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Theoretical and methodological design of a Didactic Model to enhance the teaching and learning processes of Mathematics at Instituto Tecnológico Superior de Poza Rica

Diseño teórico metodológico de un Modelo Didáctico para potenciar los procesos de enseñanza y aprendizaje de las Matemáticas en el Instituto Tecnológico Superior de Poza Rica

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Abstract

Higher Education Technological Centers through their Educational Model for the 21st century: Training and development of professional skills promote teachers to develop research projects in a way that allows them to improve the teaching process and thus contribute to the integral training of future professionals with knowledge, skills, abilities, attitudes and values that allow him to continue learning throughout his life. To achieve such purposes, a group of professors elaborated a research project in the area of Mathematics, assuming essentially the conceptual framework provided by Vygotsky's Cultural Historical Approach and the work of other authors with similar reference. The objective of this paper is to develop the conceptual and methodological bases of a Didactic Model that allows to direct in a scientific way the teaching and learning processes of Mathematics, according to the conditions of subjects such as Differential Calculus and Integral Calculus, as well as the environment which is presented in the institutions of the National Technological System, specifically in the Instituto Tecnológico Superior de Poza Rica, Veracruz state, Mexico.

Teaching model, Teaching, Mathematics

Resumen

Los centros de Educación Superior Tecnológica a través de su Modelo Educativo para el siglo XXI. Formación y desarrollo de competencias profesionales, se promueve que los profesores desarrollen proyectos de investigación de manera que les permitan perfeccionar el proceso de enseñanza y de esta forma contribuir a la formación integral del futuro profesionista con conocimientos, competencias, habilidades, actitudes y valores que le permitan continuar aprendiendo a lo largo de su vida. Para lograr tales propósitos, un grupo de profesores, elaboramos un proyecto de investigación en el área de las Matemáticas, asumiendo esencialmente el marco conceptual aportado por el Enfoque Histórico Cultural de Vygotsky y el trabajo de otros autores con similar referencia. El objetivo de este trabajo es desarrollar las bases conceptuales y metodológicas de un Modelo Didáctico, que permita dirigir de manera científica los procesos de enseñanza y aprendizaje de la Matemática acorde a las condiciones de asignaturas tales como Cálculo Diferencial y Cálculo Integral, así también el entorno que se presenta en las instituciones del Sistema Tecnológico Nacional, específicamente en el Instituto Tecnológico Superior de Poza Rica, estado de Veracruz, México.

Modelo didáctico, Enseñanza, Matemática

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Introduction

Students' performance in the subjects of the area of Mathematics in higher education is rather questioned, especially by teachers who have been working in the Technological Education System for years and who have somehow lived with different generations of students. Many teachers seek to motivate and generate efficient teaching models with the purpose of contributing to student learning.

The student's academic performance may depend on many factors: personal, social, and institutional; the latter is related to pedagogical situations where the teacher has a level of influence and is questioned by their teaching methods and strategies, update of their teacher training, organization and management of the school context, among others. Searching for ways that are at the forefront to direct the teaching-learning processes of Mathematics, as a group of professors from the Department of Basic Sciences of the Higher Technological Institute of Poza Rica (ITSPR), we intend to conduct research in the area of educational mathematics, the result of which is a didactic model to improve the way in which students learn and, in turn, teachers perform their work as facilitators in a more effective way.

In order to develop the didactic model, theoretical and methodological references from various sources are required, such as: Pedagogy, Didactics, Curricula, Sociology and Psychology, which allow us to correctly analyze the protagonist of the educational process, that is, the student, but also the teacher and their environment, as well as those guidelines that currently govern the way in which the educational process is developed in Technological Higher Education.

In this way, we follow the definition of didactic model according to Brovelli (1989), cited by Cárdenas, 2006, p.5 [I]

"A didactic model is the symbolic-conceptual representation of educational reality, which will aim to function as a mediating scheme between educational reality and thought, and serve as a structure around which knowledge is organized."

