
Modelo Didáctico de Instrucción Heurística asistida por las Tecnologías de la Información y las comunicaciones

Didactic Model of Heuristic Instruction assisted by Information and Communication Technologies (ICT)

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RESUMEN: Se presenta un modelo didáctico de la superación profesional de los profesores de Matemática del Nivel Educativo Secundaria Básica en Cuba, para solucionar las insuficiencias en su preparación teórica y metodológica. Se aporta una lógica epistemológica en las relaciones dialécticas entre los componentes Concepción, Ejecución y Evaluación del tratamiento del contenido de la Instrucción Heurística de la Matemática asistida por las Tecnologías de la Información y las Comunicaciones que favorece, mediante un enfoque heurístico, que los profesores conciben, ejecuten, regulen y evalúen el procesamiento la asimilación y la aplicación de dicho contenido.

Palabras clave: Tecnologías de la información y las comunicaciones; Secundaria básica; Instrucción heurística de la matemática; Superación de profesores.

ABSTRACT: A didactic model for the professional improvement of Mathematics teachers of the Basic Secondary Education Level in Cuba is presented, in order to solve the insufficiencies in their theoretical and methodological preparation. An epistemological logic is provided in the dialectical relationships between the components Conception, Execution and Evaluation of the treatment of the content of Heuristic Instruction of Mathematics assisted by Information and Communication Technologies that favors, through a heuristic approach, that teachers conceive, execute, regulate and evaluate the processing, assimilation and application of such content.

Keywords: Information and communication technologies; Basic secondary education; Heuristic instruction of mathematics; Teacher improvement.

Introduction

It is a requirement for the current Basic Secondary Education Level (NESB), to conceive, execute and evaluate the improvement of its teachers, in such a way that the quality of their preparation

improves more and more, a matter that imposes the improvement of their professional performance, to achieve an adequate development of professional skills that will allow them to present their ideas and arguments in a coherent and convincing way, with the use of mathematical terminology and symbology, as well as to know how to interpret the language of the Information and Communication Technologies (ICT) resources and other sources with which they interact for heuristic purposes.

After a deep study of the theory and the current state of the improvement plans and the methodological work that complements it, it is possible to consider the existence of conditions to reconstruct the theory and redesign new models, strategies and methodologies that propitiate a new form for the improvement of teachers, based on the current technological conditions and social demands.

Development

In order to reveal the essential relationships of the professional improvement process of the mathematics teachers of the NESB that are not directly observable, the following theoretical methods were used: Analytical-synthetic, Historical-logical, Hypothetical-deductive, Hermeneutic-dialectical, Modeling and Systemic-structural-functional. In order to verify the problems of the professional improvement process of Mathematics teachers in the NESB, empirical methods were used: Document analysis, Observation, Evaluation by experts' criteria, Evaluation by users' criteria and Pedagogical test.

A pedagogical experiment and a methodological triangulation were also carried out to interpret the data obtained from the application of different methods (experts' criteria, users' criteria and experiment). The interview and the survey were used as techniques to obtain information. At the statistical level, descriptive techniques were used to organize, tabulate and process the data obtained in the diagnostic process of the problem and the data from the application of the different methods used.

The population is constituted by the 346 Mathematics teachers of the NESB of the province of Granma and the provincial methodologist. The sample is formed by a total of 70 teachers selected as follows: 15 from Bayamo municipality, 15 from Manzanillo municipality, 10 from Bartolomé Masó municipality and 30 from Yara municipality.

Analysis and discussion.

The Didactic Model of IHM assisted by ICT for Mathematics teachers of the NESB is presented; it is a set of interrelated elements, understood as: A conscious and planned teaching-learning process of the method and heuristic procedures, developing the logical, creative, independent and coherent thinking of the teachers of this subject, where the conception of the ICT-assisted IHM, the Execution of the ICT-assisted IHM and the Evaluation of the ICT-assisted IHM constitute its component elements and their relationships determine the meaning around which these are integrated.

In the sources consulted, the following authors stand out: (García, 1977, p. 15); (Pérez et al., 1996, p.80); (Davidov, 1988, p.132), considering the model as: "...a simplified representation of the object or process being analyzed...", which is assumed for this research.

In the singular, it is assumed that the didactic model is "an abstraction of those essential characteristics of the object under investigation, which allows discovering and studying new relationships and qualities of that object of study with a view to the transformation of reality". (Valle, 2012, p.80). The construction of the model is based on the General Theory of Systems (Bertalanffy, 1976, p.94) and the systemic approach associated with it, as a fundamental methodological tool to model the development of heuristic thinking in Basic Secondary Mathematics teachers.

