Article **Journal-Schools of economic Thought and Methology**
June, 2020 Vol.4 No.6 15-23

Innovation and technology to strengthen the learning of Calculus

Innovación y tecnología para fortalecer el aprendizaje del Cálculo

SÁNCHEZ, Bertha†, JIMÉNEZ, Guadalupe, MONTOYA, Javier and HERNÁNDEZ, Samuel

Instituto Tecnológico de Nuevo Laredo, Reforma Sur 2007, C.P. 88250, Nuevo Laredo, Tam.

ID 1st Author: *Bertha, Sánchez*

ID 1st Coauthor: *Guadalupe, Jiménez*

ID 2nd Coauthor: *Javier, Montoya*

ID 3rd Coauthor: *Samuel, Hernández*

DOI: 10.35429/JSETM.2020.6.4.15.23 Received January 21, 2020; Accepted June 28, 2020

Abstract

The proposal aims to improve the learning process of differential and integral calculus by applying dynamic teaching strategies and the use of technological resources. Participatory methodology in a space where meaningful content are managed, updated, space and the environment with different spatial distributions depending on the type of work is controlled, posters theorems and formulas alluding to the subject are presented. The work can be individual or collective. It represents an intellectually complex work applying various skills in real world situations. Multiple elements are integrated: A server, internal network WiFi, electronic whiteboard, projector, mobile devices.

Calculus, Technological innovation, Educational technology

Resumen

La propuesta pretende mejorar el proceso de aprendizaje del Cálculo Diferencial e Integral mediante la aplicación de estrategias de enseñanza dinámica y la utilización de recursos tecnológicos. Metodología de carácter participativo en un espacio donde se manejan contenidos significativos, actualizados, se controla el espacio y el ambiente con diversas distribuciones espaciales dependiendo del tipo de trabajo, se exponen carteles con teoremas y fórmulas alusivos al tema. El trabajo puede ser individual o colectivo. Representa un trabajo intelectualmente complejo que aplica diversas competencias en situaciones del mundo real. Se integran diversos elementos: un servidor, red interna WiFi, pizarrón electrónico, cañón proyector, dispositivos móviles y pueden apoyarse en apps de smartphone, Tablet y/o pc en cualquier momento de la clase.

Cálculo, Innovaciones tecnológicas, Tecnología educativa

Citation: SÁNCHEZ, Bertha, JIMÉNEZ, Guadalupe, MONTOYA, Javier and HERNÁNDEZ, Samuel. Innovation and technology to strengthen the learning of Calculus. Journal Schools of economic Thought and Methology. 2020. 4-6: 15-23

† Researcher contributing as first author.

Introducción

A problem faced by Higher Education Institutions in Mexico is the low terminal efficiency index; linked to dropout and student lag. In Mexico, of the total number of students who enter higher education, more than 40% do not complete their studies, and of the rest, only 18% manage to obtain their degree (INEGI, 2005; SEP, 2014), while the failure rates at this level, they are higher than 39% (OECD, 2010). Mathematics subjects have low achievement rates, which contributes to some students dropping out. Situation that becomes critical in the area of mathematics due to the low preparation of students, a consequence of teaching based on memory and algorithmic practices, devoid of any meaning. Students face great challenges during their first semester or year of studies: to assimilate in a short time, a series of new knowledge. They need to have certain skills that have not necessarily been developed previously, eg, ability to carry out processes of analysis and interpretation of mathematical results, the ability to graphically analyze solutions.

The training of engineers requires a constant use of mathematical tools, however, students no longer "learn" as they did some years ago; technological and educational advances provide us with various elements that previously did not exist. Students are no longer so passive, so teachers or facilitators should strive to integrate modern and commonly used elements into the classroom to reinforce school achievement. The use of mobile technologies is current, more than 80% of students have a mobile device, they are continuously connected, so the proposal is to use this means of communication for learning.

Background

The innovation of the educational process with the introduction of the Gavilán Classroom (named after the institution's mascot), began in September 2013 in a Differential Calculus group, which continued with the project in the Integral Calculus subject in the January-June 2014 semester, some elements have been added at the suggestion of the same student users and proponents, other components have been reinforced, such as the graphing machine and the mobile application to retrieve the class images automatically just by connecting to the internal network.

