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Artículos científicos

Uso de las TIC en el aprendizaje de las matemáticas en el nivel superior

Use of ICT in the Learning of Mathematics at the Higher Level

Uso das TIC na aprendizagem da matemática no nível superior

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Resumen

Considerando que el aprendizaje de las matemáticas continúa siendo un problema nodal en México, este trabajo presenta una propuesta para utilizar las tecnologías de la información y comunicación (TIC) en el proceso de enseñanza-aprendizaje de las matemáticas en el nivel superior y así contribuir a la mejora del rendimiento académico de los educandos. La investigación se desarrolló en la Facultad de Ingeniería de la Universidad Autónoma de Guerrero (UAGro). Con un enfoque cuantitativo, de tipo exploratorio, se midió el impacto del uso de las TIC en la resolución de una ecuación diferencial no homogénea por medio del método de coeficientes indeterminados. Para ello, se evaluó tanto a un grupo control como a un grupo experimental y se realizó un cuestionario antes y después de la intervención. La importancia del uso de las herramienta tecnológicas se apreció en los resultados aquí conseguidos en el grupo experimental, donde 14 de 15 estudiantes aprobaron el nivel esperado. En consecuencia, el uso de las TIC favoreció el rendimiento académico de los estudiantes participantes del nivel superior.

Palabras clave: aprendizaje formal, ecuación diferencial, enseñanza profesional, matemáticas, TIC.

Abstract

Considering that the learning of mathematics continues to be a nodal problem in Mexico, this work presents a proposal to use information and communication technologies (ICT) in the teaching-learning process of mathematics at the higher level and thus contribute to the improvement of the academic performance of students. The research was developed at the Faculty of Engineering of the Universidad Autónoma de Guerrero (UAGro). Using a quantitative, exploratory approach, the impact of the use of ICTs in solving a non-homogeneous differential equation was measured. For this, both a control group and an experimental group were evaluated, and a questionnaire was carried out before and after the intervention. The importance of the use of technological tools was appreciated in the results obtained here in the experimental group, where 14 of 15 students passed the expected level. Consequently, the use of ICT favored the academic performance of the participating students of the higher level.

Keywords: formal learning, differential equation, professional teaching, mathematics, ICT.

Resumo

Considerando que a aprendizagem da matemática continua sendo um problema nodal no México, este trabalho apresenta uma proposta para utilizar as tecnologias de informação e comunicação (TIC) no processo de ensino-aprendizagem da matemática de nível superior e, assim, contribuir para melhorar o desempenho acadêmico dos alunos. A pesquisa foi desenvolvida na Faculdade de Engenharia da Universidade Autônoma de Guerrero (UAGro). Por meio de uma abordagem quantitativa e exploratória, o impacto do uso das TICs na solução de uma equação diferencial não homogênea foi medido por meio do método dos coeficientes indeterminados. Para isso, foram avaliados um grupo controle e um grupo experimental e realizado um questionário antes e após a intervenção. A importância da utilização de ferramentas tecnológicas foi apreciada nos resultados aqui obtidos no grupo experimental, onde 14 dos 15 alunos ultrapassaram o nível esperado. Consequentemente, o uso das TIC favoreceu o desempenho acadêmico dos alunos participantes do nível superior.

Palavras-chave: aprendizagem formal, equação diferencial, ensino profissional, matemática, TIC.

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Introduction

It is known that the learning of mathematics continues to be a nodal problem at any educational level in Mexico and other countries. In general, this is due to the little interest or fear that students have in learning mathematics. And particularly, it is due to the fact that teachers in the basic sector do not usually have specialized training in this educational area; While at the higher level, although some teachers have outstanding academic training, such preparation does not usually come accompanied by knowledge of didactics that allow the activities to be developed in the classroom to be adequately planned. For this reason, as part of this research work, a proposal was developed to use information and communication technologies (ICT) in the teaching-learning process of mathematics at the higher level. In sum, this work is oriented towards the analysis of technological tools, such as GeoGebra and Mathway, which help to improve the university student's learning of mathematics.