According to Reyes, (2015), p. 4 [II]: "The 21st Century Educational Model, which is the institutional proposal of the Technological System and which defines the philosophical, organizational and academic guidelines, can be distracting from reality and runs the risk of not transforming teaching practices and having a positive impact on the formation of future professionals, even in educational environments where conditions are favorable. On the other hand, the traditional pedagogical method in teaching Mathematics is still predominant, in which the student often acts as a receiver."

Regarding the 21st Century Educational. Training and Development of Professional Competences, prepared by a group of authors (2012) [III], which has been the guideline for four years now, and which is academically guided by the competency model as a basis for developing the teaching-learning process, we can identify areas of opportunity to improve this process. For example, Mazario, et al (2019) [IV] conducted a study in which traits of traditional pedagogy are still identified, since in the evaluations are not considered other options such as self-assessment and co-evaluation.

Likewise, in the elaboration of the complementary didactic materials (texts, videos, articles, guides, etc.) from the students' view they are perceived as insufficient. Therefore, we must consider that current generations require a more flexible curriculum, which is designed to further enhance the use of technologies, teamwork, diversification of learning contexts, among other skills that favor students and are accessible to most teachers.

From these considerations, the didactic model that would result from this research would provide the essential educational teaching guidelines to improve the teaching and learning of Mathematics in the ITSPR, since a sufficiently generalizing space would be opened so that teachers can develop a methodological work that will lead us to the achievement of higher goals in technological education.

In addition, the development of this research, which takes into account the academic and social context where our work takes place, can serve as a basis for other higher-level institutions, considering the appropriate adjustments to their context.

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That said, the present work is structured as follows:

The Development, in which the problem situation that supports the research is presented;

The Scientific Problem that poses the elaboration of the objectives and the corresponding investigative tasks.

In the next section, corresponding to the Methodology, both theoretical and empirical methods that will be applied in the investigation are presented, the results of which will be subjected to mathematical statistical analysis.

In the Theoretical Referents, the Cultural Historical perspective of Vigotsky is introduced, enriched by other significant contributions for the development of this research, specifying its Pedagogical, Didactic, Curriculum, Sociological and Psychological guidelines.

Subsequently, the Distinctive features and stages of the research process (Planning, Organization, Implementation and Adjustments, and Assessment) are presented.

Finally, we offer the Results and Conclusions of this paper.

Development

To carry out the investigation, several stages were organized with specific tasks for each of the members of the working group. First, the theoretical methodological framework of the research is established, based on the analysis of the bibliography, application of diagnostic instruments and interviews with experts, in order to identify all the elements that would be included in the research protocol. The structure of the project is presented below.

Problematic situation

From the analysis of the previous section, we identified some aspects in the teaching and learning processes in the ITSPR which shape the problematic situation and require an investigation in the area of Educational Mathematics:

- There are significant dropout and failing rates due to difficulties with the assimilation of mathematical content.
- Not all mathematical education plans and programs are designed to favor teaching-learning processes, as demanded by the working sector, educational institutions and their contexts.
- It is necessary to identify training areas in order to adequately prepare teachers to develop the 21st Century Educational. Training and Development of Professional Competences proposed by the National Technological Institute of Mexico for its educational institutions.
- Difficulties are detected regarding the proficiency of learning techniques and strategies.

On the other hand, we identified the following conceptual and practical limitations within the mathematical formation of students:

1. The assimilation process of mathematical contents presents difficulties with previous contents.
2. The process of early professionalization which must train professionals capable of applying mathematical content does not have a quality response in the mathematical preparation of students.
3. The curriculum is not designed to favor mathematical education.
4. There is no defined line of action by the teaching staff to integrate efforts in the mathematical education of students.
5. The students are not aware of the importance of their mathematical training.
6. Problems in the integration of mathematics with other subjects.

Scientific Problem

From the above, the following Scientific Problem arises.

What pedagogical proposal is necessary in order to overcome the difficulties related to the teaching-learning process of Mathematics in the ITSPR?

As a general objective we propose:

To develop the conceptual and methodological bases of a didactic model which allows to direct in a scientific way the teaching-learning process of Mathematics in the ITSPR.