"All educators want to help their students succeed in life. What was considered a good education 50 years ago, however, is no longer enough to succeed in college, career, and citizenship in the 20th century. XXI "(NEA, 2012).

Therefore, a new framework for learning was developed in 2002, and timely adjustments in 2012, calling it the "Four Cs", which encapsulates the skills that are most important to an education in a global era: critical thinking, communication, collaboration and creativity.

Critical Thinking - the ability to make decisions, solve problems, and take appropriate action.

Communication - the ability to synthesize and transmit ideas both in written and oral form.

Collaboration - the ability to work effectively with others, including those of diverse groups and opposing views on a particular topic.

Creativity - the ability to see what is not there and make something happen.

According to Robledo (2014): “A great challenge for students and educators is deciding what type of devices will be used in the classroom”.

It also establishes 3 tips to start the implementation of mobile teaching.

– Ask yourself what you are trying to achieve.
– ""Ask your students which mobile devices they have."
– "Ask your students to make suggestions."

Aula Gavilán effectively complies with these four points of the NEA (2012) as well as with the suggestions of Robledo (2014) and uses them in the development of knowledge / power in the learning of mathematics.

ISSN 2523-6997

Existing technologies and competitors

Nearpod:

This application allows the teacher to project his presentation on all the devices of his students in a very simple way. The teacher searches his library for the presentation, the system gives him a PIN and the students, with that PIN, access it. Students have the explanation at their fingertips to be able to take notes and follow it without missing any detail. It allows you to save, buy applications, access exams and display graphs of responses. However, free access is very restricted, it is paid and necessarily requires the use of the internet.

Symbaloo

It is a page where it is possible to have all the material of the classes, share any type of files even in an entire institution. Disadvantages: it requires the use of the internet, and it is paid. There are various applications that can be incorporated through the use of technologies, the difference in Aula Gavilán is the didactic use of all those tools, the proposal consists of the incorporation of various elements that are constantly being evaluated and may vary according to the characteristics of the group of students, that is, innovation is in the use of existing resources, the generation of strategies with problems of daily life, not the resources themselves.

Aula Gavilán uses free access resources or those created by the students themselves (such as Celmath). Which do not require internet for use in the classroom. Social groups are manipulated outside the classroom. It has no monetary price, it is to use free resources and applicable to teaching.

Methodology and description

Participatory methodology, since the students themselves were involved in the execution of the project, their suggestions were taken into account to incorporate or eliminate work elements, evaluations and opportunities for improvement were continuously made.

The main axis of the project is the creativity and innovation applied in each of the strategies and works that are integrated during the course, Imbernón (1996) defines educational innovation as "the attitude and the process of inquiry of new ideas, proposals and contributions carried out collectively, for the solution of problematic situations of practice, which will entail a change in the contexts and in the institutional practice of education ".

Etymologically, innovate comes from "innovatio", derived from the Latin "novus" which means new or novelty; the prefix "in" provides it with an internal meaning, from the inside, so it can be considered as "introducing something new" (Font, Díaz Godino & Planas, 2011)

"Creativity is the human ability to produce mental content of any kind, which can essentially be considered as new and unknown to those who produce it" (Serrano, 2004)

In this sense, a classroom was designed in which students, with the help of different tools, achieve learning and improve their performance; In this classroom, some technological resources were used, including a computer, an e-Beam electronic board, a projector, etc.

In the same way the didactic resources and strategies both didactic and rearrangement of the physical space. The application was in Differential Calculus followed by Integral Calculus in this semester, however, the proposal is valid for any subject.

Technology as an Educational Resource

"The pedagogical use of new technologies makes it possible to make learning more effective and enhance the capacities of teachers and students.

The advancement and penetration of technologies lead us to reflect not only on how we better use them to educate, but even to rethink the processes and the contents of education "(Guadamud, Montanero, Velásquez, & Intriago, 2010). E-Beam electronic whiteboard: it is a system capable of converting any whiteboard into a digital whiteboard with all the features and functions of special whiteboard digital screens.

