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DIGITAL TRANSFORMATION AND INNOVATION IN THE TEACHING OF MATHEMATICS

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ABSTRACT

The article considers the basic components of the methodical system of teaching mathematics, including purposes, content, methods, forms and tutorials, with an innovative component of the use of information and communication technologies in the educational process. In addition, the article describes science in various segments of math teaching, starting with the nature of math to mathematical tasks as an important method of forming a system of basic mathematical knowledge, skills and habits of students. This technique greatly facilitates the assimilation of the material, allows you to clearly show logical transitions and highlight the key points of lectures and practical classes of the educational process when teaching mathematics. This article attempts to discuss innovations and innovative practices in teaching mathematics, within the framework of teaching methods, strategies, and pedagogic resources, within the innovative component of the use of information-and-communication technologies in the educational process.
Keywords: *Teaching methods, Mathematical education, Mathematical skills, ICT.*

1. INTRODUCTION

At the stage of modernization of education, it faces many tasks: increasing the availability, quality and effectiveness of education, significantly updating the content of education, bringing it in line with the requirements of the time and the tasks of the country's development. The modern pedagogical paradigm connects the quality of education not only with knowledge of the basics of science and pedagogy, focused primarily on action but also on mastering various skills that make it possible to become an active and successful member of civil society. One of the urgent tasks of education today is the creation of such an education system that would provide access to educational resources based on ICT, allowing to create a qualitatively new information educational environment.

In today's complex society, the study and understanding of mathematics and natural sciences have become necessary for the comprehensive development of everyone. The ability to understand mathematics and mathematical judgment is crucial for the future professional careers of students. The development of the economy of each country depends on an individual simulation, development of new modern technologies and reinforcement of the connections between scientific disciplines.

The importance of mathematics has recently increased because of the huge application of computers, information technologies, modelling and simulation.

Research in mathematics education is a fast-growing field as evidenced by the success of the Thematic Research Group on Mathematics Education at the Tertiary Level within the framework of the International Congress on Mathematical Education (ICME) (Lerner , 1981; Dalinger, 2021). The study of the structure of the competence-oriented paradigm approach in teaching mathematics to students has shown that we can consider it as an open sequence of approaches in the principle's mathematics learning. Recent researches have focused on the

difficulties experienced by students when starting studies at a tertiary level.

This includes teaching styles, instructional approaches, studying and learning strategies as well as views on mathematics, specific mathematical concepts, mathematical knowledge, and goals of learning.

Some studies suggest that beginning undergraduate students do not consider university mathematics topics as continuation, extension, or generalization of topics previously studied at school -they tend to regard these as completely different subjects. Such results on students' conceptions indicate a need for research focusing on how and to what extent connections between school and higher mathematics are established in undergraduate instruction, including teaching, syllabuses, and textbooks (Lerner , 1981; Dalinger, 2021).

The research in mathematics education at the tertiary level is a constantly growing field that has been endorsing a broad range of theoretical and methodological approaches including a significant shift in attention to socio-cultural, institutional and discursive approaches. Modern methods of teaching mathematics offer various possibilities for solving the problem of involving students in independent and research work, develops their problem-solving skills, creative thinking processes and knowledge.

Generally, the main purpose of teaching mathematics is to mathematician students' thinking. The clarity in students' thinking, the simplicity in students' assumptions and deduction of logical conclusions are based on mathematics. One of the most important goals of the mathematics is to develop student's skills for understanding the abstract mathematical concepts and solving real-life problems. Mathematics, being an important subject and occupying a central position since the ancient period till date, has not been of interest to many students. The reason is mainly that there is an aspiration but it is difficult to achieve. Being highly abstract, it is concerned with interrelated ideas, and with the manipulation of symbols.

The teaching of mathematics involves not only the computational know-how of a subject but is also concerned with the selection of the mathematical content and communication leading to its understanding and application. Thus, while teaching mathematics one should use the teaching methods, strategies and pedagogic resources that are much more effective in getting adequate responses from students.

This research attempts to discuss innovations and innovative practices in teaching mathematics, within the framework of teaching methods, strategies, and pedagogic resources, within the innovative component of the use of information-and-communication technologies in the educational process.