More precisely, it was based on the assumption that the implementation of didactic strategies that resort to the use of ICT for the learning of mathematics in the educational program of Computer Engineering of the Faculty of Engineering of the Autonomous University of Guerrero (UAGro) contributes to improve the academic performance of students and, therefore, to reduce the failure rate.

It is important to point out that the use of ICT by higher-level students is the spearhead to consolidate an organizational discipline on the activities that they must develop throughout their academic training. In addition, it encourages collaborative work and, through this, to improve the social environment of which they are part. On the other hand, the teacher will also benefit from including ICT in their work as a facilitator of knowledge.

From a professional perspective, throughout their career, the student should take ownership of the competences reflected in the graduation profile of the UAGro Computer Engineering program, so that, once their university stay is over. , is able to compete in the labor market and has a successful performance. From the teacher's point of view, he should strive to be up-to-date in the pedagogical use of ICT in the teaching-learning process of mathematics at the higher level, here of particular interest, or in any other area of knowledge

and level. educational. In other words, be aware of the advancement of technology, so that it affects the process of acquisition of knowledge by the student body and facilitates the understanding of the concepts or operations between the elements or objects of mathematics, in this case.

Regarding the characteristics of this research, it adopts a quantitative approach to measure the impact of ICT on the performance of students in solving mathematical problems. The foregoing through the implementation of a didactic sequence whose pillar is the use of ICT and with the purpose of creating a mentoring program, and in particular, a peer counseling.

In the field of mathematics, there is research that justifies the use of ICT in teaching practice. These efforts describe teaching strategies that have allowed the appropriation of knowledge by students in an easy way. Of course, these antecedents were the basis for the elaboration of an innovative proposal that would strengthen the academic and intellectual formation of the community that makes up the Faculty of Engineering of UAGro.

Background

In the educational program of Computer Engineering of the Faculty of Engineering of the UAGro, a high failure rate has been observed in the first semesters of the professional career, which has led students to abandon their studies on some occasions.

According to Galán et al. (2009), mathematics plays a triple role in engineering: instrumental, formative and theoretical. "In its instrumental role, mathematical knowledge provides basic techniques and strategies for other subjects of study and for professional activity" (p. 3). Regarding the educational role, "they contribute to the improvement of mental structures and the acquisition of skills whose usefulness and scope go beyond the scope of mathematics itself" (p. 3). Finally, regarding the theoretical foundation, "definitions, demonstrations and conceptual and logical linkages, insofar as they give validity to the intuitions and give meaning to the applied techniques, must be introduced in these studies with a certain formal level" (p. 3).

Now, Romo, Lemarie and Vidal (2013, p. 222) carried out a study on the pedagogical conditions of the Internet and of different web 2.0 tools at the secondary level, which includes the chapter on the equation of the line. In the methodological design, two groups were considered, one experimental and the other control. With the experimental group, the

contents of the mathematics unit were addressed using web 2.0 tools. In the control group, we worked with learning guides and traditional media. A post-evaluation was administered in both groups. In the results, it was found that the students who carried out innovative pedagogical activities obtained better results than those of the control group, who worked with learning guides in a traditional way.

Along the same lines, Sánchez (2012, p. 27) establishes that technological resources must have a pedagogical application and be supported by the different theories proposed by mathematics didacts; Sánchez (2012) emphasizes the semiotic dimension of this language. The didactics of mathematics, as a pedagogical science, focuses its study on the resulting processes and phenomena that occur within the classroom and outside of it.

From the socializing perspective of this theory, ICTs allow building bridges by offering communicative and operational tools in order to specify the construction of knowledge. Open educational systems, on the other hand, will depend on the conditions offered by the educational centers and the particular characteristics of the students that promote communicational exchange with other groups trained to learn mathematics.

