

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

<http://dx.doi.org/10.35381/e.k.v3i6.827>

## **GeoGebra como estrategia de enseñanza de la Matemática**

### **GeoGebra as a Mathematics teaching strategy**

Jenny Fernanda Alvarez-Matute

[jfalvarezm@ucacue.edu.ec](mailto:jfalvarezm@ucacue.edu.ec)

Universidad Católica de Cuenca, Azogues  
Ecuador

<https://orcid.org/0000-0003-1990-9719>

Darwin Gabriel Garcia-Herrera

[dggarciah@ucacue.edu.ec](mailto:dggarciah@ucacue.edu.ec)

Universidad Católica de Cuenca, Azogues  
Ecuador

<https://orcid.org/0000-0001-6813-8100>

Cristián Andrés Erazo-Álvarez

[cristianerazo@ucacue.edu.ec](mailto:cristianerazo@ucacue.edu.ec)

Universidad Católica de Cuenca, Cuenca  
Ecuador

<https://orcid.org/0000-0001-8746-4788>

Juan Carlos Erazo-Álvarez

[jcerazo@ucacue.edu.ec](mailto:jcerazo@ucacue.edu.ec)

Universidad Católica de Cuenca, Cuenca  
Ecuador

<https://orcid.org/0000-0001-6480-2270>

Recepción: 09 abril 2020  
Revisado: 15 de mayo 2020  
Aprobación: 15 junio 2020  
Publicación: 1 de julio 2020

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

## RESUMEN

El objetivo estuvo centrado en describir el uso de la herramienta GeoGebra como alternativa en el proceso de enseñanza-aprendizaje de la Matemática, a fin de proponer una guía para la formulación de un plan de estrategia didáctica dirigido a los docentes del área de matemática de la ciudad de Azogues. Se fundamentó desde el enfoque positivista y se desarrolló con base en la metodología cuantitativa. La población estuvo conformada por 84 docentes del área de matemática. Los resultados de la tabla 2 revelan que el 71,8% de los docentes encuestados ocasionalmente, casi nunca y/o nunca utilizan algún tipo de software educativo para impartir su cátedra de Matemática. La población estuvo conformada por 84 docentes del área de matemática. El modelo ADDIE propuesto para la implementación del uso de GeoGebra en el aula permite al docente identificar los aspectos positivos y negativos en cada fase del ciclo metodológico, para mejorar y renovar sus actividades didácticas y así obtener una mejor participación estudiantil.

**Descriptor:** Informática educativa; programa informático didáctico; tecnología educacional; álgebra. (Palabras tomadas del Tesoro UNESCO).

## ABSTRACT

The objective was focused on describing the use of the GeoGebra tool as an alternative in the teaching-learning process of Mathematics, in order to propose a guide for a didactic strategy plan formulation aimed at mathematics teachers of Azogue city. It was based on the positivist approach and was developed under a quantitative methodology. The population was made up of 84 teachers in the area of mathematics. The results of Table 2 reveal that 71.8% of the teachers surveyed occasionally, almost never and / or never use some type of educational software to teach their mathematics chair. The ADDIE model proposed for the implementation of GeoGebra in the classroom allows the teacher to identify the positive and negative aspects in each phase of the methodological cycle to improve and renew their didactic activities and thus obtain better student participation.

**Descriptors:** Computer uses in education; educational software; educational technology; algebra. (Words taken from the UNESCO Thesaurus).

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

## INTRODUCTION

Since ancient times, mathematics has been considered as a basic learning for the development of thought within all formal education systems. That is why the (Ministry of Education of Ecuador [MINEDUC], 2016) proposes that the mathematics teaching in the curricular framework must be focused on: being able to reason, think, relate, apply knowledge and mathematical premises to real situations of everyday life. However, such purposes lead to considering the learning of mathematics as a process that is often difficult, given the complexity, accuracy and the abstract nature of many contents for students in a pedagogical-didactic context that may be deficient with respect to strategic performance of the teacher.

In this sense, (Orrantia, 2006) points out that the problems generated around the teaching and learning of Mathematics is a perennial concern of professionals dedicated to teaching, since the students' failure rates are high in this discipline at all educational levels. Such is the case of the difficulties of understanding and graphing mathematical concepts and problems both for the teachers, who often do not have the appropriate strategies and tools, and for the students who find it difficult due to possible comprehension problems and even tedious because they do not feel motivated towards this type of learning.