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Thus, with the achievement of this objective, it is hoped to strengthen the methodological preparation of the teachers of the Department of Basic Sciences of the ITSPR, and consequently improve the teaching-learning process of Mathematics in this institution of Technological Higher Education.

The following scientific questions are derived from the general objective of the investigation.

1. What are the theoretical references that allow the development of a didactic model to favor the teaching-learning process of Mathematics in the ITSPR?
2. What conceptual, practical and attitudinal limitations do students enrolling in the ITSPR have in their mathematical training that influence the significant drop-out and failing rates in the different majors studied in said institution?
3. What are the theoretical and methodological assumptions that make up a didactic model to favor the teaching-learning process of Mathematics in the ITSPR?
4. What structural and operational characteristics should be considered in the design of the didactic model to favor the teaching-learning process of Mathematics in the ITSPR?
5. To what extent is the didactic model feasible to favor the teaching-learning process of Mathematics in the ITSPR?

Consequently, the following research tasks are proposed.

1. Outline of the theoretical references that support pedagogically and mathematically the didactic model to favor the teaching-learning process of Mathematics in the ITSPR.
2. Outline, through diagnosis, of the situation presented by students trained as engineers in the ITSPR regarding the assimilation of mathematical contents and their predisposition for the study of this science.
3. Foundation of the theoretical and methodological assumptions that make up a didactic model to favor the teaching-learning process of Mathematics in the ITSPR.
4. Elaboration of a didactic model to favor the teaching-learning process of Mathematics in the ITSPR.
5. Validation of the didactic model and methodology to favor the teaching-learning process of Mathematics in the ITSPR through the instruments developed for this purpose.

Methodology

The methodology corresponds to a descriptive evaluative project based on a field study. The population is comprised of 275 students from the Industrial Engineering major, 53 from the Petroleum Engineering major, and 8 professors from the Mathematics area, who teach in these courses.

To carry out the study, a sample of approximately 30% of the students was selected, while, with the teachers, we worked with the entire population, since it is small. For this, probabilistic sampling was used with a simple random sample procedure.

As Research Methods Castellanos et al (2005) [V]; Colás & Buendía, (1992) [VI] for the development of this work, the following were used:

Theoretical level

Historical and logical. According to Calzadilla-González et. al. (2017) [VII] mention that the criteria of Ramos (nd), Alpizar and Anorga (2017), Delgado (2010), González (2011), Sánchez and González (2014) who state that in society problems or phenomena do not occur by chance, but are the result of a long process. We can conclude that the current model is the result of a process, as well as the teaching of Mathematics is the result of a process that has evolved over time and with the changes of models that have occurred since the creation of the ITSPR.

With the use of this method it is intended to perform a logical historical analysis of the elements that make up the current model within the institution, as well as the features that characterize the teaching-learning process of Mathematics within the ITSPR.

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To reach an answer about the theoretical references that allows us to elaborate a didactic model to favor the teaching-learning process of Mathematics in the ITSPR we implemented a documentary analysis.

Analytical-synthetic. Once the logical-historical stage is carried out, the synthetic-analytic step is implemented, which allows us to perform the separation of the whole into parts in order to study each of the elements detected in the logical-historical stage, as well as the relationship between the parts of the process.

On the other hand, the synthetic method allows us to gather the most important aspects after having carried out an analysis, so that we can know the parts and particularities within the process, and then integrate them with new features within the didactic model that we want to establish in the ITSPR.

Determining the conceptual, practical and attitudinal limitations that the students have in their mathematical training which influence the significant drop-out and failing rates in the different majors studied in said institute.

As well as determining the theoretical and methodological assumptions that make up a didactic model to favor the teaching-learning process of Mathematics in the ITSPR.

Modeling. This stage will allow us to propose concrete actions to establish the performance of students, as well as the role that the institution will play in the process. Also raising the structural and operational characteristics that should be considered in the design of the didactic model to favor the teaching-learning process of Mathematics in the ITSPR.