Avilés, Feliciano, Cuevas and Alonso (2015, p. 10) managed to show the importance of the application of the GeoGebra online mathematical software to determine maximums and minimums of a real variable function. The use of this tool has allowed the student to develop differential calculus skills and confirm the efficiency of the software. These learnings gave the student certainty about the importance of the use of software in teaching, which facilitated the achievement of the competence of the learning unit. Likewise, Feliciano, Cuevas and Catalán (2016, p. 84) corroborated the effectiveness of GeoGebra as an auxiliary teaching tool in calculating the area between two real functions.

Other examples of these technological tools for educational purposes are matrix calculators, for example Matrix calculator and Solve Matrices. Both softwares solve elementary matrix problems and are available at http://www.resolvermatrices.com/ and https://matrixcalc.org/es/, respectively, where the user is offered the opportunity to perform the indicated operations (Nieto , Cuevas and Feliciano, 2016).

On the other hand, Feliciano and Cuevas (2017, p. 53) described the process to create video tutorials with Windows Movie Maker software. As an example, the authors created a video tutorial that can be used by teachers and higher-level students who are interested in learning integral calculus. Thus, they demonstrated to teachers that it is possible to prepare visual didactic material that facilitates the presentation of mathematics content.

The advancement of technology in the development of mobile devices has also been impressive. Gone are those devices that only served to call and send messages. In the educational field, one of the first changes in this evolutionary process was that the mobile phone practically replaced the calculator, due to the ease of finding mathematical software on the Internet and installing it on the cell phone to turn it into a support tool for the teaching-learning of mathematics. Now programs like GeoGebra, MathPapa and Mathway are quite popular to calculate, for example, roots of a polynomial of degree greater than three (Maximino, Cuevas, Guinto and Feliciano, 2017).

Of course, the evolutionary line of these digital tools applied within the school classroom has been accompanied by theoretical and pedagogical references such as behaviorist, cognitive, constructivist theory and the recent sociocultural theory (Fernández, 2017). These theories have shown the transformations that have taken place in education from the incorporation of digital technologies and the use of the computer. However, mathematics has been one of the fields of knowledge that has taken the longest to incorporate these strategies towards the use of ICT as support in learning processes. In learning mathematics, the use of structured and sequential curricula has been the basis for acquiring procedural skills, essential in addressing mathematical concepts (Vega, Niño & Cárdenas, 2015).

In this regard, Triana, Ceballos and Villa (2016) recover, among the testimonies of the participants of their study, the importance of developing reflection and discussion skills around mathematical issues and going beyond the rote and mechanical. This establishes an essential starting point for the development of interactive resources to support the teaching and learning of mathematics. A particular case that shows the importance of the use of technological tools in mathematics education processes is found in Ramírez (2015, cited in Grisales, 2018), who, through Mathematica 10 software, developed a series of tools that facilitate the learning of certain pre-calculus topics with college students.

And returning to pedagogical references, David Ausubel, an educational psychologist from the 60s, left an important legacy through his theoretical elaborations on the way in which intellectual activity is carried out in the school environment. His work and that of some of his followers have marked the deficiencies of educational psychology, especially of the cognitive movement. Ausubel's position is characterized as constructivist and interactionist; For him, study materials and external information are interrelated and interact with the prior knowledge schemes and the personal characteristics of the learner (Díaz, 1989, cited in Díaz and Hernández, 2015). Likewise, he conceives the student as an active processor of

information, and affirms that learning is systematic and organized, since it is a complex phenomenon. Despite the importance of discovery learning, it is considered that it is not feasible that all meaningful learning that occurs in the classroom should be through this option. However, it encourages meaningful verbal learning, which allows the mastery of curricular content taught in schools, especially at the intermediate and higher level.

Finally, Díaz and Hernández (2015) mention that learning implies an active restructuring of the perceptions, ideas, concepts and schemes that the learner possesses in their cognitive structure.