2. RESEARCH FRAMEWORK AND HYPOTHESIS

Teaching and learning mathematics involve complexities that can be overcome if certain rules are followed. The nature and quality of instructional material, presentation of content, teacher pedagogical skills, learning environment, student motivation are all important and must be considered to ensure the quality in teaching and learning mathematics. The essence of the approach –based on the competence paradigm, that is in the integrated, optimal, synergetic and effective usage of approaches obtaining different didactic potential: competence-based, playing a leading role as well as the contextual, interdisciplinary, discipline-based and information technology approaches and fundamentalization. These approaches according to their didactic potential contribute to developing the mathematics teaching content to estimate their efficiency.

Besides the huge importance and application of mathematics in the other sciences, and the application of mathematical knowledge in everyday life, but in many countries in the world, mathematics is not a popular subject among students. All good practices as methods are classified into seven groups, which can be illustrated in Figure 1.

The classification of the methods is done according to the methods' content, the possibilities for their implementation in the learning process (in what form they could be used), the activities/actions that the practice involve and according to the resources necessary for the application methods in the process of teaching mathematics. Mathematical understanding has three specific contexts namely:

- ✓ Situational context;
- ✓ Cultural context;
- ✓ Conceptual context.

Situational context refers to an individual's interaction with the same materials, environment, or actions.

Cultural context refers to behavioural patterns.

The conceptual context refers to a personal understanding of the situation.

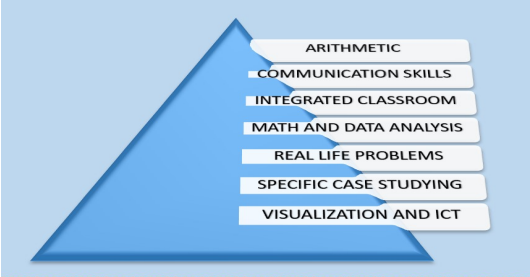

Figure 1: Good practices as methods group of the mathematical knowledge

The integrative structure of students' mathematical competence, which focuses on cognitive, practical, motivational and value components, as well as reflexive and evaluative components, leads to the necessary integrated use of different approaches to mathematics teaching. This contributes to developing all mathematical competency components including the approaches based on various educational paradigms.

The essence of the transition from knowledge-based mathematics learning to competency-based learning consists of the complete realization of common didactic principles: professional orientation, interdisciplinary links, informatization and fundamentalization. If these principles were not in demand and were not obtained within the framework of knowledge-based learning that the stated general didactic principles can be considered as a didactic basis for the principles teaching mathematics based on competencies.

Innovative teaching approaches are usually introduced in the context of a new curriculum, teacher training and professional development program, or a combination of them. However, it is important to emphasize that innovation is not good for it self-not all teaching innovations are improvements.

Firstly, in order to distinguish between changes and improvements in teaching, it is essential to explicate what is worth knowing and doing mathematically, in the process of delineating mathematical learning goals.

Secondly, the widespread introduction of e-learning into the education system is quite relevant, especially taking into account the requirements of educational standards of the new generation. However, such widespread use of computer technology and orientation to distance learning technologies require the development of special computer training programs using ICT technologies. The use of innovative methods such as the use of ICT in educational institutions has the potential not only to improve education but also to empower people, strengthen governance and intensify the effort to achieve the human development goal for the country.

The introduction of ICT into the learning process creates fundamentally new pedagogical tools, thereby providing new opportunities. In addition, the development of fundamentally new teaching materials is required. To implement the development of special computer training programs using computer technology, such components are required as:

- ✓ Hardware and software basis;
- ✓ Trained teachers;
- ✓ Electronic educational resources.

Within the using ICT, the other approaches can be used as approaches that define the forms, methods and tools of mathematics training and contributing to achieving the goal and the result of the competence approach.

The effective teaching-learning methods of Mathematics. Based on the main training principles of mathematics learning within the contextual, interdisciplinary, discipline-based and information technology approaches and fundamentalization, the basic principles of competency-based training in many university disciplines and disjunction-conjunction system of the content selection have been formed; they have been successfully tested for teaching mathematics. This can be varied in terms of methods and pedagogical resources used in the teaching-learning process. A method is a style of presentation of content in the classroom. The following are the innovative methods of teaching mathematics that can be used to improve the efficiency of the process of teaching mathematics, shown in Figure 2.