ISSN 2523-6997

Create a group on a social network (Facebook): It was created with the aim of having a space for interaction between the students themselves and the teacher, during hours outside of class, when students have any questions regarding the tasks or assignments commissioned , the teacher can solve them instead of looking for it in the institution facilitates accessibility to the answers. It is a way of sharing videos that will be useful in class to complement it, forms, links to specialized pages on a topic, example or problem that will be or was seen in class; reasoning questions, and documents with content that will be useful in class.

To interest them in the class, one of the strategies used via Facebook is to "launch" questions regarding the topic being studied at that time and "award" points to those who give the correct answer.

Another advantage is the ease of sending "information capsules" of the matter, which are seen almost immediately by most of the members of the group, in addition to the possibility of interacting.

Figure 1 Mathematics group

Open Sankoré: it is a free access software which allows that through the use of a special pen on a tablet, the teacher write the class to be projected and this is saved in pdf format, and then share it through celmath or Web page. The writing can be freehand or with the text editor that the application contains, it handles different colors and thickness of the lines, which allows the main ideas to be highlighted or to emphasize some points.

Location of furniture and equipment

The arrangement of furniture and equipment is constantly monitored to identify the optimal way in which students have: the best visibility, the most adequate way of working and comfort.

It changes depending on the way in which the development of the class requires it: teacher presentation, teamwork, individual work, student exposition, video projection, etc.

Printed Canvases: Printed canvases are recommended as they can be easily stored and exchanged, the canvases contain the formulas used in class and their location is strategic so that everyone can visualize them properly. Some change according to the topic discussed, others are maintained throughout the semester due to their algebraic utility.

Collaboration in the generation of alternative teaching resources

Cell phone application:

Due to the need to support mathematics students to improve their learning and take advantage of the opportunity on the wide availability of a Smartphone (8 out of 10 students). CelMath arises as a didactic proposal that allows the student to perform graphing of functions (in its first version), with the ease of sharing it in real time with their facilitator and analyzing in a group way, thus reinforcing their learning, using a manual graphing method as verification. , in order to create a scenario by creating a need to be solved by the student (problem-based learning).

"Educators and developers (of Applications) can support students by developing more readable content with formats that can be accessible from mobile devices" (Kraut, 2013).

CELMATH is a mobile application in which students can download the daily classes (figure 2); this in order that they are attentive to the class without being distracted by passing notes. Optimizing class time to increase class time making it more effective.

ISSN 2523-6997

Figure 2 Students using CELMATH

Graphing of functions; the user enters the function (observing syntax rules), then with a click on the graph button, the corresponding graph will be displayed on the screen (figure 3).

Figure 3 Celmath App for Android

Blackboard to image: The user enters the name of the class in the text box and clicks on get, the application shows a preview of the class, and stores a copy of the original file directly in the SD of the mobile or on the laptop or pc (figure 4).

Figure 4 Student giving support in capturing images in class

Ongoing evaluation of classroom design and resources

The design of the classroom is constantly evaluated in order to monitor the activities carried out, and in this way verify which strategies or resources are necessary or not in the development of the project.

Videos

Every day videos were projected alluding to the subject: algebraic content, limits, methods of solving derivatives, application of various formulas and topics of daily life with some mathematical application, in order to complement the activities. The videos were projected at any time during the class

Conceptual development of the class

Regarding the content, a point that is important to clarify is the type of applications of mathematics in everyday life situations, with the aim of extending the concepts and knowledge acquired through the investigation of various problems that arise. This can be done individually or in teams so that certain learning tasks can be carried out. The result is a flexible product suitable for each study group, thus transforming the conception that the teacher is the only one who knows and students enter the path of "learning to learn", increasing their negotiation capacity where they are they show the knowledge and skills acquired. Exercises that do not present the same type of difficulties are proposed, with the aim that students integrate intra and extra-mathematical knowledge, to avoid mechanization in solving them.

