THE PROCESS OF TEACHING INFORMATICS

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Abstract

This article examines the pedagogical foundations of developing students' algorithmic thinking in the process of teaching informatics in higher pedagogical education. Algorithmic thinking is interpreted as an integrative cognitive ability that enables learners to analyze a problem, identify its essential components, establish logical sequences, construct step-by-step solutions, and evaluate the efficiency of the obtained result. In the context of informatics education, the formation of this type of thinking is associated not only with mastering programming elements, but also with developing reasoning, abstraction, decomposition, modeling, and structured decision-making. The study is focused on the educational conditions, instructional methods, and didactic tools that support the gradual development of algorithmic competence among students preparing for professional activity in the field of IT and informatics. Special attention is given to problem-based learning, practical tasks, visual modeling, digital environments, and interactive forms of instruction that stimulate independent analytical activity. The article also considers the relationship between algorithmic thinking and broader educational outcomes, including academic autonomy, problem-solving readiness, and professional adaptability. The findings indicate that systematic integration of algorithmic tasks into the content of informatics courses increases students' logical consistency, operational accuracy, and ability to transfer computational approaches to new academic and practical situations. As a result, the development of algorithmic

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thinking is presented as one of the central objectives of contemporary informatics teaching and as an important condition for improving the quality of pedagogical training in digital education.

Keywords: Algorithmic thinking, informatics education, problem-solving, computational reasoning, programming instruction, logical analysis, digital pedagogy, abstraction, decomposition, educational technology.

Annotatsiya

Ushbu maqolada informatika fanini o‘qitish jarayonida talabalarning algoritmik tafakkurini rivojlantirishning pedagogik asoslari tahlil qilinadi. Algoritmik tafakkur muammoni tahlil qilish, uning tarkibiy qismlarini ajratish, mantiqiy ketma-ketlikni belgilash, bosqichma-bosqich yechim tuzish hamda olingan natijaning samaradorligini baholashga xizmat qiluvchi integrativ kognitiv qobiliyat sifatida talqin etiladi. Informatika ta’limi sharoitida mazkur tafakkur turini shakllantirish faqat dasturlash elementlarini o‘zlashtirish bilan cheklanmay, balki tahliliy fikrlash, abstraksiyalash, dekompozitsiya, modellashtirish va strukturaviy qaror qabul qilish ko‘nikmalarini rivojlantirish bilan ham uzviy bog‘liqdir. Tadqiqotda IT va informatika yo‘nalishida kasbiy faoliyatga tayyorlanayotgan talabalar orasida algoritmik kompetentlikni bosqichma-bosqich rivojlantirishga xizmat qiluvchi ta’limiy sharoitlar, o‘qitish metodlari va didaktik vositalar yoritiladi. Muammoli ta’lim, amaliy topshiriqlar, vizual modellashtirish, raqamli muhitlar hamda interfaol o‘qitish shakllarining talabalarning mustaqil analitik faoliyatini faollashtirishdagi o‘rni alohida ko‘rib chiqiladi. Shuningdek, algoritmik tafakkurning akademik mustaqillik, muammoni hal qilishga tayyorlik va kasbiy moslashuvchanlik kabi kengroq ta’lim natijalari bilan aloqasi ochib beriladi. Tadqiqot natijalari informatika kurslari tarkibiga algoritmik topshiriqlarni tizimli ravishda integratsiya qilish talabalarning mantiqiy izchilligi, amaliy aniqligi va hisoblash yondashuvlarini yangi vaziyatlarga ko‘chira olish

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qobiliyatini kuchaytirishini ko'rsatadi. Shu bois algoritmik tafakkurni rivojlantirish zamonaviy informatika ta'limining ustuvor vazifalaridan biri va raqamli pedagogika sharoitida bo'lajak mutaxassislar tayyorgarligi sifatini oshirishning muhim omili sifatida baholanadi.

Kalit so'zlar: algoritmik tafakkur, informatika ta'limi, muammoni hal qilish, hisoblash tafakkuri, dasturlashni o'qitish, mantiqiy tahlil, raqamli pedagogika, abstraksiya, dekompozitsiya, ta'lim texnologiyalari.

Introduction

The rapid expansion of digital technologies has significantly transformed the aims and content of contemporary education, especially in the field of informatics. In this context, the development of students' algorithmic thinking has become one of the most important pedagogical objectives. Algorithmic thinking is not limited to the technical ability to write program code. It reflects a broader intellectual capacity to understand a problem, divide it into manageable elements, identify patterns, establish a logical sequence of actions, and construct an effective solution. For students studying informatics in pedagogical universities, this competence is particularly valuable because it serves both as a professional tool and as a foundation for future teaching practice.