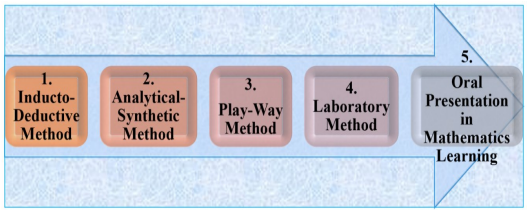

Figure 2: The effective teaching-learning methods of Mathematics

1. Inductive-Deductive Method. The inductive method consists in moving from concrete examples to generalization and the deductive method consists in moving from generalization to concrete examples. Usually in classrooms, instructions start with abstract concepts which are beyond the comprehension of students.

Formulas, theorems, examples, results are derived, proved and used. But the teacher needs to start with concrete examples and things and then move to generalizations and abstract things. Then the teacher again needs to show how to generalize and conduct it on concrete examples. This method helps students for better understanding; they don't have to cram things and will have a lasting effect.

2. *Analytical - Synthetic Method.* Analytic is the destruction and transition from the unknown to the known and synthetic is unification of known fragments of information and the transition from the known to the unknown. These methods are basically used in proving the results and solving problems. So, the teacher has to combine both to explain and relate each step logically.

3. *Play - Way Method*. This method includes play and fun activities that are related to numbers.

4. *Laboratory Method.* With the advent of computers, many colleges are well equipped with computer laboratories. The availability of computing software can be used in addition to teaching mathematics in the classroom for:

- ✓ Promote students´ active engagement and learning;
- ✓ Exchange long and difficult numerical and algebraic manipulations by communication of supporting reasoning when answering mathematical questions;
- ✓ Make experimental activities easier to handle;
- ✓ Develop problem resolution skills dealing with more interesting and difficult problems as far as numerical, algebraic graphical and programming resources are available;
- ✓ Encourage discussion of different solutions or strategies working with multiple representations of the same mathematical object or process;
- ✓ Motivate the development of paired concepts such as discrete/continuous and finite/infinite.

In connection with the emergence of such tools as software such as Maple, Mathematica, MathLab, GeoGebra, Group Algorithm Program (GAP), mathematics began to provide more opportunities for this stage of the study.

During the lesson, students can generate various hypotheses using computer programs. To do this, students are offered ready-made models or the task of constructing the desired model using the capabilities of software. By influencing these models, students manage to find some regularities, invariants. The hypothesis methodology can be different:

- ✓ After posing a problem, students are encouraged to independently put forward hypotheses about a possible solution to the problem and immediately test them;
- ✓ Students are asked to solve a number of similar problems before this, and then the question is raised about putting forward hypotheses to explain the observed patterns.

Example 1: The task is to build a graph of functions:

$$y = \frac{2}{100}x^7 + \frac{8}{100}x^6 + 9x^4 - 100x^2 + 1 \; for \; x \in [-6,4]$$

Execution leads to the construction of a graph of the function, which can be presented in Figure 3.

Example 2: Abstract of a research lesson on the topic "*Triangle Inequality*".

The purpose of the lesson: to study the relationship between the sides of the triangle and find an application of new knowledge.

Lesson type: the lesson on learning new material.

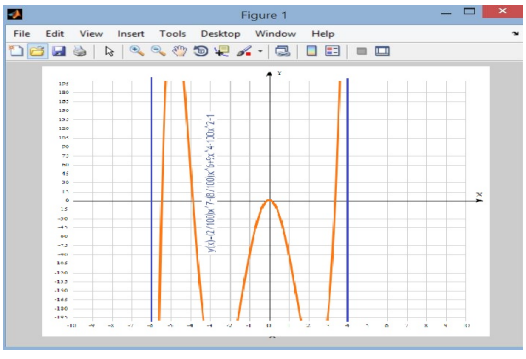

Figure 3: The graph of functions

Equipment: computers, interactive whiteboard, workbooks for work.

Lesson plan:

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1. Updating basic knowledge: solving problems according to ready-made drawings on the topic "The relationship between sides and angles in a triangle".
2. Motivation and formulation of a research problem: Solving a constructive problem in software (computer programs).
3. An experiment to study the dependence of the sides of a triangle software (computer programs - pair work).
4. Developing and verification of the hypothesis.
5. Proof of the triangle inequality theorem (group work).
6. Conclusion based on the results of the work.
7. Assignments.