A reconstruction of the NESB Mathematics teacher's improvement aimed at ICT-assisted heuristic preparation is modeled, based on the studies conducted by (Añorga, et al. 2010). Therefore, the model consists of three components, the Conception of the ICT-assisted IHM, the Execution of the ICT-assisted IHM and the Evaluation of the ICT-assisted IHM, which has a systemic nature, evidenced in the structural-functional interrelationship established between the subsystems, ensuring the relevance and effectiveness of the process in its relational dynamics, establishing its organization and functions.

The objective is to represent, from the theoretical point of view, the IHM assisted by ICT for Mathematics teachers of the NESB, so to achieve it, its systemic functioning and its purpose for which all the component elements were ordered; as well as the dialectical relationships established among them. The frontier of the didactic model of IHM assisted by ICT is circumscribed to the

context of the NESB, contextualized to the teacher of this subject within the framework of his professional improvement.

Entropy is manifested by the subordination and coordination links between the subsystems of the model, where the subsystems Execution of the HMI and Evaluation of the HMI are subordinated to and depend on the subsystem Conception of the HMI due to the level of hierarchy it possesses. Homeostasis is present when revealing the subordination links that are expressed through the dialectic relationship between the subsystems Execution of the MMI and Evaluation of the MMI, since they allow the stable functioning of the system; in turn, this relationship of dependence makes possible the development and concretion of the subsystem Conception of the MMI since it is the most entropic component of the system, establishing the premises for the functioning of the rest of the subsystems and its own, according to the reality and the characteristics of the MMI process.

Recursivity is manifested in the dialectical relationships that occur within each subsystem and that reveal the resulting qualities. These subsystems are structured by components that are intimately related and in constant interaction, whose links make explicit the expressions of the internal movement of the IHM process, revealing its systemic nature and expressing the relationship between the proposed demands and indicators and the teacher's preparation to achieve a better performance during his professional improvement, in order to respond to the existing contradiction.

There are levels of subordination between the teachers who participate in the professional improvement process and the mediating agents of improvement (provincial and municipal methodologists, general coordinators, grade heads and assistant principals), who conceive the process in such a way that the teacher participates as an active subject and protagonist.

The conception of the ICT-assisted IHM constitutes the initial process and, as a subsystem, reveals the organizational and structural aspects necessary for its achievement, elements to be taken into account for the determination of the preparation needs and general elements for the planning of the process. This subsystem has an organizational function in the model, establishing the guidelines for its development, which makes it possible to give way to the appropriation and application of the IHM assisted by ICT with an active participation of teachers in the process, starting from the actions to be carried out for its achievement.

It shows the need to prepare the conditions for the execution of such instruction, composed of three dialectically related components: Diagnosis of the development of ICT-assisted HMI, Determination of the content to develop ICT-assisted HMI and Planning of ICT-assisted HMI.

The ICT-assisted HMI diagnosis component is understood as the systematic and continuous process of determining the current state of ICT-assisted HMI, making it possible to know and identify the teacher's potential and needs as a result of his/her professional performance and professional development. It is a process of exploration, which allows the identification of common and specific problems that manifest themselves during the treatment of the IHM within the professional improvement of teachers in NESB.

The diagnosis of the level of development of the IHM, allows characterizing the preparation of teachers for its application in teaching in a conscious and planned way from the use of its elements during their professional performance, so that their strengths, potentialities and weaknesses are known for the organization of the process.

The component Determination of the content to develop the IHM assisted by ICTs constitutes the process oriented to the study and selection of the knowledge, habits, skills and modes of action necessary to develop the IHM that, according to the results of the diagnosis carried out, allow its development. This expresses the preparation of the conditions to develop the content of the IHM, the objective and subjective conditions existing in the professional improvement process of the NESB Mathematics teacher and its context are underpinned.

By determining the necessary elements to develop the content of the IHM, its functioning is made available and foreseen from the integration of the influences of the mediating agents and the conditions to achieve the development of heuristic instruction, in correspondence with the aspirations of the NESB's purpose and the elements to be taken into account for the improvement of Mathematics teachers. The necessary elements of the content of the ICT-assisted IHM and its necessary linkage with the potentialities and limitations regarding the use of ICT as an auxiliary heuristic means during professional improvement are established.