Results

The development and implementation of the proposal was carried out in the subjects of Differential Calculus (2013) and Integral Calculus (2014) at the engineering level, this can be implemented in any subject of the various careers with some adjustments, for example: in Chemistry it would be convenient have an app that supports the balancing of reactions; change the forms for the periodic table, valency tables, basic formulas, etc., find or create videos that support the learning of chemistry, perhaps a virtual laboratory. The other elements of the proposal are valid for this and other subjects.

ISSN 2523-6997

Students are continuously connected, for them, it is more interesting to be on Facebook or the news than in the classroom, so you have to learn to channel those digital impulses in an effective and current learning environment.

By incorporating technology into classes, students see them as attractive, current and that corresponds to their reality. It is a process of adjusting the way we pay attention and learn. What makes the proposal applicable in any matter.

Math (Facebook)

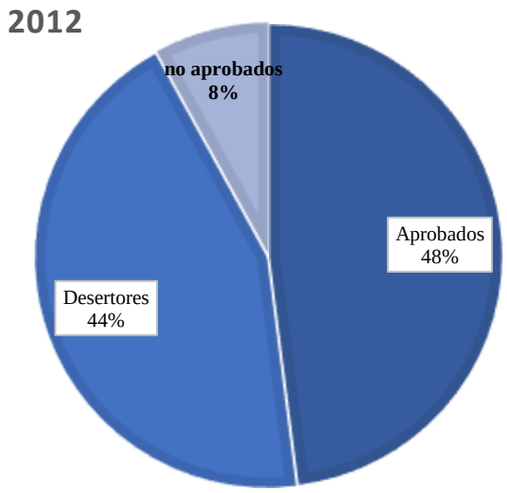
It was constantly evaluated through the visits of the students to the page, since the page itself contains a counter of visits per publication, that is, when "uploading" an image shows how many and which people have seen the publication regardless of the "I like it", in this way the impact of each comment or image was evaluated, obtaining between 70 and 90% acceptance.

The comments made by the participants indicate that the learning process was significantly improved through didactic interaction with technological equipment, transforming a traditional classroom into an active, dynamic and functional classroom.

The strategies that were applied such as the projection of videos helped the students to complement the classes by facilitating the resolution of exercises; the "Matemagicas" group demonstrated a new form of interaction between Teacher-Student that can be amplified beyond the classroom; As for the posters, it helped them to memorize the formulas, theorems and laws applied in the matter, in the location of the furniture, the most appropriate way to take the class was found

The student beneficiaries of this work showed their satisfaction with the furniture and technological resources received as well as a positive response to the different jobs that were asked of them during the semester.

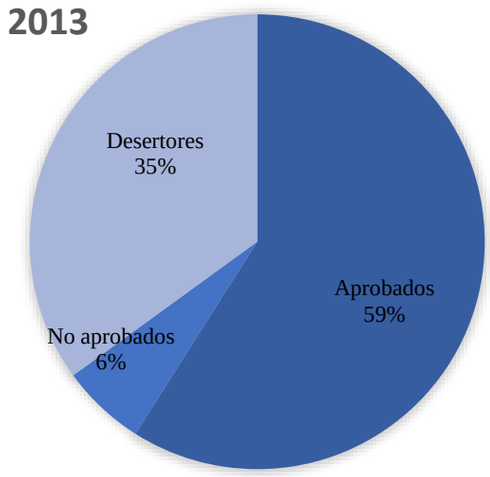
Regarding figures, the data of the Differential Calculus group taught by the same teacher in 2012 were obtained without applying the strategies described in this project (Graph 1).



Graph 1 Percentages 2012 without including technologies

.

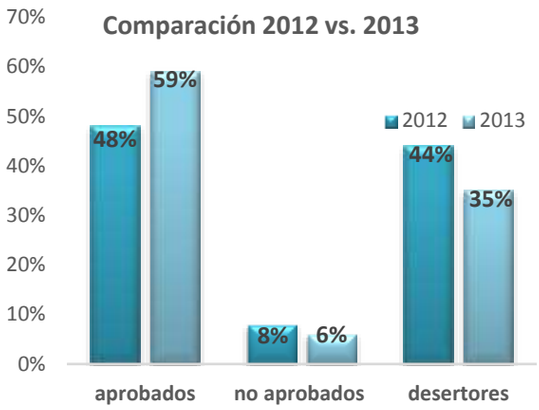
Graph 2 contains the percentages for the year 2013 after the application of the strategies mentioned above.