The course of classes:

1. Application of fundamental knowledge. In the course of the frontal survey, students' repetition of knowledge and skills on the relationship between the sides and angles of the triangle, the comparison of the leg and hypotenuse of a right triangle, the property and sign of an isosceles triangle are organised with the help of tasks.

Homework: Task 1: Find the correspondence between the sides of the triangle and their lengths if the angles are known and can be represented in Figure 4.

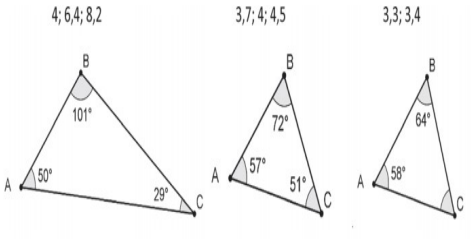

Figure 4: Triangle Inequality

Progress:

1. Solve the problem analytically.
2. Create a computer simulation of the scenario. Use it to construct geometric locations for angles defined by measurement errors.
3. The solution.

Example 3: The task to build a graph of functions:

$$x^5 + 8x - 9 = y.$$

Results on process the solution can be observed in Figure 5.

Oral Presentation in Mathematics Learning. Reaching parts of the brain that usual educational methods haven't reach may be the answer to those poor students who do not have a "mathematical brain". The theory of multiple intelligences and brain-based learning may be the tool that will aid these students to be more confident about their mathematical ability. Oral presentations provide all students with the opportunity to demonstrate their knowledge in a fun and creative way.

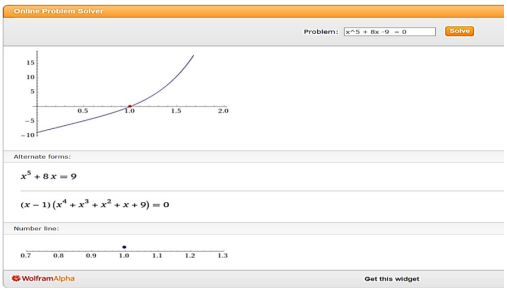

Figure 5: Process the solution

The interest aroused when researching the topic may give rise to a new curiosity about mathematics. The oral presentation is an activity of sharing ideas and clarifying understanding verbally:

- ✓ Firstly, this method is considered as an alternative assessment method for teachers to gather information about their students' learning of mathematics and make relevant instructional decisions.
- ✓ Secondly, it is also considered as a tool for developing students' communication skills.

For example, to study the course "Higher Mathematics" requires knowledge, skills, methods of activity acquired by students as a result of mastering the previous disciplines: higher algebra, mathematical analysis, etc. And the section of mathematics "Number theory" logically precedes the study of the discipline "Number systems", the content of which is associated with the deepening of professional knowledge in the specified subject area. The purpose of the discipline is to present basic information from elementary number theory and to form students' deep arithmetic concepts. Let's list the competencies formed by students as a result of mastering the discipline:

- ✓ Possession of the culture of thinking, the ability to generalize, analysis, perceive information, goal setting and choosing the ways to achieve it;

- ✓ Willingness to cooperate with colleagues, work in a team;
- ✓ Possession of the basic provisions of the classical sections of mathematical science and methods of mathematics, the system of basic mathematical structures and the axiomatic method (competence is formed partially);
- ✓ Possession of the culture of mathematical thinking, logical and algorithmic culture, the ability to understand the general structure of mathematical knowledge, the relationship between various mathematical disciplines, to implement the basic methods of mathematical reasoning.

One of the methodological methods in the study of mathematics is the effective use of practical lessons in mathematical disciplines, the main purpose of which is to ensure a personality -oriented interaction between the teacher and students.

A practical lesson is an activity conducted under the guidance of a teacher in a classroom, aimed at deepening scientific and theoretical knowledge and mastering certain methods of independent work, which forms practical skills (Emelina & et al., 2010). Practical classes in mathematical disciplines are fundamental because they perform many important functions:

- ✓ Teaching (*mastering the mathematical apparatus*);
- ✓ Developing (*development of a culture of thinking*);
- ✓ Upbringing (*the ability to overcome cognitive difficulties);*
- ✓ Controlling: *operational diagnostics of the obtained learning outcomes* (Emelina & et al., 2010).