Considering this context, the problems and difficulties that have arisen in Ecuador and that have concerned the learning of mathematics have been quite significant. It was evident in the results of the educational evaluation carried out by the National Institute of Educational Evaluation (INEVAL, 2018) for the period 2017-2018. In this respect, the national test '*Being Student*' reflected that 53.3% of students of 4th, 7th and 10th grade in Basic General Education (BGE) showed a level of insufficiency in the field of Mathematics. Likewise, the results of the '*Being a High School Graduate*' revealed that

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

this field of Mathematics had the highest level of insufficient, which represented 27.5% of the sample in the 3rd year of the Unified General Baccalaureate (UGB).

These levels are indicators taken from the reality of learning and the knowledge acquired in mathematics within the educational process, which imply that knowledge is not assimilated in an appropriate way, triggering desistance and demotivation in them. For this reason, the Educational System must focus on the development of concrete actions that contribute to the improvement of the teaching-learning of Mathematics.

It also means that the teacher must face this situation, which is very worrying, with the search and application of pertinent methods and strategies so that the didactic process of Mathematics may be more dynamic and interesting to make the students become active subjects in managing their own learning process. This approach is validated by (Rodríguez-Uribe, 2017) when he affirms that the teaching of Mathematics has become a challenge for most educators, who should try to incorporate new ways of teaching through the use of innovative strategies and resources, leaving aside the traditional ones and incorporating new ways of teaching.

So, as a possibility to improve the didactic process in the area of Mathematics, educational systems have begun to formally incorporate strategies that promote innovation and integration of technological resources. Based on this, technology is currently immersed in all aspects of people's daily lives with the purpose of providing benefits to society through innovation.

In consequence, teachers increasingly need to use Information and Communication Technologies (ICT) to develop the teaching-learning process through tools such as educational platforms and applications that help students and teachers develop abilities and skills in a better way, contributing significantly to educational quality (Arévalo-Duarte & Gamboa-Suárez, 2015).

It should be added that the proper management of ICT in the classroom helps the active participation of students, since they are immersed in a world where most of the activities

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

are dominated by the use of various electronic devices and programs. In view of this, it is important that the teacher has the necessary resources and timely preparation in terms of managing strategies and technology for ICT-mediated learning (Erazo-Álvarez & Narváez-Zurita, 2020).

With regard to educational platforms and applications, it is important to know that this is intended to capture the students' attention in order to achieve substantial changes in their learning. In relation to this, as (Saltos-Cedeño, et al., 2020) expressed the use of ICT in the classroom and specifically, in the area of mathematics promotes significant and non-mechanistic learning, since new knowledge is related to existing knowledge and also helps the student to develop logical and mathematical reasoning.

Likewise, these educational platforms and applications are computer software-type tools that serve as a support for the acquisition of knowledge to help the students become more active and participatory and; in this way, decentralize the teacher as the axis of the process (Fernández, et al., 2017). That is why in order to improve the level of knowledge of students in different areas and, especially, in mathematics, these types of innovative educational resources must be incorporated to achieve significant changes in the way of teaching and learning. Thus, both teachers and students are not limited to the use of conventional materials, but they opt for the use of programs or applications focused on interaction, cooperative work and self-management of learning. (Rodríguez, Erazo, & Narváez, 2019).

At present, there are a number of educational platforms and applications that allow carrying out a more effective educational work in Mathematics, so that the students do not worry about constant repeating exercises in an abstract and mechanical way; on the contrary, by mediating the process with these tools, the learning work focuses on analyzing and understanding in detail how mathematical processes develop.

In relation to this, one of the most complete educational applications is undoubtedly GeoGebra. In this regard, (Pari-Condori, 2019) affirms that GeoGebra is the software of

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

great help for the online or offline teaching of Mathematics that supports multiple platforms and includes geometry, algebra, arithmetic, analysis, statistics and probabilities in one program. It means that it is a complete application that involves all branches of mathematics and has an interactive, simple and friendly interface that allows a better understanding of mathematical concepts to enrich knowledge and obtain meaningful learning.

The use of the GeoGebra platform in mathematics classes represents a significant change, as it favors students' understanding more efficiently through graphics, demonstrations and mathematical simulations. Therefore, it is necessary for basic level to help students learn the contents and develop their mathematical logical thinking from the beginning of their learning process; due to this benefit, this platform has also generated a great demand, especially, at the higher level.

Based on this, there are many authors, both from the Latin American field and from Ecuador itself, who have considered GeoGebra as a tool that favors the acquisition of knowledge and promotes students' improvements in academic performance and motivation within the different branches of Mathematics study. In this respect, (Salas-Rueda, 2018) with his study developed in Mexico about the impact that the GeoGebra platform has on the cloud, expresses that it is an indispensable tool for the teaching-learning of mathematics; since it is an easy-to-use program that allows the graphing of all kinds of functions and notably improves the academic performance of students by strengthening their knowledge of geometry, algebra, calculus and statistics.