Informatics as an academic discipline provides unique opportunities for cultivating structured and logical reasoning. Unlike many other subjects, it directly engages learners in the processes of modeling, planning, testing, correcting, and optimizing solutions. These processes require students to operate not only with ready-made knowledge, but also with intellectual strategies that support independent analysis. Algorithmic thinking therefore becomes a bridge between theoretical concepts and practical implementation. When students learn how to formulate step-by-step procedures, compare alternative approaches, and predict the consequences of specific actions, they gradually acquire a deeper

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understanding of both computational systems and general problem-solving methods.

The relevance of this issue is increasing under conditions where education is expected to prepare learners for complex digital environments. Modern society demands graduates who are able to think systematically, process information critically, and respond flexibly to changing technological challenges. In this regard, the teaching of informatics can no longer focus exclusively on memorizing commands, definitions, or software functions. It must be directed toward the formation of intellectual mechanisms that enable students to work productively with information, build algorithms consciously, and apply computational logic in different academic and professional situations. This shift changes the role of the teacher as well. The teacher is no longer only a transmitter of technical content, but also an organizer of cognitive activity aimed at the development of analytical and algorithmic culture.

The formation of algorithmic thinking is especially important in pedagogical universities that prepare future teachers of IT and informatics. Such students must master algorithmic reasoning for their own academic success, but they must also learn how to explain algorithmic concepts to school pupils in accessible and methodologically sound ways. Therefore, the development of this competence has a dual significance. On the one hand, it improves students' own ability to solve tasks involving logic, programming, modeling, and digital systems. On the other hand, it strengthens their readiness to design lessons, choose effective methods, and foster computational literacy among future learners.

Despite the recognized importance of algorithmic thinking, its development in educational practice often remains inconsistent. In many cases, students perform formal exercises without fully understanding the logic behind them. This creates a need for pedagogical approaches that integrate visual models, practical problem-solving, interactive technologies, and reflective analysis. The present study is devoted to examining how algorithmic thinking can be developed more

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effectively during the teaching of informatics, what educational conditions support this process, and how such development contributes to the broader professional preparation of students in the field of IT and informatics.

Methods

The study was organized on the basis of a pedagogical approach that combines theoretical analysis, instructional design, observation of learning activity, and evaluation of educational outcomes related to the development of algorithmic thinking in informatics classes. The methodological framework relied on the idea that algorithmic thinking is formed most effectively when students are systematically involved in problem-solving situations that require decomposition, abstraction, sequencing, generalization, and reflection. In accordance with this position, the teaching process was structured not around passive reception of information, but around active cognitive engagement with algorithmic tasks of increasing complexity.

At the initial stage, a diagnostic review of the educational process in informatics was carried out in order to identify the typical difficulties students experience when solving algorithmic problems. Special attention was given to errors connected with misunderstanding the logic of task structure, inability to distinguish essential and secondary elements, weak planning skills, and dependence on memorized patterns rather than conscious reasoning. On the basis of this analysis, a system of pedagogical conditions was defined. These conditions included the gradual complication of tasks, the use of visual schemes and flowcharts, regular engagement with practical assignments, the integration of digital tools for modeling algorithms, and continuous reflection on the strategies used by students.

The instructional process was implemented through several interconnected methods. Problem-based learning was used as one of the central approaches. Students were presented with educational situations in which ready-made

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answers were not provided, and they had to independently determine the sequence of actions needed to reach a solution. This stimulated analytical effort and encouraged them to justify each step of their reasoning. Alongside this, project-based elements were introduced in the form of mini-projects where students designed simple algorithms for educational, social, or technical tasks. Such work made it possible to connect abstract informatics content with meaningful practical application.

Modeling methods also played an important role. Students worked with block diagrams, pseudocode, tabular plans, and verbal descriptions of procedures before moving to formal programming implementation. This sequence was chosen deliberately in order to ensure that algorithmic logic would be understood conceptually before being translated into code. Interactive teaching methods, including pair work, group discussion, peer explanation, and collective debugging, were used to strengthen communication around reasoning processes. These methods helped students compare alternative solutions and identify the advantages or limitations of different algorithmic constructions.