As a rule, practical exercises in mathematical disciplines are the practice for solving typical mathematical problems, the main purpose of which is the formation of mathematical skills, and not the development of competencies. Thus, when conducting practical classes, it is necessary to take into account the psychological characteristics of students, this can be done as follows:

Firstly, stick to a certain structure of the practical lesson:

- ✓ Motivation stage: The necessity and expediency of this lesson for each student;
- ✓ Updating stage: Actualization of the necessary knowledge and skills, eliminating gaps in mathematical knowledge and skills accelerated development of the topic;
- ✓ The Stage of the indicative basis: familiarization with the lesson plan, clarification of the meaning, features, and expected difficulties in completing math's tasks;
- ✓ Practice stage: Independent or group performance of mathematical tasks, acquisition of new experience;
- ✓ The Stage of individual counselling: teacher's help in overcoming cognitive difficulties by each student;
- ✓ The Stage of reflection: awareness by each student's enrichment of mental experience for new knowledge, skills, ways of activity.

Secondly, the teacher makes a chooses among various types of practical training: *group practice(training), mutual training, laboratory workshop, work in small groups, individual counselling (see Table 1).*

Table. 1. Examples 4 Math 1 Lesson Plans

Time scheduling, min.	STAGES OF THE LESSON	TEACHER ACTIVITIES	STUDENT ACTIVITIES
2-5	Greetings	Mathematical warm-up (oral thematic exercises, stimulating intelligence, quick mental counting).	Answer questions orally, solve problems; discuss possible solutions in a group.
2–5	Motivation	Formulates the topic of the lesson, justifies the need to study it.	Listen and ask questions.
5–10	Updating	Finding out the level of preparedness of students for the lesson: ✓ question-answer procedures; ✓ resolution of disputes and difficulties; ✓ placing emphasis on key tasks.	They ask questions of the teacher in case of difficulties and answer the teacher's questions about the completed tasks.
3–5	Indicative of the foundation	The teacher offers a lesson plan with comments on the need to complete the planned tasks.	Listen and ask clarifying questions.
35–40	Practice using ict	Using a teaching methodology, they solve key tasks and provide group work on their solutions.	Perform math assignments using a variety of tools.
10–15	Individual counselling	Give individual support to those students who have difficulties solving problems.	In workbooks, they perform tasks on the topic, if necessary, consulting the teacher on the correctness of their conclusions.
5 -10	Reflection	Summary of the lesson.	Conscientiously develop newly acquired knowledge and skills.

These interactive methods using ICT (computer programs) confirm a high degree of involvement of students in the educational process, activate cognitive and creative activity, form critical thinking, and develop communication skills, which correspond to the goals and objectives of teaching mathematics.

The pedagogical work required to create and implement learning situations to actualize these potentialities constitutes a major challenge to teachers. Some mathematical problems can be solved through computer programs such as Maple, Mathematica, Matlab, GeoGebra, Group algorithm program (GAP), which are powerful software programs used to solve general-purpose mathematical problems.

Problems in mathematics, natural sciences and engineering can be investigated using in-built commands of these programs or using these programming languages to create one's personalized programs. They can be used to solve problems in Calculus, Algebra, Solution of Differential Equations, Linear Programming, Statistics, plotting points in two and three dimensions, as well as to create a three-dimensional representation of an object and much more.

3. RESULTS AND DISCUSSION

Digital modernization of education require extensive skills to master and apply technologies in the teaching of problem innovative practices, which is closely related to mathematical thinking, so being familiar with new innovation processed in to educate mathematic. Digital Transformation and Innovation in the organization of professional competence of IT specialists has based on the analysis of the content of functional tasks of IT infrastructure:

Firstly, in addition, the importance of 21st-century learning environments where digital transformation and innovation in the Teaching in mathematics teaching will be maded was also emphasized. All this is due digital transformation makes a direct contribution education concepts have been observed to increase in learning environments organized as required transformative by the 21st-century.

Secondary, digital modernization of mathematics education transformative professional competence of ICT futures specialists is relevant because the lack of an easy-to-use IT job classifier and IT competency models.

Because, success in modeling in the organization of professional competence of IT specialists requires not only the ability to recruit prior knowledge but also the ability to establish strong connections between new and existing technologies to form knowledge clusters around core principles and including mathematical ability and critical thinking.

The use possibility of the digital transformation and innovation ICT allows for a step-by-step presentation of educational material with any degree of detail using different effects (colours, animation, graphs, diagram, etc.) of the educational process when teaching mathematics.