The development of the content of the ICT-assisted IHM is organized in a conscious way, thus constituting a very important element in the mediator's work, taking into account the aspects that support the treatment of the content of the ICT-assisted IHM, carrying out a study of the theoretical, didactic, methodological, procedural and technological elements of the ICT-assisted IHM method,

as well as the theoretical, didactic, methodological, procedural and technological elements of the method, procedural and technological elements of the heuristic method and its resources, in order to achieve an adequate professional performance of the teachers in accordance with the demands of professional improvement and the training model of the Mathematics teacher, providing this improvement process with the necessary heuristic approach during the treatment of this content.

The ICT-assisted HMI planning component is understood as: the continuous process of study, determination and specification of actions to be followed, according to the results of the diagnosis carried out, which allow the development of ICT-assisted HMI.

The analysis of the NESB model as well as that of professional improvement is carried out, to take them into account in the impact of the model from the knowledge, skills and standards for the interaction with the development contexts, it is determined how the work will be concretized by assuming ICT as auxiliary heuristic means using a heuristic approach during their professional performance and the proposal of activities that correspond to situations of practice. The potentialities of ICT as auxiliary heuristic means are taken into account, actions are planned to develop in teachers their use, which guarantees the heuristic approach in the treatment of IHM content assisted by ICT.

From the dialectical relationship between the components Diagnosis of ICT-assisted HMI, Determination of the content to develop ICT-assisted HMI and Planning of ICT-assisted HMI, a new quality emerges within the process: Intentionality of the ICT-assisted IHM, understood as the feature that characterizes the relationships of the conception of the ICT-assisted IHM, an element that accounts for the intentional character from a heuristic approach and consciously and coherently confers the process from where the needs for improvement are understood, recognized and accepted and allows favoring the solution to problems of the professional practice.

The relationship between these components, energized by the dialectical contradiction between the traditional approach to the treatment of the HMI and the heuristic approach with the use of ICT as an auxiliary heuristic means, allows revealing higher order qualities in the theoretical interpretation of the process mediating and conditioning the transition from the subsystem Conception of the ICT-assisted HMI to the subsystem Execution of the ICT-assisted HMI.

The subsystem ICT-assisted HMI implementation is represented as the cooperative and collaborative process obtained as a result of the active and conscious participation of professional

development mediators and teachers, based on previously designed actions, in order to achieve such instruction, in a way that favors the appropriation and application of its contents in an independent and creative way. It is structured in three interrelated components: ICT-assisted HMI content treatment orientation, ICT-assisted HMI content appropriation and ICT-assisted HMI content application.

The Orientation component of the ICT-assisted treatment of the IHM content is understood and represented as a continuous and gradual process in which the counseling established between the professional development mediators and the mathematics teachers is expressed. Its starting point and necessary condition is the relationship between the cognitive interest to face the task of learning the content of the IHM and the professional improvement needs of teachers, in which intentional actions aimed at guiding, facilitating, mediating and stimulating learning, which ensures the successful fulfillment of the teaching tasks assigned in professional improvement, take shape.

By orienting the content of the ICT-assisted IHM, the necessary elements for its development with a heuristic approach are specified, taking into account that the use of the heuristic method and procedures helps teachers to develop their professional performance during their professional development.

In this sense, it is necessary that teachers know the elements of the content and focus their attention on the mastery of the knowledge of the theoretical and didactic-methodological foundations on which the process of ICT-assisted HMI is based. The orientation of the teaching task developed from the contents of the IHM during professional development is carried out with the purpose that the teacher acquires a level of understanding of what he/she is going to do and its sequence, which favors the development of professional skills and professional performance that allow him/her to learn to operate with it during the process.

The component Appropriation of the ICT-assisted HMI is understood as the process of a systematic and continuous nature in which the teacher assimilates the content of the ICT-assisted HMI according to the specific needs and demands of his/her professional improvement that allow him/her to achieve a better professional performance. Teachers have an active attitude in their improvement, by consciously participating in the search for and processing of information, in problem solving and in decision making that have an impact on the development of their

professional performance as a result of their didactic preparation, an indispensable element for their development.

The appropriation of the ICT-assisted IHM specifies the elements, concepts or basic ideas, related to the method, heuristic procedures, auxiliary heuristic means, as well as the use of the general heuristic program, for the understanding of its essence and thus achieve a precise construction of the content to be learned, expressed in the conscious character and active participation of teachers during the construction and reconstruction of knowledge.

The structuring of the content of the IHM assisted by ICT, specifies the elements, concepts and basic characteristics for its development and understanding in order to achieve an adequate professional performance from what is intended to be learned. In this process, the heuristic approach plays a key role in the development of ICT-assisted HMI in teachers, taking into account that the use of methods that correspond to it favors an active position of teachers in the process of professional improvement.