In order to achieve the objective or some of the objectives proposed in the investigation, the following procedures are used:

– Comparison
– Induction-deduction
– Generalization
– Systematization

Empirical level

– Observation
– Teacher interview
– Student interview

Mathematical statistical methods

– Mathematical methods
– Statistical methods

Theoretical Referents

As noted, the conceptual support of the research is basically Vygotsky's Cultural Historical approach and the work of other authors with similar reference, without ignoring the contributions of other trends that play a part in this research. In summary, the theoretical references of the research are the following.

– Pedagogics.
  a. The object of study of Pedagogy as a science.
  b. Categories: education, teaching, instruction, training or pedagogical process (school or non-school). Conscious, organized and directed character.
  c. Integral humanist social formation.

– Didactic:
  a. Mathematics learning- teaching proces.
  b. Laws of teaching.
  c. Training by competences and mode of action.
  d. Methodological work.

– Curricula.
  a. Curriculum as an integral educational project with process character.
  b. Professional profile model: scientific, technological and humanistic.
  c. The research-labor practice, an important axis in curriculum planning.

– Sociologic:
  a. University –Society: labor research practice.
  b. Knowledge society: Tendency in learning to learn.
  c. ICT development.
  d. Tendency to skills training.

– Psychologic:
  a. Constructivist approach.
  b. Teacher as guide, mediator of aids to learn.

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c. Role of collaborative activity and teamwork.
d. Development of critical, analytical, generalizing and reflective thinking.

Distinctive features and stages of model development

Distinctive features of the model:

1. Objective correspondence with the modeled object.
2. The ability to offer in the course of the investigation certain information susceptible to experimental verification.
3. The existence of precise rules to pass from the information offered by the model to information about the modeled object itself.
4. The functions of the model are: translational, predictive, approximate, substitute-heuristic, transformative and illustrative.

The review of the works of Prieto (2016) and Sánchez, (2016), were very useful to determine the stages of elaboration and instrumentation of the didactic model, which are the following:

First Stage

Planning. It involves actions such as: diagnosis and detection of educational needs, identification of the scientific problem and determination of objectives.

Second Stage

Organization. Development of the didactic model and creation of the conditions for its application.

Third Stage

Implementation and adjustments. Implementation of the model budgets and decision making regarding the adjustments and corrections of the plan.

Fourth Stage

Assessment. Continuous feedback process and data recording that will be subjected to statistical and mathematical methods leading to the conclusions of the research process, feedback and new problems.

Results

Since the investigation is in its first stage, we provide partial results in the elaboration of the didactic model itself, as well as the previous work that consisted essentially in the observation of the educational teaching activity in the ITSPR, and the work with the documentation available and provided by the different departments of the institution. In addition to the application of interviews and surveys to both teachers and students, which allowed us to characterize the work done by teachers and the academic performance of students. These partial results have already been presented to the Academy of Basic Sciences and at national and international conferences.

Although we are in the first stage of the investigation, through the design of the research protocol itself some of the actions that characterize the following stages have already been carried out, such as: awareness by making changes or adjustments in the teaching-learning process, the presentation of diagnostic results and others related to the organization of the educational and institutional scenario for the application of the model.

Conclusions

After the first investigation stage has been carried out, the following conclusions were reached:

– The didactic model has been developed taking into account the educational guidelines proposed within the 21st Century Educational. Training and Development of Professional Competences proposed by the National Technological of Mexico.
– The theoretical references of the cultural historical approach have been taken into consideration for the elaboration of the model, taking into account the members of the research team, who follow the educational problem of the teaching-learning process in the ITSPR, as well as the information available on the objectives of the new educational reform proposed by the current government
– The process of spreading the theoretical and methodological budgets of the educational model in its first stage has had favorable opinions of teachers, students and institutional authorities.

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– With the elaboration of the didactic model it is considered that the teachers of the Department of Basic Sciences of the ITSPR will be organized in a space that promotes feedback and exchange of ideas and outlines the methodological teaching work to potentiate the teaching-learning process with the scientific support of educational research.
– The results achieved during the completion of the first stage of the research and the perspectives posed by the following steps are considered to consolidate the methodological work of the Department of Basic Sciences of the ITSPR and will contribute to the improvement of the teaching-learning process of Mathematics in this institution of Higher Technological Education.

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