PriMera Scientific Engineering
Volume 2 Issue 2 February 2023
DOI: 10.56831/PSEN-02-031
ISSN: 2834-2550

PriMera Scientific Publications

Digital and 21st Century Competences: Challenges and Difficulties in The Teaching and Learning of Mathematics by Ecuadorian Teachers

Type: Review Article
Received: December 27, 2022
Published: January 07, 2023

Citation:
Abdón Pari Condori., et al. "Digital and 21st Century Competences: Challenges and Difficulties in The Teaching and Learning of Mathematics by Ecuadorian Teachers". PriMera Scientific Engineering 2.2 (2023): 13-24.

Roxana Auccahuallpa Fernandez[1] and Abdón Pari Condori[2]*

[1]*Education Department, Universidad Nacional de Educación, Ecuador*

[2]*Education Postgraduate, Universidad Adventista de Bolivia, Bolivia*

***Corresponding Author:** Abdon Pari Condori, Universidad Adventista de Bolivia, Av. Pairumani 1.5 Km., Vinto, Cochabamba, Bolivia.

Abstract

The objective of the study is to identify the challenges and difficulties faced by Ecuadorian Teachers in the implementation of GeoGebra as a didactic resource for the teaching and learning of mathematics. The research is framed in a mixed exploratory sequence approach with a population of 832 teachers who were trained by the Ecuadorian Institute of GeoGebra (IEG) at the National University of Education in the period 2017-2020. The sampling was non-random conformed by N=144 teachers, who answered the online questionnaire. The instruments were the 32-item questionnaire grouped into three parts: (1) sociodemographic aspect, (2) difficulties in implementing GeoGebra in the classroom, (3) challenges of implementing GeoGebra rated on a Likert scale, and (4) open-ended questions about the advantages and disadvantages of using GeoGebra in the teaching and learning of mathematics. Quantitative and qualitative data were analyzed with SPSS and ATLAS.ti. The results show that the difficulties that teachers have faced in the implementation of GeoGebra in the classroom is the digital gap existing in the 21st century through lack of access to technological equipment (87.5%), followed by the lack of training in the use of GeoGebra (79.1%). The advantages of using GeoGebra respond to the potential of using GeoGebra in the teaching and learning of mathematics, which are linked to the dynamic, innovative, interactive and user-friendly tool.

Keywords: GeoGebra; Teaching Mathematics; Learning Mathematics; Teachers' training

Introduction

Please mention reason for the study, identify and discuss findings of others. Consistently use two spaces after the period in a sentence. Currently has brought many setbacks in all aspects of life, including education (Agabo, 2015). Education worldwide has been affected by enormous changes as a consequence of the new Coronavirus called SARS-Cov2, the disease called COVID-19. According to UNESCO, by 2020 education has changed from a face-to-face to a virtual teaching and learning scenario, so more than 1.7 billion students worldwide, representing 89.4%, have been forced to interrupt their face-to-face education (Hurtado, 2020).

In this perspective, all educational systems have been literally shaken and teachers have been exposed to new educational scenarios with new challenges and unprecedented difficulties. This is the new reality of learning, in which the teacher must take into account that it is impossible to transfer the face-to-face structure of their way of teaching to an online or virtual system. In this context, educators have to assume modified and special roles (Weinhandl, et al, 2021). In addition, the teacher in this new educational reality considers technological resources as a fundamental tool to generate a meaningful teaching and learning process.

However, since 2017, the Ecuadorian Institute of GeoGebra IEG at the National University of Education-UNAE has begun to train teachers in the use of GeoGebra as a didactic resource for teaching mathematics at different courses in a bimodal way: face-to-face (16 hours) and virtual (134 hours) (Pari, et al, 2020). Not necessarily to address the sanitary crisis, but as part of an educational innovation. Innovation is related to invention, but it is not the same, since innovation usually involves the practical application of an invention to achieve a significant impact on the teaching and learning process.

In addition, Information and Communication Technologies (ICTs) have assumed a leading role in the Era of Technological Revolution with huge technological advances, where people no longer need to leave home to look for food or buy something because they can use an application from *PedidosYa* and others, and the ordered food will arrive at the doorstep (Zetriuslita, 2021). In that line we find stores like Tokopedia, Shopee, Amazon and others, which will solve the needs of all families and the items will arrive at home just using a Smartphone. However, not all sectors of Ecuadorian society can access these digital resources and benefit from the opportunities and facilities associated with their incorporation into everyday life (Astudillo, 2021).