The component Application of the content of the ICT-assisted MMI is understood as the process that expresses the practical and contextualized use of the content of the ICT-assisted MMI during the professional improvement process of the NESB mathematics teacher, and also implies the recognition of the need for its assimilation and appropriation.

The degree of application of the contents of the ICT-assisted IHM reached by the teacher is determined from the professional performance shown in his actions, evidenced during the confrontation of problems related to the work he performs, which allows him to conceive his actions consciously, including the planning and organization of actions, search strategies for solution ideas to be carried out, information processing and analysis; he makes decisions to carry out his actions during his professional performance.

The teacher applies the acquired elements of the content of the ICT-assisted IHM, developing his/her potentialities regarding the use of ICT as an auxiliary heuristic means during professional improvement, elaborating the way to search for knowledge from the independent use of the heuristic approach during his/her professional performance.

Through the treatment of the content of the discipline, the following should be achieved in teachers: Systematic study and development of skills for independent work. Developmental learning. The relationship between the subject, ICT and the needs of the NESB. The integration of technological

resources: videoclasses, educational software, methodological videoclasses and didactic means elaborated by the NESB, cellular technology, as well as the rest of the mathematical assistants.

The subsystem Execution of the ICT-assisted MMI has as its function the realization of actions that guarantee the domain for the orientation, elaboration and development of the ICT-assisted MMI content, expressing the need for its development in the teachers during their professional performance from the integrating relations mediated by the orientation of the treatment of the ICT-assisted MMI content, its appropriation and application, in correspondence with what is established for its achievement.

From the dialectic relationship between the components Orientation of the treatment of the ICT-assisted HMI content, Appropriation of the ICT-assisted HMI content, and Application of the ICT-assisted HMI content, within the subsystem Execution of the ICT-assisted HMI, results the quality Availability of the ICT-assisted HMI content, understood as the feature that characterizes the treatment of the ICT-assisted MMI content, which creates the intention, disposition and conditions to understand and interact with such instruction within the professional improvement process, enabling the teacher to appropriate, apply and systematize this content, which favors the development of his/her professional performance.

From the dialectical relationship between the subsystems Conception of the ICT-assisted HMI and Execution of the ICT-assisted HMI, emerges the quality Accessibility to the content of the ICT-assisted HMI, understood as the feature that makes possible the processing and guarantees the treatment to the content of the ICT-assisted HMI to the NESB Mathematics teacher, creating the intention, disposition and conditions for its development from its understanding and professional performance.

The relationship between these components, energized by the dialectical contradiction between the traditional approach to the treatment of heuristic instruction of Mathematics and the heuristic approach with the use of ICT as an auxiliary heuristic means, allows revealing higher order qualities in the theoretical interpretation of the process, mediating and conditioning the transition from the subsystem Execution of the ICT-assisted MIHM to the subsystem Evaluation of the ICT-assisted MIHM.

Thus, the development of the ICT-assisted MMI needs its evaluation for the assessment of the results achieved, giving rise to the subsystem Evaluation of the ICT-assisted MMI, which is

understood as: an integral and systematic process aimed at controlling and assessing the compliance, appropriation and application of the content established for the development of the ICT-assisted MMI during the professional improvement process of the NESB Mathematics teacher.

The subsystem Evaluation of the search and processing of the content of the ICT-assisted IHM, together with the previous ones, constitutes a dialectical unit, fulfilling an important valuative function so it is directed to the evaluation of the development of the ICT-assisted IHM in the teachers of this subject, taking place the integrating relations that are synthesized in the evaluation of the search and processing of the content of the ICT-assisted IHM, the evaluation of its appropriation and the evaluation of its application.

For the evaluation to be effective, it is necessary to apply different forms of evaluation, such as: self-evaluation, co-evaluation and heteroevaluation, giving it a reflective, constructive and meaningful character, which makes possible the creation of favorable environments among the actors of the process, taking into account the interactivity, collaboration and complementation of knowledge, serving as a reference to the mediators of the improvement for the improvement of the professional improvement process and the professional performance of the teachers.

From the heteroevaluation, the mediator favors the generation and development of an evaluation in which the teachers as a whole are allowed to participate in the establishment and assessment of the learning achieved, either by some of its members or by the group as a whole.

Co-evaluation makes it possible to identify personal and group achievements, to give an opinion on their performance within the group; highlighting general ideas to find solutions to similar problematic situations, from encouraging participation, reflection and constructive criticism; demonstrating that collective work contributes to obtaining new learning and developing the professional performance of teachers.