Graph 2 Percentages of students passed, failed and dropped out 2013

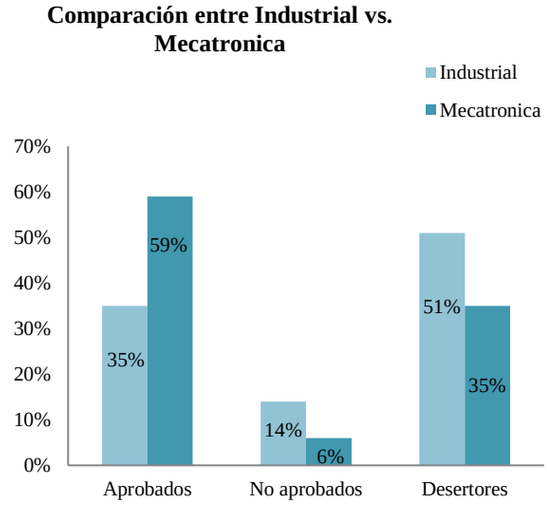
In Graph 3 it can be seen that the percentage of failures is slightly lower during the application of the strategies. The dropout percentage decreased by 9% and the approval rate increased by 11%, which translates into a benefit for students through the application of the classroom project.

ISSN 2523-6997



Graph 3 Comparison between the years 2012-2013

Graph 4 shows the comparison between groups in 2013 in the Mechatronics Engineering group (in which technological tools were included) presented better progress than Industrial Engineering (without technological tools) since there were more failures and more students than they dropped out of the subject during the semester, resulting in students dropping their grades and showing a certain apathy towards class activities.



Graph 4 Comparison between Industrial Engineering (without technology) -Ing Mechatronics (with technology)

Gratitude

To the Program for the Professional Development of Teachers for the Superior type (formerly the Teacher Improvement Program, Promep) for the support granted to carry out this project to strengthen Academic Bodies. Academic body recognized by Promep "Educational innovation and mathematics at the higher level" key ITCdJ-CA-1, from the Technological Institute of Cd. Jiménez.

Conclusions

The application of the participatory methodology with the inclusion of technologies is an effective pair according to the results obtained during the two semesters of the Calculus course. A decrease in the failure rate was obtained in the Mechatronics Engineering students participating in the project in the matter of Differential Calculus compared to the previous year with Mechatronics Engineering students without the application of the project.

In reference only to the year 2013, when comparing the groups of Mechatronics Engineering (with project), it presents a percentage of approved of 59% and that of Industrial Engineering (without project) of 35%, which represents a difference of 24% with the inclusion of strategies. The comparative failure rate is 8% (14% vs 6%) favoring the Mechatronics group. Dropout students show a difference of 16% in both groups (51% Mechatronics vs 35% Industrial). Therefore, it is concluded that the application of the strategies generated a positive impact on the performance of the students. As for the dropout percentage, it decreased by 9%, which has a positive impact on the permanence of students in the institution, since being in the first semester they require passing 4 subjects of the regulatory load, which translates at the same time in a social benefit.

Academic impact

It is important to emphasize the importance of the application of technology not only as a study and innovation tool, but as a way of capturing and maintaining the attention of students when using the means of everyday and common use such as mobile devices (cell phones). and Tablet), leads us to a change in attitude towards mathematics as they are attracted to the use of new technologies. In addition to developing computer skills and competencies, the ability to search and apply resources is privileged.

Technological Impact

Achievement of a harmonious and productive combination between the use of mobile devices and the generation of knowledge in secondary and higher education schools. On the other hand, mobile devices would be conceived as a tool, not just as an accessory or a distraction.