Likewise, (Vargas-Vargas & Gamboa-Araya, 2013) referred that they carried out a study in Costa Rica with high school students based on the application of learning activities focused on the Pythagorean Theorem with the GeoGebra program. This study allowed evidencing that the learners improved their knowledge, self-confidence and motivation towards learning through such activities. In the same way, when inquiring about the perception of teachers in relation to the advantages of GeoGebra for learning

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

Mathematics from the context of the Colombian school, (Tamayo-Martínez, 2013) stated that this is a tool that allows dynamic interaction between the student and math. Furthermore, it is a useful instrument to investigate previous knowledge and consolidate the construction of new knowledge by facilitating students to explore the contents with greater precision.

On the other hand, (Barahona-Avecilla, et al., 2015) studied the influence of the GeoGebra program on the learning of exact sciences carried out at the Polytechnic School of Chimborazo. In this research, they exposed that the correct use of GeoGebra program is beneficial for achieving a better level of knowledge, as well as a favorable academic performance. In the same way, (Guerrero-Garcés, et al., 2018) showed that when teachers used the GeoGebra tool as a didactic resource for reasoning, understanding and solving problems of inequalities, this had a satisfactory effect on the improvement of academic performance of university students.

To complement all the aforementioned, GeoGebra platform allows students to enrich their knowledge, in the sense that they may understand mathematical concepts through demonstrations and graphic simulations, on the computer or cell phone screen (Cordero-Naspud, et al., 2020). It provides multiple benefits, since it is accessible online and may be used anywhere on different devices such as computers, smartphones and tablets (Carrillo de Albornoz-Torres, 2019).

Everything that has been raised shows that the GeoGebra technological platform is an educational tool that is presented as a favorable didactic proposal for the teaching-learning process of Mathematics, since the teacher significantly changes the way of teaching and the student becomes a subject that leads their self-training for a better understanding of mathematical processes. Besides, this tool provides significant advantages in terms of the transformation of the teaching process, the construction of knowledge, academic performance and the motivation of students towards Mathematics. Finally, the foregoing motivated the development of this research, whose objective was

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

centered on describing the use of the GeoGebra as an alternative tool in the teaching-learning process of Mathematics, in order to propose a guide for the formulation of a plan of didactic strategy aimed at teachers in the area of mathematics in the city of Azogues.

## **METHOD**

The study was based on the positivist approach and the quantitative methodology. In view of this, the design was defined as non -experimental, transectional and as field research, since the study variables were observed as they occur in their real context, at a single moment and without deliberative manipulation of them (Palella and Martins, 2015). Likewise, the research was developed at a projective level.

The sample was made up of 71 teachers chosen through the use of the stratified random sampling technique, with a 95% confidence level and a 4.75% margin of error. The survey was the technique used to know and describe the use of technological resources and GeoGebra in the classroom. For this, a Likert scale questionnaire was used, obtaining a reliability of 0.890.

To finish the research, the analysis of the information was based on descriptive statistics, Pearson's Chi-square test and the IBM SPSS Statistics 22.0 software for the structuring of the results (Palella and Martins, 2015).

## **RESULTS**

### **1. Frequency in the use of conventional material (books, printed material, photocopies, blackboard) in mathematics class.**

In relation to this aspect, 92.9% of the teachers in the Mathematics area, always or almost always use conventional material such as books, printed material, photocopies, blackboard. In this sense, despite being in the XXI century, many teachers in the area of



Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

Mathematics remain linked to traditional teaching and tied to texts, notebooks and pencils to teach the contents of this subject. Besides, apparently, they do not make use of teaching alternatives focused on ICT, which are currently present in the students' daily lives.

## **2. Frequency of teachers using educational software**

In this case, 71.8% of the teachers occasionally, almost never and / or never use educational software to teach their mathematics chair. This means that despite the existence of a number of online and offline computer applications or programs aimed at the area of Mathematics, the frequency with which teachers use them is significantly low. Maybe, it is due to ignorance, lack of training, insufficient resources, among others.

## **3. Frequency of teachers using GeoGebra**

In relation to this aspect, 74.6% of the teachers occasionally, almost never and / or never use the GeoGebra computer program to impart their mathematical knowledge. Hence, it would be very important for teachers to know the benefits that GeoGebra offers so that Mathematics classes do not become abstract and boring, such is the case when an exercise is explained on the blackboard and the student solves the other ones mechanically. To improve this, the use of GeoGebra in the classroom allows a better understanding of the contents, making it more and more interesting.