To evaluate the effectiveness of the instructional model, qualitative and quantitative indicators were considered. Students' performance was analyzed in relation to their ability to formulate algorithms independently, maintain logical consistency, select efficient solution strategies, detect and correct errors, and transfer learned methods to new tasks. Observation of classroom activity, analysis of completed assignments, and reflective feedback from students served as the main sources of pedagogical evidence. The methodological emphasis throughout the study remained on the creation of a learning environment in which algorithmic thinking develops as an integral intellectual and professional competence within informatics education.

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Results

The implementation of the proposed instructional approach in the process of teaching informatics demonstrated noticeable positive changes in the development of students' algorithmic thinking. At the beginning of the educational process, many students showed fragmented understanding of algorithmic structures. They were generally able to reproduce isolated operations or follow sample models, but they experienced difficulties when they were required to independently analyze a task, define a sequence of actions, or justify why a particular solution was appropriate. In particular, weak performance was observed in tasks involving decomposition of complex problems, identification of input and output conditions, prediction of intermediate steps, and detection of logical errors in algorithmic constructions.

After the systematic use of problem-based tasks, visual modeling, practical exercises, and reflective analysis, the quality of students' reasoning became more structured and consistent. A significant number of students began to demonstrate greater independence in organizing solutions. They more confidently divided large tasks into smaller logical components, established cause-and-effect relations between operations, and selected more rational sequences for solving informatics problems. Their performance also improved in situations that required transfer of previously learned methods to new contexts, which indicates that algorithmic thinking was developing not as mechanical repetition, but as a flexible cognitive ability.

One of the most visible outcomes concerned students' capacity for abstraction. At the initial stage, many learners tended to focus on superficial features of tasks and often confused specific details with essential structural elements. As the instructional model progressed, students became more capable of identifying the general logic behind different assignments. They learned to represent similar tasks through common algorithmic patterns and to distinguish between the conceptual structure of a solution and its specific technical implementation. This

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result is especially important in informatics education because it supports a deeper understanding of how algorithms function across different programming and problem-solving environments.

The use of block diagrams, pseudocode, and verbal step-by-step planning also produced meaningful pedagogical effects. Students who previously rushed directly into coding without fully understanding the logic of the task began to show more deliberate planning behavior. Their work became less chaotic, and the number of errors caused by omitted steps, incorrect branching, or inconsistent variable use gradually decreased. In collective discussions and peer explanation activities, students increasingly used precise logical language to describe their thinking, which indicates the emergence of a more mature algorithmic culture within the learning process.

Another important result was related to students' motivation and confidence. At the beginning, algorithmic tasks were often perceived as difficult, highly technical, or accessible only to students with strong prior preparation. However, when the educational process included gradual task progression, collaborative work, and visible modeling tools, students became more willing to engage with unfamiliar problems. Their fear of making mistakes declined, and they showed greater readiness to test hypotheses, revise solutions, and compare alternative strategies. This change suggests that the development of algorithmic thinking is closely connected not only with cognitive growth, but also with the creation of supportive pedagogical conditions.

Overall, the obtained results confirm that the systematic integration of specially organized algorithmic tasks into informatics teaching positively influences students' logical consistency, planning skills, independence, and practical problem-solving readiness. The findings also show that algorithmic thinking develops most successfully when it is treated as a comprehensive intellectual competence supported by methodical instruction, visualization, practice, and reflection.

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Discussion

The findings of the study make it possible to interpret the development of algorithmic thinking as a multidimensional pedagogical process that cannot be reduced to teaching programming syntax or training students to reproduce standard solutions. The positive changes observed in students' ability to analyze tasks, organize logical sequences, and transfer solution strategies to new contexts confirm that algorithmic thinking functions as a broader intellectual formation. It integrates analytical reasoning, abstraction, anticipation of outcomes, and conscious control over problem-solving procedures. In this sense, the teaching of informatics becomes most effective when it is aimed not only at content transmission but also at the formation of stable cognitive mechanisms that support structured action.

One of the central pedagogical implications of the results is that algorithmic thinking develops more successfully in an environment where students are not passive recipients of ready-made instructions. When learners are placed in situations that require exploration, comparison of alternatives, explanation of their reasoning, and correction of errors, they begin to construct a deeper internal understanding of algorithmic logic. This supports the idea that algorithmic competence emerges through guided intellectual activity rather than through simple repetition. The role of the teacher in such a model is especially important. The teacher must organize learning conditions in which students gradually move from externally supported reasoning toward independent planning and self-regulation.