Methodology

Following Hernández and Mendoza (2018, p. 106), this research is located in the exploratory field, because there are no written documents on the design of didactic strategies using ICT in the process of learning to solve a differential equation inhomogeneous by the method of indeterminate coefficients at the top level. However, it is important to note the existence of some isolated materials: books, mathematical software and videos. Due to the aforementioned, some tools were analyzed to group them according to their functionality and use them in a combined way in the teaching of mathematics at the higher level.

To obtain information, two groups were considered: one experimental and one control. For the first, a didactic sequence was designed using ICT. While in the control group, it was worked in a traditional way, without using complementary didactic strategies. For both groups, two questionnaires were designed: one for before the intervention and the other for afterwards. It should be noted that these questionnaires were identical for both groups but different for each moment and that they were endorsed by six experts, two of them with a teaching profile, three with an engineering profile and one with a mathematics area profile (Campbell and Stanley , 1970, p. 11).

The hypothesis raised in the research work was based on the supposed assessment of the impact of the use of ICT didactic strategies under a constructivist approach in the learning of mathematics. It is an effort to improve the academic performance of the student of the Computer Engineering program at UAGro.

Results

Two questionnaires were applied, in two stages, to the control and experimental groups: 15 closed multiple-choice questions based on the resolution of a non-homogeneous differential equation by means of the indeterminate coefficients method. The first as a pre-test and the second as a post-test, with the same type of questions, but without being the same. The control group was made up of 15 students from the 2017 generation of the Computer Engineering degree program (5th semester, morning shift). While the experimental group was made up of 15 new students of the master's degree in Engineering for Innovation and Technological Development.

Pretest test results

Table 1 shows the results obtained from the pretest applied to the control and experimental groups.

Tabla 1. Resultados de la prueba pretest

Grupo de control		Grupo experimental	
Estudiantes	Número de reactivos correctos	Estudiantes	Número de reactivos correctos
E_2	1	E_1, E_2	1
E_{10}	2	E_4, E_5, E_6, E_{10}	2
E_6, E_7, E_9, E_{12}, E_{14}	3	E_7, E_9, E_{11}	3
E_3, E_4, E_5, E_8	4	E_3, E_{12}, E_{13}, E_{14}, E_{15}	4
E_1, E_{11}	5	E_8	5

Fuente: Elaboración propia

It is observed that a similar performance was obtained in both groups, which is not so relevant, since these results correspond to the application of the instrument to collect information before starting the activities of the topic, which refers to the resolution of a differential equation inhomogeneous by the method of indeterminate coefficients.

Post-test results

Table 2 shows the results obtained from the application of the post-test to the two groups participating in the research. It should be remembered that both the control and the experimental had a total of 15 members.

Tabla 2. Resultados de la prueba postest

Grupo de control		Grupo experimental	
Estudiantes	Número de reactivos correctos	Estudiantes	Número de reactivos correctos
E_5	6	-	-
E_6, E_{10}, E_{12}	7	E_{10}	7
E_1, E_2, E_4	8	E_2, E_3, E_5, E_9	8
E_7, E_{11}, E_{14}	9	E_6, E_7	9
E_9 E_{13}	10	E_8	10
E_3 E_{15},	11	E_{11} E_{12} E_{14}, E_{15}	11
E_8	12	E_4	12
-	-	E_1, E_{13},	13

Fuente: Elaboración propia (Feliciano, 2020)

It is also important to note that a minimum of eight correct answers were considered, so it can be stated that 11 members of the first group achieved the expected competence, while 14 individuals from the second reached the desired competence.

Results comparison

In the first place, it was observed that 11 students from the control group achieved the proposed goal, which represents 73% of achievement, while 14 members of the experimental group achieved the objective, which represents 93%. This means that the use of ICT tools had a positive impact on the resolution of a non-homogeneous differential equation through the method of indeterminate coefficients. Therefore, it can be said that the use of ICT favored the learning of mathematics at the higher level and in a particular way in the Computer Engineering program at UAGro, which, above all, allows us to suggest the use of the technological tool as a didactic support in the learning of mathematics for the higher level.