For an in-depth description of the use of GeoGebra in the Mathematics teaching-learning, Pearson's Chi-square test has been carried out, contrasting the following hypotheses:

-H1 (Alternative hypothesis): The use of educational software is significantly related to the use of GeoGebra hypothesis.

-H0 (Null hypothesis): The use of educational software is not significantly related to the use of GeoGebra.

**4. Cross tabulation:** Frequency with which teachers use educational software - Frequency with which teachers use GeoGebra.

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

According to the results obtained in the Chi-square tests, it shows that the value of asymptotic significance (2 faces) is  $0.00 < 0.05$ ; giving rise to the alternative hypothesis (H1) and discarding the null hypothesis (H0). In consequence, the use of educational software is significantly related to the use of GeoGebra.

Regarding the perception of teachers about the type of mathematical thinking that students develop through GeoGebra, diverse opinions have been obtained. However, the following views, significantly, stands out: 49.3% of them express that GeoGebra develops a type of numerical thinking and 28.2% of the teachers are not aware of the existence of the software.

It is relevant to highlight that according to the results obtained in the study, there is no significant use of GeoGebra, despite the fact that it provides multiple advantages for the development of the teaching-learning process. One of such advantages is the students' motivation towards learning and the construction of mathematical knowledge in an innovative way. This is corroborated by (Zulnaidi & Zamri, 2017) who state that students that use GeoGebra obtain greater conceptual and procedural knowledge in Mathematics than those who do it in a conventional and / or traditional way. Finally, a methodological guide is proposed below for the formulation of a didactic strategy plan to use the GeoGebra tool as an alternative in the teaching-learning process of Mathematics.

## **PROPOSAL**

This proposal arises from the results obtained in the research in order to offer the Mathematics teachers a methodological guide for the formulation of a plan that involves the alternative use of GeoGebra as a didactic strategy in the teaching- learning process of such subject. Consequently, the ADDIE model is incorporated as a structure that methodologically guides the development of the didactic strategy plan. It comprises the development of five (5) phases described as follows: analysis, design, development, implementation and evaluation.

ADDIE Model. Source: Own elaboration (2020)

**Analysis:** In this phase, the teachers must take into account the group of students with whom they will work to address mathematical knowledge. This analysis should be oriented from aspects such as:

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

- The prior knowledge that students have and should have about mathematics and computer science.
- People with special educational needs.
- The environment where the teachers will teach may be a computer lab or a room with the students' own devices.
- The mathematical contents with which they are going to work.

**Design:** In the design phase, the teacher must formulate the learning objectives and content, in addition to organize the different resources and materials that will be used in each of the activities. In this sense, the learning content must be included in different ways, such as: text, audio and video compatible with the GeoGebra software, which will be the main tool to carry out the process.

**Development:** In this phase, the contents, resources and materials necessary to develop the subject are linked with the GeoGebra tool. The teachers are clear about the orientation that they intend to provide with the use of the application, which may be: analysis, representation, interpretation, simulation, animation, among others of the established theme.

**Implementation:** This phase implies the deployment of the training process itself; that is to say, it involves the development of the mathematical contents linked to the GeoGebra tool. To do this, prior training of the teacher in the use of GeoGebra has been considered in order to offer a more practical accompaniment to students throughout the process.

**Evaluation:** Finally, in this evaluation phase, the teachers determine whether the plan has been accomplished. For this, the two types of evaluation must be considered: the formative one that is carried out during the learning process and the summative one at the end of it. The evaluation is displayed with the resources that the GeoGebra software contains for the classroom, since the application offers a number of online models that arise from the collaboration of many users and also, possibly, from the teacher's creation to generate their own. As a consequence, the results of the evaluation must be used to know the aspects to improve in relation to the previous phases of the model.

## CONCLUSIONS

The results of the research show that there is a considerable number of teachers in the area of Mathematics who use conventional and / or traditional ways to teach and are not familiar with the use of educational software or programs such as GeoGebra to impart their knowledge; therefore, it is very important to promote the use of these resources to innovate in the classroom.

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

GeoGebra is an educational tool that is based on the symbolic and graphic representation of the different mathematical contents for a more active and meaningful learning; that is, with this tool, students may understand the concepts and procedures clearly and timely by allowing them to carry out demonstrations, simulations and representations, as a complement to each moment of learning Mathematics.

The ADDIE model proposed for the implementation of the use of GeoGebra in the classroom allows the teacher to identify the positive and negative aspects in each phase of the methodological cycle, to improve and renew their didactic activities and thus obtain better student participation. Specifically, GeoGebra educational software as an educational technological tool, offers many advantages in regard to the didactics of Mathematics. Therefore, the teachers may change the way they teach their subject in order to make their students more active and participatory.