ICTs have brought about a pedagogical change that favors and promotes true experiences and activities focused on a deeper learning (Cabero y Barroso, 2018), interactive, dynamic, creative and critical present in mathematics education and necessary for the education of the XXI century. The integration of ICTs in education and its research had to be justified before, but now it is indispensable. Nevertheless, the integration in the classroom is a complex and multifactorial process because the teacher can encounter a large number of difficulties (Barrantes, et al, 2011).

In this perspective, GeoGebra is a free software and dynamic mathematics program for teaching mathematics at different levels that has spread almost all over the world. GeoGebra integrates in a dynamic, interactive, constructive and creative way topics such as geometry, algebra, calculus, statistics and probability through its different views and is suitable for all levels of the educational system.

According to Agabo (2015), ICTs can be considered not only as artifacts that replace didactic strategies in the educational process, but also as instruments that support new forms of teaching and learning. For Álvaro Marchesi, Secretary General of the Organization of Iberoamerican States (OEI), "Iberoamerican Society and education face an enormous challenge: to ensure the well-being of its citizens, economic development and social cohesion in a world undergoing profound and accelerated transformations" (Marchesi, 2021). Nevertheless, access to the digital world made possible by information and communication technologies (ICTs) is today considered fundamental for the functioning of the various spheres of society.

Regarding the integration of ICTs at the classroom, we pose the following research question: What difficulties and challenges do Ecuadorian teachers face in the implementation of GeoGebra software as a didactic resource in the classroom for the teaching and learning of mathematics in virtual education?

In particular, in this new challenge of the 21st century and a pandemic that still exists in Ecuadorian society, the challenges faced by the learning community (teacher, students, family and community) are related to educational equity, professional training of teachers, the ability to integrate new methodologies in the teaching and learning process, the digital gap in rural versus urban areas, the time of virtual class hours, school dropout, among others. We ask ourselves: Is the teacher prepared to generate a virtual teaching and learning process with the demands of the 21st century and the new reality? (Hurtado, 2020).

The new reality demands changing the perception of traditional education in which the teacher had the absolute truth and the students were conceived as recipients of information. Therefore, it is necessary to change the educational paradigm and achieve a comprehensive training of the student in the virtual modality by integrating free and practical educational software such as GeoGebra in the teaching and learning process of mathematics.

Objective of Research

General objective

To identify the challenges and difficulties faced by Ecuadorian teachers in the implementation of GeoGebra as a didactic resource for the teaching and learning of mathematics in the period of pandemic Covid-19, with the purpose of giving some suggestions that may contribute to improve mathematics learning.

Specific objectives

- To carry out a theoretical, pedagogical and didactic review issued by different authors on the difficulties for the integration of GeoGebra in the classroom.
- Design and apply an instrument for the identification of challenges and difficulties in the implementation of GeoGebra in the pandemic Covid-19.
- To identify the difficulties perceived by the teachers participating in a GeoGebra course for the teaching and learning of mathematics in the implementation in the classroom.
- To investigate the challenges and challenges perceived by teachers participating in a GeoGebra course in the process of integrating GeoGebra software as a didactic resource for teaching mathematics.

Background

Challenges of education in the 21st century

The environment of the teaching and learning at the education of the 21st century cannot be separated from the integration of information and communication technologies. This phenomenon somehow challenges contemporary teachers, even forces teachers to create their own teaching strategies and techniques combined with the use of technology.

In this sense, for Bialik (2015) and Pamungkas, et al., (2020), 21st century learning is defined as learning that provides skills and abilities for students namely the 4Cs that include: (1) communication skills; (2) collaborative skills; (3) critical thinking and problem-solving skills; and (4) creative and innovative skills. In addition, this 21st century learning includes ways of thinking, ways of working, tools for working and living in a changing and globalized society (Grifin, 2021).

Moreover, this century is characterized by the exponential growth of science and technology, thus requiring human beings to work with complex thinking and communication skills (Bery, 2010). As well, contemporary teachers are required to be prepared to develop the 4Cs of the 21st century. Since, the 21st century presents political, social, ethical, educational and cultural demands and challenges (Widya, et al., 2019).