Discussion

Educational technology, according to Cabero (2007) and Belloch (2012), went from being a static tool to a living, dynamic one. In effect, it is now a didactic support for teaching that favors the development of skills in the student to apply them in their environment. Cabero (2007) also points out that educational technology is one of the disciplines that has evolved the most and that, it is worth defining it, studies the processes of teaching and transmission of culture mediated technologically in different educational contexts.

In addition to the above, it is necessary to bring to the table the internal and external changes of ICT in its conceptualization and application: they are no longer conceived as transmitting tools of information, but as instruments of thought and culture. From this perspective, it is justified that ICTs are didactic, educational and intellectual tools. Historically, three evolutionary moments were registered: 1) the insertion of the media, 2) the conception of educational technology by the application of behavioral psychology and 3) the support of systems theory and the systemic approach applied to education (Cabero , 2003, 2007).

Now, Belloch (2011, 2012) affirms that educational technology is located in the field of didactics and its development has been based on the scientific advances produced in the fields of computing and telecommunications. The changes produced by the use of ICT in the educational field have achieved that attention is not focused so much on the teacher and teaching and more on the student and the learning process and on building alternatives with the postulates of the socio-constructive study and the principles of meaningful education (Belloch, 2011, 2012).

Regarding the main authors approached in this work, who coincide in working on content of differential equations incorporating ICT, affirm the importance of using software to develop this activity, applying didactic strategies and interacting with students. As can be seen, the proposal presented to develop didactic strategies using a technological tool to address the content of the resolution of a non-homogeneous differential equation by means of the method of indeterminate coefficients is just one more way to incorporate ICT in the teaching-learning process. learning mathematics.

The importance of the use of the technological tool can be seen in the results obtained from the experimental group, where 14 of 15 students reached the expected level. It should be noted that eight correct answers were considered acceptable as a minimum. This means

that the use of technology favored the resolution of a non-homogeneous differential equation through the method of indeterminate coefficients.

Therefore, it is inferred that the use of ICT had a favorable impact on the learning of mathematics at the higher level and in a particular way in the Computer Engineering program at UAGro. Thus, it is recommended to use the technology tool in learning mathematics at UAGro.

Conclusions

Once the path to this point has been traveled, it is possible to answer the questions posed at the beginning of this research work.

If the methodology used in the didactic strategy facilitates the learning of mathematics, the student will be motivated by the incorporation of ICT in their academic training. In addition, since the student is motivated with the use of the technology tool in his mathematical training, he can build meaningful learning.

Learning is significant for the student if it has been acquired from previous knowledge. Indeed, if this has been acquired from the precursor knowledge, it has generated a relational knowledge about the conceptual structure of the student.

The use of the technological tool allowed the student to focus on the approach rather than on routine work and to solve a non-homogeneous differential equation with some ease by means of the method of indeterminate coefficients. But above all, the didactic strategy implemented in the proposal favored the use of the technological tool in problem solving. Indeed, the assessment of the didactic strategy by the students has been good, that is, there is a high degree of satisfaction on the part of the schoolchildren regarding the use of ICT.

Future Research Lines

Despite being a great advance, the information obtained in this research is considered insufficient, so it is pertinent to carry out new explorations to respond to the concerns of the students of the Faculty of Engineering of the UAGro. In the first place, the incorporation of ICT should be promoted to address the contents of the Differential Equations subject, as well as in the other learning units in the area of mathematics in university careers. Secondly, under this orientation, a forthcoming work on solids of revolution corresponding to the Integral Calculus subject is in mind, included in the study plans of the four careers offered in the

Faculty of Engineering, using computational tools according to the times; In particular, it is intended to use GeoGebra, which is being of great help at different educational levels, from a methodological approach and a multimodal format.

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