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Summarized Report

OLIVEIRA, Naralina Viana Soares da Silva. *Contributions of the Galperin, Talízina, and Majmutov teaching system to the development of problem-solving skills in differential and integral calculus in mathematics education students at Universidade Federal de Pernambuco*, 247f. Thesis (Doctorate in Science and Mathematics Education). Universidade Federal de Mato Grosso, Cuiabá, 2021[1]

Resumo

OLIVEIRA, Naralina Viana Soares da Silva. *Contribuições do sistema didático Galperin, Talízina e Majmutov para formação da habilidade de resolver problemas em Cálculo Diferencial e Integral em estudantes de Matemática-Licenciatura da Universidade Federal de Pernambuco*, 247f. Tese (Doutorado em Educação em Ciências e Matemática). Universidade Federal de Mato Grosso, Cuiabá, 2021[1]

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The following summary deals with doctoral research that aimed to understand the process of developing students' guiding principles during the development of problem-solving skills in twenty students involving knowledge inherent to the Calculus 1 course in the Mathematics-*Licenciatura*[3] degree program at the Universidade Federal de Pernambuco.

[1] Thesis developed in the Graduate Program in Science and Mathematics Education at the Rede Amazônica de Educação em Ciências e Matemática – REAMEC (Belém Campus), Universidade Federal do Mato Grosso. Supervised by Prof. Dr. Héctor José García Mendoza.

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[3] Note of translator: the Licenciatura degree corresponds to a university bachelor's degree that entitles the holder to teach in the second segment of elementary school and high school.

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There is a significant demand in higher education for the development of skills and qualifications, particularly with relation to the ability to solve mathematical problems, and this requires a new way of organizing the teaching and learning process.

To this end, a teaching system based on Problem Situations Activity was planned and tested, with the aim of identifying the contributions of this methodology to the development and re-development of problem-solving skills. From this standpoint, its theoretical basis was reinterpreted from the perspective of Majmutov's Problem-Based Teaching, intertwining the Galperin-Talyzina teaching system with the principles proposed by Majmutov.

The scientific problem of this research study was formulated as follows: "What are the contributions of using the teaching system formed by Galperin's theory of step-by-step formation of mental actions, Talízina's study activity approach, and Majmutov's problem-based teaching in the process of developing students' problem-solving skills in differential and integral calculus in mathematics education students at Universidade Federal de Pernambuco?" To analyze the contributions of using the Galperin-Talízina Majmutov didactic system in the process of developing students' problem-solving skills in Differential and Integral Calculus in students of the Mathematics-*Licenciatura* course at Universidade Federal de Pernambuco, it was necessary to pursue the following specific objectives: to diagnose the students' starting level in relation to their problem-solving skills; verify the formation of the Guiding Basis for Action through the use of the Learning Problem Situations Activity; and analyze the stages that students reached after using the teaching system.

During the problem-solving procedure, licensees, when expressing themselves independently, face difficulties and contradictions related to the reproductive and productive aspects of mental activity. They are accustomed to reproducing, but when there is a need for production, for a new mental activity that requires creativity, obstacles arise. The internal contradictions that arise as a reflection of external contradictions, or from the environment, are sources of

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mental development during the assimilation process. Therefore, contradiction plays a fundamental role in problem-solving and can contribute to the development of skills and to the teaching and learning process.

It is from this perspective that the notion of problem adopted in this study is consolidated, based on the concept developed by Majmutov (1983), who originally defined *teaching problem*[4] considering different aspects of the problem-solving process.

In this sense, Majmutov considers both the didactic and psychological aspects of the problem, stating that the fundamental elements of a teaching problem (hereinafter replaced by learning problem) is the set of knowledge already known to the student (this set includes the data from the assignment instructions, all prior knowledge, and the individual's personal experiences), the set of unknown knowledge (composed by what is unknown, what is requested, and the procedure for achieving the objective), and their respective relationships. Drawing a parallel with Vygotsky's ZPD, it is possible to say that the unknown is equivalent to the zone of potential development and the known to the zone of actual development.

It is with this proposal, called Enseñanza Problémica or Problematic Teaching, that Majmutov (1983) advocates the development of students' cognitive independence, advancing their thinking to new levels of development, starting from what students already know and are able to do, towards what they wish to achieve in terms of new knowledge by solving a learning problem (NASCIMENTO, 2015, p. 23).