From self-evaluation, teachers are able to make value judgments about themselves and the activity they perform according to previously established evaluation criteria or indicators, even proposed by themselves; stimulating their constant feedback, as well as that of others to improve their professional performance in a critical manner in the construction of their learning.

The component Evaluation of ICT-assisted HMI content search and processing is understood as the comprehensive and systematic process aimed at verifying the quality of the degree to which teachers comply with the actions to develop the conscious search and processing of ICT-assisted

HMI content based on the approach, achievement, empowerment, understanding, expression and communication of the acquired elements previously established for their development.

The evaluation of the empowerment of the assimilated content is required, due to its complex form that is not reduced only to knowledge and skills, thus developing the formation of intellectual habits, modes of action, as well as the systematization and automation of its fulfillment, allowing the development of activities aimed at summarizing, taking notes, making worksheets and planning work, thus contributing to the success and solution of professional problems.

The component Evaluation of the appropriation of the content of the ICT-assisted IHM is understood as the integral and systematic process oriented to assess the action and result of the appropriation of the content of the ICT-assisted IHM that allow the mastery of the elements of such instruction, the active and creative appropriation of the theoretical elements of the process is evaluated, as well as the actions and indicators for the treatment and development of the ICT-assisted IHM, taking into account the teachers' capacity for the production, transformation and management of the information acquired in a conscious and creative way to face different situations, during their professional performance.

It also implies taking into account whether the mathematics teacher during the professional improvement process is able to orient himself and undertake with little or no help the coherent use of the elements of the content of the IHM, integrating new knowledge to the one he has, expanding his own knowledge and improving his professional performance; in addition, the ability to use, apply and explain the knowledge on the use of the method and heuristic resources, being able to express his ideas in different ways without changing the essence of the content and identifying contradictions between his knowledge and skills from learning situations is also valued.

This component evaluates the empowerment and conscious application of the elements corresponding to the IHM oriented to the fulfillment of the use of the materialized resources that facilitate the search for knowledge, the mental resources that allow it to orient itself, as well as the logical sequence of the actions to be developed at each moment during the development of the professional improvement process.

The component Evaluation of the application of the content of the ICT-assisted HMI is understood as the comprehensive process aimed at assessing the action and effect of the application and

compliance with the content of the ICT-assisted HMI established for its use that allow the active search for knowledge and the solution to problems during the professional improvement process.

Based on self-evaluation, co-evaluation and heteroevaluation, the teacher is able to characterize and evaluate his/her learning strategies in different situations, also taking into account the capacity of ICT as auxiliary heuristic means to enhance the restructuring of these strategies in correspondence with the results and contexts of development, which generates great usefulness in the determination of the guiding ideas or invariants that constitute the maximum generalizations that express the system of knowledge, methods and work techniques, expanding the content from the recognition, meaning, importance and need for professional improvement, which favors the teacher's professional performance.

From the dialectic relationship produced internally in the Evaluation of the ICT-assisted IHM between the components Evaluation of the search and processing of the content to the content of the ICT-assisted IHM, Evaluation of the appropriation of the content of the ICT-assisted IHM and Evaluation of the application of the content of the ICT-assisted IHM, results to the interior of the subsystem the quality: Effectiveness of the ICT-assisted IHM, understood as the feature that characterizes the ability to achieve the proposed objective between what was planned by mediators and teachers and the result obtained from the development achieved by them in the process of professional improvement, serving as a permanent evaluation.

This, in turn, implies a transformation in the quality of the professional performance of the NESB Mathematics teacher, endorsed by the knowledge, the degree of information he/she possesses about the content and the appropriation achieved, as well as his/her mastery for the development of the professional improvement process according to his/her individual and collective needs, based on his/her efficient improvement and the capacity to search for creative solutions to his/her professional problems.

Conclusions

The Didactic Model reveals a logic with a heuristic approach for the treatment of the ICT-assisted IHM, expression of the relationships between the components Conception, Execution and Evaluation of this, which allows explaining didactically the heuristic approach during the professional improvement of the NESB Mathematics teacher as an essence from the dialectical relationships that regularly occur within the system and components assumed.

The construction of a Didactic Model of ICT-assisted IHM for NESB Mathematics teachers is described, considering as subsystems Conception, Execution and Evaluation of ICT-assisted IHM, as well as its components explaining their relationship and thus revealing a new way of dealing with it during the professional improvement of the NESB Mathematics teacher.

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