## REFERENCES

- Arévalo-Duarte, M. A., & Gamboa-Suárez, A. A. (2015). ICT in the mathematics curriculum. An orientation from the framework of educational policies and projects. *Inter-American Journal of Research, Education and Pedagogy*, 8(1), 169-187.
- Barahona-Avecilla, F., Barrera-Cárdenas, O., Vaca-Barahona, B., & Hidalgo-Ponce, B. (2015). GeoGebra for the teaching of mathematics and its impact on student academic performance. *Technological Journal-ESPOL*, 28(5), 121-132.
- Carrillo de Albornoz-Torres, A. (2019). Materials and resources to take advantage of what the GeoGebra community offers. *Memories of the I Ecuadorian Conference of GeoGebra*, 1, 51-60. Available from <https://n9.cl/m6yur>
- Cordero-Naspud, E. I., Erazo-Álvarez, J. C., Narváez-Zurita, C. I., & Cordero-Guzmán, D. M. (2020). Corporate business intelligence solutions in small and medium enterprises. *Koinonía Interdisciplinary peer-reviewed Journal*. 10(5); 483-513. <http://dx.doi.org/10.35381/r.k.v5i10.703>

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

Erazo-Álvarez, J. C., & Narváez-Zurita, C. I. (2020). Measurement and management of intellectual capital in the leather industry - footwear in Ecuador. *Koinonía Interdisciplinary peer-reviewed Journal*. 9(5); 437-467. <http://dx.doi.org/10.35381/r.k.v5i9.662>

Fernández, I., Riveros, V., & Montiel, G. (2017). Educational software and mathematical functions. An appropriation strategy. *Omnia*, 23(1), 9-19.

Guerrero-Garcés, L., Villa-Escudero, I., Martínez-Muñoz, O., & Hernández-Allauca, A. (2018). The use of GeoGebra software in solving inequality systems. *Atlante Journal: Education and Development Notebooks*. Available from: <https://n9.cl/xzud>

Ministry of Education of Ecuador. (2016). *Curriculum of compulsory education levels*. Available from <https://n9.cl/mnlj>

National Institute of Educational Evaluation (2018). Education in Ecuador: achievements and new challenges. Educational result 2017/2018. Available from <https://n9.cl/5yjg>

Orrantia, J. (2006). Difficulties in learning mathematics: an evolutionary perspective. *Psychopedagogy Journal*, 23(71), 158-180.

Palella, S. & Martins F. (2015). Methodology of quantitative research. Venezuela. FEDEUPEL

Pari-Condori, A. (2019). GeoGebra's impact on the professional development of mathematics teachers. *Memories of the I Ecuadorian Conference of GeoGebra*, 1, 23-36. Available from <https://n9.cl/5bbt>

Rodríguez, D., Erazo, J., & Narváez, C. (2019). Quantitative techniques of marketing research applied to meat consumption in Cuenca City millennial generation. *Journal: Spaces*, 40(32); 20.

Rodríguez-Uribe, L. A. (2017). GeoGebra as an educational resource for Teaching mathematics in higher education. Militar University of New Granada. Available from <https://n9.cl/zn71>

Jenny Fernanda Alvarez-Matute; Darwin Gabriel Garcia-Herrera; Cristián Andrés Erazo-Álvarez; Juan Carlos Erazo-Álvarez

Salas-Rueda, R. A. (2018). Use of the GeoGebra cloud service during the teaching-learning process on mathematics. *RIDE Ibero-American Journal for Research and Educational Development*, 8(16), 23-52.

Saltos-Cedeño, A., Vallejo-Valdivieso, P., & Moya-Martínez, M. (2020). Innovation in higher basic mathematics education during confinement by COVID-19. *EPISTEME KOINONIA*, 3(5), 142-161. <http://dx.doi.org/10.35381/e.k.v3i5.723>

Tamayo-Martínez, E. D. (2013). Didactic implications of GeoGebra on the significant learning of the types of functions in secondary school students. *Opening*, 5(2), 58-69.

Vargas-Vargas, G., & Gamboa-Araya, R. (2013). The teaching of the Pythagorean theorem: classroom experience with the use of geogebra according to Van Hiele model. *Uniciencia*, 27(1), 95-118.

Zulnaidi, H., & Zamri, S. (2017). The effectiveness of the GeoGebra software: The intermediary role of procedural knowledge on students' conceptual knowledge and their achievement in Mathematics. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(6), 2155-2180.