ISSN 2523-6997

Social impact

The quality of knowledge, as well as the motivation and rediscovery of the ways to obtain it, would be higher, and consequently the decrease in failure rates would be evident. Presenting examples and projects of everyday life as a source of knowledge is very important because tolerance is developed, respect for others, their opinions. It is a complex job with application in real world situations, where various strategies of analysis and systematization of information are applied to arrive at the correct solution.

The knowledge becomes usable, to arrive at the "know-how". The evaluation is, then, a continuous process, which allows the relevant aspects to be identified immediately and, where appropriate, to solve them. And the dual of knowledge and power is recognized in the learning of Mathematics (knowledge is knowledge, power is the student's ability to apply that knowledge in various theoretical and practical situations) (Oliveros, 2010). The logical and critical thinking of the student is promoted.

Differentiation

The innovative use that is being given to resources to obtain better results, considered as a utility model

Barriers to its implementation

Because the innovation does not have a price for itself, this is not an aspect that prevents its use.

1. Institutional barriers:
a. Lack of investment to use a projector with a tablet and pen, or
b. Lack of investment for a device (ebeam) that transforms the blackboard into electronic;
c. Not providing a physical space which is set up as a Gavilán Classroom.

2. Teaching barriers:
a. Willingness to adopt technologies inside and outside the classroom.
b. tudent barriers:
c. Lack of mobile device.
d. Previous and future stagesProject scheduling

Research and application of technologies in Differential Calculus was carried out to test the process, later it was continued in Integral Calculus, it is planned to assign it to most of the subjects.

Project needs

The need arises from the difficulty of understanding mathematics in traditional learning environments.

Project control

In case of expanding the installation of this type of technology, the control of the project would be in charge of the academic development department since it has the function of controlling the audiovisual equipment owned by the institution.

References

CC Creative Commons. Atribución-NoComercial-SinDerivadas 2.5 México (CC BY-NC-ND 2.5 MX) Disponible en https://creativecommons.org/licenses/by-nc-nd/2.5/mx/

De Bono Edward (1992) pensamiento creativo. Editorial Paidos Mexicana S.A.

Font, V., Díaz Godino, J. y Planas, N. (2011) Jesús María Goñi (coord.) Matemáticas. Investigación, innovación y buenas prácticas. Número 12 vol3. Editorial Graó. Barcelona, España

García Hoz Víctor, (1991). Ambiente, organización y diseño educativo (1991) (Vol. 8). Ediciones Rialp.

Guadamud, L.; Montanero, E.; Velásquez, A. Barberán; Intriago, Ana Mercedes Castillo (2010) "Mejorar la enseñanza de las asignaturas de química y biología mediante la adecuación e implementación de una aula con mobiliario pedagógico, recursos didácticos y tecnológicos creando un ambiente didáctico que facilite el aprendizaje de los estudiantes de la facultad de filosofía, letras y ciencias de la educación" ; Tesis de investigación; Portoviejo Manabí Ecuador.

Imbernón, F. (1996). En busca del Discurso Educativo. Edit. Magisterio del Río de la Plata, Buenos Aires – Argentina

INEGI.(2005). Estadísticas de Educación. Estadísticas en educación básica, media superior y superior. 2005.

Kraut, R. (2013). Policy guidelines for mobile learning. Francia: United Nations Educational, Scientific and Cultural Organization

Martín López Calva, (1998); Pensamiento crítico y creatividad en el aula; Editorial Trillas
OCDE. Panorama de la Educación 2010. indicadores OCDE. Madrid, España: Santillana.
Oliveros. E. (2010). Matemática viva 10: Guía del docente. Grupo Editorial Norma.

Pizarro, R., Rocha, T. e Ibarra, T. (s.f.). Mercadotecnia: Módulo 6. JICA/Secretaria de Economía. México.

Robledo, S, J. (2014). Mobile Devices for Learning, What you NEED to KNOW. Google Apps for Education

SEP. (2014). Principales cifras del Sistema Educativo Nacional 2013-2014. Dirección General de Planeación y Estadística Educativa: México.

Serrano M.T. (31 enero 2004) Creatividad: definiciones, antecedentes y aportaciones. http:/www.revista.unam.mx/vol5/num1/art4/art4.htm