In the context of the teaching and learning process, the term "skill" can take on different meanings, even becoming confused with the term "competence." For Dias (2010), the concept of competence has been replaced by the concept of skill. He states that it is competence that allows students to face

[4] In Brazil, the term teaching (*docente*) refers to the specific activity of a teacher, whereas in Spanish it refers to the activity inherent in the teaching and learning process. Considering that the student is the central figure in this process, in order to avoid conflicts of meaning, the term "teaching" has been replaced by the term "learning."

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and adequately regulate a set of actions in learning situations. From the point of view of French sociologist Phillipe Perrenoud (1999), skills and competencies are closely related, with skill being a kind of unit of competence; that is, competence is formed by a harmonious system of skills, and he focuses his studies on competencies.

In the historical-cultural approach, which we adopt in this work, Núñez, Ramalho, and Oliveira (2016) state that skill is a type of cognitive, practical, and evaluative activity that puts theoretical knowledge into action; that is, skill is the content of the actions performed and mastered by the individual. From this perspective, procedural content should not be viewed in a fragmented way, separated from conceptual content.

In this research, the term skill was considered as a type of activity, equivalent to the term action, and when structuring a system of actions that the student must perform to assimilate concepts, the conditions for skill formation are also being organized.

Along these lines, Talízina (2000) states that knowledge assimilation does not occur in isolation from actions; in other words, knowledge is always associated with know-how. It is through skill that students relate to the object of study, appropriate it, transform it, and transform themselves, with a motive, in pursuit of a goal.

From this perspective, the ability to solve learning problems, as a type of activity, constitutes a system of motivated actions, each composed of a system of operations (operational invariant) that mobilizes a set of conceptual and procedural knowledge to solve learning problems within the limits of application of Differential and Integral Calculus (Function, Limit, and Derivative).

Every action has an invariant functional structure that includes guidance, execution, and control. The quality of the action, as well as its monitoring and control, depends on the guidance that the student has.

Therefore, the orientation of the action is understood as a direction to guide the learning process and the formation of skills and concepts or to guide the process

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of incorporating new qualities into skills or knowledge already mastered. It can also be conceived as a connection between theory and practice, where students mobilize their theoretical, conceptual, and procedural knowledge to use it in practice when solving a new problem.

The process of developing and reworking the Guiding Basis for Action, more specifically, the process of transforming external and material action into psychic and mental action, occurs in accordance with the development of certain qualitative characteristics of actions. According to Talízina (1988), Galperin presents the characteristics related to the *form*, *generalized character*, *detailed character*, *assimilated character*, and *independent character* of actions as parameters of quality of formation, presenting them as independent characteristics and calling them *primary characteristics* of actions. These characteristics can be developed at different levels/degrees of quality.

As for *form*, it is determined by how the student appropriates the action in the transformation of external activity into internal activity. There are four fundamental types of forms for following this path. The *material* or *materialized form* occurs when the student has direct contact with the object of the action in its real (material) form or through drawings, graphs, models, and schemes (materialized). The *perceptual* form occurs when the student interacts with the object through the ability to hear and see. The *external verbal* form occurs when the student interacts with the object through oral or written language. And the *internal verbal*, or *mental,* form is when the student performs the action for oneself; it is the mental performance of the action.

As for *generalization* (*generalized character)—this*refers to the student's ability to identify the essential and non-essential properties for performing the action, which can vary from non-generalized to fully generalized.

As for *detailing* (*detailed character)—this* refers to the student's ability to perform all the operations that make up an action in detail. To the extent that the operations that comprise the action are no longer performed in detail, it is said that the *detailing* is *reduced*.

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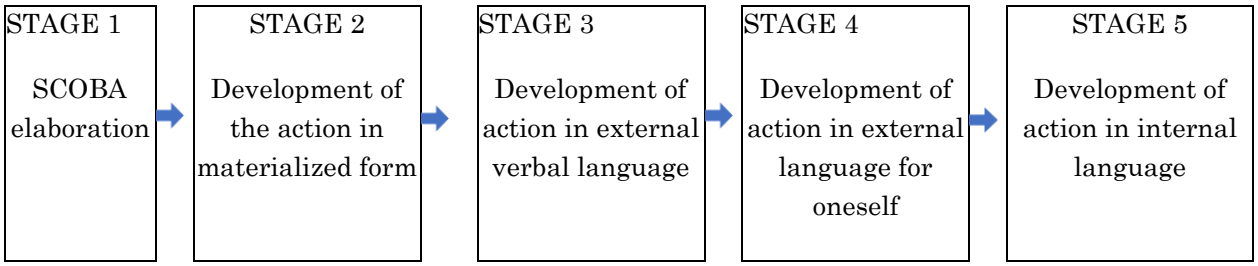
As for *assimilation* (*assimilated character*), it refers to the level of automation of the action, the ease and speed with which an action is performed. The student begins to perform an action with awareness of it and gradually increases the pace of its execution.