The method of step-by-step output of information in the form of separate fragments is very convenient for displaying formula, graphs, charts, tables, etc. This technique greatly facilitates the assimilation of the material, allows you to visually show logical transitions and highlight the key points of the lecture and practical lessons of the educational process when teaching mathematics.

The experience at the of practical training has shown the control processes of a methodical system of teaching mathematics students' acquisition of information in the form of charts depends on external and internal factors (motivation, methods and conditions of learning) but for students at the other psychological features had a greater impact on their assimilation of visual information.

Thus, to meet the demand for producing an IT workforce grounded in technological advances, mathematics teachers must collaboratively embrace and increase emphasis essential mathematical competence during instruction and to attain the purpose, it is necessary to discuss the following issues:

- ✓ What are the core competencies that support 21st century mathematics teaching skills?
- ✓ What are the instructional designs involved in using the mathematics teaching?

However, it does not mean that textual information or multimedia presentations are ineffective and should be excluded from the teaching and learning process. There is a correspondence between students' psychological characteristics and the forms of visual information with using computer programs, and we cannot claim that only illustrations using images in presentations work more effectively for all students.

4. CONCLUSIONS AND FUTURE WORK

The introduction of information technology into the learning process creates fundamentally new pedagogical tools, thereby providing new opportunities:

- ✓ At the same time, the functions of the teacher are changing, and at the same time, the sector of independent educational work as an integral part of the educational process is significantly expanding.
- ✓ The use of the animation effect in the presentation program allows for a step-by-step presentation of educational material with any degree of detail using different colors. This technique greatly facilitates the assimilation of the material, allows you to visually show logical transitions and highlight the key points of the lecture and practical lessons of the educational process when teaching mathematics.
- ✓ The mastery of mathematical concepts has a complex psychological structure: firstly, it depends on the formation of prerequisites (cognitive, speech and personal); secondly, from the basis in the form of mental activity (analysis, synthesis, generalization, classification, etc.).

In the future, one of the further directions of research might be to identify the specificity of acquisition of animated information, and its dependency on students' psychological characteristics for teaching mathematics. It is necessary to create conditions for students' more effective assimilation of visual information by taking into account the correspondence between their students' psychological characteristics and forms of multimedia presentations used in the classroom. In addition, to be more attentive to students' behaviour to make conclusions about which form of visual information it will be better for them to use.

Conducting learning mathematical education processes with using ICT provides other advantages, namely: the teacher is always facing the audience, sees the work of each student, has additional opportunities to keep the audience's attention and make adjustments in time.

However, analyzing the possibilities of ICT training, it should be remembered that computer programs does not replace the teacher, but only serves as an assistant in the educational process.

Conversely, modern ICT is capable of performing some functions that were previously inherent only in the teacher: to analyses the student's actions and issue a hint, ask questions and evaluate the answer, answer questions, revealing certain topics of the subject area, including variably.

This research has limitations that can be overcome in future studies. This study is also a pre-experimental doctoral study with a one-group post-test design, so there are no control class and no pretest. Finally, this quantitative research needs to be followed up through quasi or future experiment research.

The model using digital transformation and innovation ICT of teaching methodology for teaching mathematics is the first step of the process of developing a new methodology and creating innovative ways of teaching and learning Mathematics using modern technologies.

Future research on the topic may relate to the use of other methods of measuring technological componence's of the methodical system of teaching mathematics, including purposes, content, methods, forms and tutorials, with an innovative component of the use of information and communication technologies in the educational process.

The study is the doctoral empirical research in Kazakhstan to investigate teachers' knowledge of ICT and their knowledge about the use of ICT in teaching process that involved a relatively large number of student's participants.

As a developing country, Kazakhstan believes that the results of this study have implications not only for the country but also for other developing countries that are keen to integrate ICT (as an open -source software) in the classroom. This study provides specific information about the ICT - skills of mathematics learning. It is also interesting to study the correctness of the forecasts made on the development of faculty members' technological competencies, checking the correctness and practical value of the obtained forecasts in three years.

Some of the limitations found in the development of this research would be the deficiencies found in the scientific literature regarding the research focused on the value of the method as a didactic resource. The main limitation of this study focuses on the scarcity of national and international studies that address the central theme of study and that serve as a reference to develop a discussion of the data that contrasts them in a deep and adequate way. The novelty of the topic is a limitation of the research.

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