The findings also show that visual and intermediate forms of representation play a substantial role in the formation of algorithmic thinking. Block diagrams, pseudocode, verbal descriptions, and structural schemes help students externalize logic before translating it into formal code. This is pedagogically significant because many students encounter difficulty when abstract computational processes are presented only through programming language structures. Visual

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and semi-formal tools reduce unnecessary complexity and make the sequence of operations more transparent. As a result, students can focus on the logic of the solution itself rather than becoming prematurely overwhelmed by syntax. This confirms that effective informatics teaching should include multiple representational formats adapted to different stages of conceptual development. Another important aspect concerns the relationship between algorithmic thinking and students' emotional and motivational readiness. The results suggest that confidence, willingness to experiment, and tolerance toward mistakes increase when the educational process is organized progressively and supportively. This indicates that algorithmic thinking is not formed in an exclusively cognitive domain. It is closely connected with the learner's perception of difficulty, sense of competence, and readiness to engage in sustained problem-solving. Therefore, pedagogical strategies that encourage reflection, peer support, and gradual increase in task complexity are likely to be more productive than rigid models based on immediate correctness alone.

For pedagogical universities, the importance of these conclusions is even greater. Students in IT and informatics programs are future educators who will later influence how school pupils perceive digital logic and computational reasoning. If they themselves experience algorithmic learning as meaningful, structured, and pedagogically well-supported, they are more likely to reproduce similar educational values in their future professional practice. Thus, the development of algorithmic thinking in higher education has a double pedagogical effect: it improves students' own intellectual preparedness and simultaneously shapes their methodological readiness for teaching informatics effectively.

In general, the discussion confirms that algorithmic thinking should be regarded as one of the key educational outcomes of contemporary informatics instruction. Its successful development depends on methodological consistency, active learning formats, visualization, reflection, and the deliberate connection between theory and practical problem-solving.

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Conclusion

The development of students' algorithmic thinking in the process of teaching informatics should be regarded as one of the most important strategic directions of modern pedagogical education. The conducted analysis demonstrates that algorithmic thinking is not a narrow technical skill connected only with writing code or following formal instructions. It is a complex intellectual competence that includes the ability to analyze a problem, distinguish its essential elements, construct a logical sequence of actions, evaluate the efficiency of solutions, and transfer acquired methods to new educational and practical situations. In this sense, algorithmic thinking occupies a central place in the preparation of future specialists in IT and informatics, especially in pedagogical universities where students are expected not only to master digital knowledge themselves, but also to teach it effectively in the future.

The results of the study confirm that the successful formation of algorithmic thinking depends on the organization of a purposeful pedagogical environment. Such an environment should be based on gradual complexity, active problem-solving, visual modeling, practical application, and constant reflection on reasoning processes. When informatics teaching is structured in this way, students begin to move beyond mechanical reproduction of sample tasks and develop a more conscious understanding of algorithmic logic. They learn to plan actions in advance, justify each stage of their solutions, detect mistakes independently, and compare different strategies according to their effectiveness. These outcomes are especially significant because they reflect the formation of sustainable intellectual habits rather than temporary mastery of isolated учебных операций.

An important conclusion of the research is that algorithmic thinking develops most productively when it is treated as an integrative educational objective. It should not be confined to one section of the curriculum or associated only with programming disciplines. On the contrary, algorithmic approaches can be

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embedded into different topics of informatics, including data processing, modeling, digital systems, information analysis, and educational software design. This broad integration allows students to perceive algorithms not as abstract constructions detached from reality, but as universal instruments of rational action in digital environments. Such understanding increases the educational value of informatics and strengthens its connection with broader goals of intellectual and professional development.

The study also makes it possible to conclude that algorithmic thinking has substantial pedagogical potential for the future professional activity of students. For prospective teachers of informatics, this competence becomes a methodological foundation for organizing lessons, explaining concepts clearly, sequencing educational material, and guiding pupils through structured problem-solving processes. Therefore, the development of algorithmic thinking in higher pedagogical education has a dual function. It supports students' individual academic growth while simultaneously preparing them for the effective teaching of computational logic and digital literacy in school practice.

In summary, the development of algorithmic thinking in the teaching of informatics should be considered a key condition for improving the quality of pedagogical preparation in the digital age. It contributes to logical culture, cognitive independence, adaptability, and professional readiness. The systematic use of pedagogically grounded methods and tools can significantly strengthen this process and ensure that students become not only competent users of digital technologies, but also thoughtful, methodologically prepared educators capable of fostering algorithmic culture in the next generation.

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