As for *independence*, this refers to the student's ability to perform all operations correctly with or without external help. During the assimilation stages, the student begins by sharing the execution of actions, progressing to independent execution and achieving a high level of autonomy in solving tasks.

Therefore, Galperin argues that the transformation of external action into internal action, which represents the process of assimilating knowledge and skills, occurs in five stages, where in each stage the student develops the action by transitioning through different forms of execution, passing through different levels of development of the characteristics of the actions, as shown in Figure 1.

Figure 1: Stages in the formation of mental actions and concepts according to Galperin



Source: Adapted from Talízina, 1988.

Both the characteristics of the actions and the specificities of each stage elucidated by Galperin were considered during the development and implementation of the didactic system proposed for use in the Calculus 1 component.

The research was conducted in four stages. The first stage aimed to perform an initial diagnosis of the participants' level of performance in solving student problems using Functions. At this stage, only the diagnostic assessment, consisting of four tasks, was used to collect data, which was then processed and converted into numerical data for quantitative analysis, which in turn guided the qualitative analysis and triangulation. Thus, the initial diagnosis was reached, also called the

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starting level by Talízina, or the zone of actual development by Vygotsky, or even the element known to students by Majmutov. With this information, it was possible to plan a more targeted formative experience.

In the second stage, there was no collection or analysis of empirical data. However, it was dedicated to the organization and structuring of the didactic system, with planning of the formative experience and the construction of other data collection instruments.

The third stage aimed to carry out the formative experience and, consequently, collect data, which was collected during classes using the observation technique, where these guides were filled out after each class for subsequent qualitative analysis. In addition, participants responded to the problem-solving tasks of the five formative assessments and the final diagnostic assessment to be analyzed quantitatively and qualitatively, which served for further triangulation.

In the fourth stage, a comparative analysis was performed based on the results presented since the initial diagnosis, covering the performances presented during the training experience up to the final diagnostic evaluation. From this analysis, the real advances and the most frequent obstacles were understood, and the students' orientation after using the proposed didactic system was characterized.

The diagnostic evaluation showed that the students had a mistaken, fragmented, and incomplete understanding and orientation of the ability to solve problems involving functions; that is, they were at an unsatisfactory level of execution of problem-solving involving functions, making it necessary to update the conceptual and procedural core on functions and their different representations in order to increase the level of elements known by students, enabling them to make connections between the known and the unknown in the zone of proximal development during the process of forming the ability to solve problems using functions.

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With the initial diagnosis, it was possible to organize and plan the formative experience, considering the principles that guide Problematic Teaching, as well as the invariant operations of problem solving, that is, LPSA's (Learning Problem Situation Activity) SCOBA. In addition, the knowledge to be worked on with the tasks was selected; then, the problematizing tasks were developed according to the specific characteristics of each stage of Galperin, anticipating possible feedback and corrections during the process of reformulating the skill orientation. Finally, the final assessment tasks were organized.

The experiment was carried out in four stages, namely: stage 0, which refers to the updating of the conceptual and procedural core of the function and motivation; stage 1, which refers to the establishment of the invariant structure of operations together with the students; stage 2, which refers to the execution of actions and operations to solve problems in a materialized way; and stage 3, which refers to the use of external language during the execution of actions and operations to solve problems in a verbalized way. Throughout the experiment, we sought to understand the process of developing student guidance in relation to the ability to solve student problems.

Given the dialectical relationship between teaching and learning during the process of reformulating skills orientation, subjective contradictions did not always correspond to the objective contradictions anticipated by the teacher, requiring different reorientations to continue the development of the formative experience.

Through the analysis of the experience's implementation process, it was possible to perceive that, at the beginning, some of the students used erroneous assimilations about the conceptual and procedural core of the knowledge worked on, showing signs of dealing with contradictions in the wrong way. However, in the materialized stage, they used the guidance card, contributing to the formation of awareness, as well as requesting help from their colleagues and the teacher-researcher, which helped them to identify their mistakes and difficulties and correct them. In addition, it was also found that between one

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formative assessment and another, that is, when changing the conceptual and procedural core to be used, there was a slight decrease in the number of correct answers in the initial task, increasing the number of correct answers in the following tasks.

In the external verbal stage, it was noticed that the participants used oral language to explain the resolution of problems to their colleagues, a fact that contributed to the formation of awareness, as well as to the process of reworking the orientation of actions. In addition, some participants showed a slight reduction in the execution of actions and operations. Regarding independence, the class significantly reduced requests for help, but there were still students who had difficulty explaining the reasons for their solutions without help from the teacher-researcher. Thus, it is understood that the second specific objective was achieved, given that the contributions of the didactic model to the reformulation of the orientation of the aforementioned skill were analyzed.

The analysis of the data collected in the final assessment showed that approximately 65% of the class was able to use the LPSA guidelines designed to solve problems involving situations different from those previously worked on, a fact that reveals signs of the beginning of generalization. Based on the analysis of the data collected in stages 2 and 3 and the final evaluation, it can be said that 65% of the class showed signs of having managed to reformulate the orientation of the aforementioned skill, characterized by a reduction in detail, beginning generalization, with sharing and awareness. However, 35% of the class had difficulties in mobilizing the orientation of actions to new situations, finding themselves in the transition between the materialized stage and the external verbal stage, as they presented a guiding basis for the skill with detail, not generalized, shared, and conscious. Thus, it was possible to analyze and describe the guiding basis in relation to the ability to solve student problems after using the proposed didactic system, as proposed in the third specific objective.

Based on these analyses, it was possible to see that there had been progress in terms of the level of understanding and guidance of LPSA actions in relation to

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the starting level. In addition, the primary characteristics of the actions were reformulated throughout the process, showing evidence of the continuous reformulation of this skill.

The use of the tasks solved in stage 1 and the LPSA model recorded on the guidance card in materialized form contributed to the development of explanation and awareness regarding the execution of the actions. The use of oral communication, terms, signs, symbols, mathematical language, and the mother tongue in detail at the beginning of the external verbal stage also contributed to the development of awareness and generalization.

In general, during the development of the guidance for the actions, what they learned most easily was how to solve the problem; secondly, how to formulate the learning problem; and thirdly, how to construct the conceptual and procedural core. The action they found most difficult was analyzing the solution.

O this end, the implementation of feedback loops aimed to reorient the actions, tasks, and questions, emphasizing a problematizing approach, was employed. This pedagogical strategy contributed to enhancing student motivation, active participation, and comprehension throughout the process.

The proposal of problematic tasks throughout the process contributed to the development of the orientation of students' problem-solving skills, since facing contradictions is the driving force for thinking and reasoning. This was evident in the students' active participation in the problem-solving process, in search of understanding and independence.

The present study suggests that the implementation of the didactic system founded on Galperin's Theory of the Formation of Mental Actions in Stages, as delineated in Talízina's Study Activity Direction and Majmutov's Problematic Teaching, has demonstrated a capacity to enhance the reformulation of the orientation of the ability to solve student problems in differential and integral calculus among mathematics-*licenciatura* students at Universidade Federal of Pernambuco.

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References

DIAS, I. S. Competências em Educação: conceito e significado pedagógico. *Revista Semestral da Associação Brasileira de Psicologia Escolar e Educacional*, São Paulo, v.14, n. 1, p.73-78, 2010.

MAJMUTOV, M. J. La Enseñanza Problémica. Habana: Pueblo y Revolución, 1983.

NASCIMENTO, R.O. Uma Introdução à contribuição de Mirza Majmutov para a teoria e prática do Ensino Problematizador. In: PUENTES, R. V; LONGAREZI, A.M. (org.). *Ensino Desenvolvimental: vida, pensamento e obras dos principais representantes russos*. Livro 2. Uberlândia: EDUFU, v.1, p. 379-404, 2017.

NÚÑEZ, I. B.; RAMALHO, B. L.; OLIVEIRA, M.V. F. A Formação de Habilidades Gerais no Contexto Escolar: contribuições da teoria de P. Ya. Galperin. In: NÙÑEZ, I. B.; RAMALHO, B. L. (org.). *P. Ya. Galperin e a Teoria da Assimilação Mental por Etapas: pesquisas e experiências para um ensino inovador*. Campinas-SP: Mercado de Letras, 2016.

PERRENOUD, Phillipe. Construir competências é virar as costas aos saberes? In: Pátio – *Revista Pedagógica*, Porto Alegre, n. 11, p. 15-19, nov. 1999.

TALIZINA, N. F. *Manual de psicología educativa*. México: Facultad de Psicología: Universidad Autónoma de San Luís Potosí, 2000.

TALÍZINA, N. F. *Psicología de la Enseñanza*. Moscou: Editorial Progreso, 1988.

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