In this challenge, the education of the 21st century, demands new methodologies and teaching strategies, therefore, one of the methodologies of this century is STEM (Science, Technology, Engineering and Mathematics), in which science, technology, engineering and mathematics were developed to respond to the challenges of the century, where students are not only cognitively intelligent but

also skilled. The benefits of applying STEM education are to improve the skills of creative, logical, innovative, productive and directly related to the reality of society (Chusni, et al., 2020). In this regard, the research of Pamungkas, et al. (2020) constructed the following table on 21st century skills.

Framework for 21st Century Skills	***IP-21CSS***	***Aspect***
Creativity Thinking and innovation	4Cs	• Thinking creatively • Work creatively with others • Implement innovation
Critical Thinking and Problem-solving		• Effective reasoning • Use a thinking style • Make judgments and decisions • Solve the problem
Communication and Collaboration		• Communicate clearly • Collaborate with others
Information, Media and Technology Skills	ICTs	• Access and evaluate information • Use and organize information • Analyze and product media • Apply technology effectively
Life & Career Skills	Character Building	• Demonstrate the scientific behavior of attitude (desire to be curious, honest, thorough, open and prudent) • Demonstrate acceptance of the moral values prevailing in society
	Spiritual life	• Live the concept of God through of science • Internalize spiritual values in every day

Table 1: Framework for 21st Century Thinking concepts in Indonesia.

Currently the students have different learning styles at the time of learning. According to Pamungkas, et al. (2020), students are active, sensitive, visual and global. That is, they prefer to learn by manipulating, doing hands-on activities, group work and collaboratively. They even prefer to use concrete materials and have fun explaining in detail when solving problems using predetermined methods, as well as using visualization as a way of learning through images, diagrams, videos and others.

In addition, another widely used methodology of the 21st century is the flipped classroom, since it is one of the most used approaches in the teaching practices of the 21st century due to the development of technology and having immediate information on the web (Wasriep & Lajium, 2019). The digital era and its technologies are having a profound impact, especially on the digitally enhanced generation that is growing up with digital habits (TV, cell phones, video games, etc.). These are necessary to develop new competencies and skills among which human creativity, innovation. Therefore, the education system is struggling to keep up with the demand of these new digital challenges (Bruno & Canina, 2019).

Challenges of education in the 21st century

Currently, the immersion of Information and Communication Technologies are tools of the knowledge society, the lack of training and updating in the use of ICTs as teaching material is a worldwide challenge that every teacher faces in this changing society. Accord-

ing to Weinhand, et al. (2021) and Campuzano & Pazmiño (2021) ICTs provides tools that allow solving problems of everyday life in the environment in which the citizen is involved, adapting in a practical, fast and above all innovative way. Being the teacher the only person suitable to help discovering strategies that contribute to the development of 21st century learning competencies (1) communication skills; (2) collaborative skills; (3) critical thinking and problem-solving skills; and (4) creative and innovative skills. UNESCO has stated in 2017, that the implementation of ICTs as learning tools in students and teachers is very effective because it allows access to information and select data that facilitate learning in an innovative way. (UNESCO, 2019). In this perspective, we opted for the formation and training of teachers in the use of GeoGebra from the Ecuadorian Institute of GeoGebra at UNAE.

GeoGebra

According to Arteaga, et al. (2019) the GeoGebra program was developed by Markus Hohenwarter as part of his Master's thesis, presented in 2002 at the Salzburg University, Austria. It was hoped to achieve a dynamic geometry program with those of the symbolic calculus systems. It is a dynamic and interactive application combining various branches of mathematics such as geometry, algebra, analysis, statistics and probability intended for teachers and students that can be downloaded free of charge from www.geogebra.org (Ago, 2015; Hohenwarter & Fuchs, 2004). GeoGebra functions as a tool for visualizing mathematical concepts that are useful as learning aids. Regarding Arteaga, et al., (2019) GeoGebra is a very versatile tool for teaching mathematics and can be used in many different ways: (1) As a means of demonstration and visualization of certain mathematical concepts, (2) As a means of construction as a means of demonstration, (3) As a discovery tool, and (4) GeoGebra for the preparation of teaching materials.

Students' mathematical understanding can be improved by using GeoGebra. Nowadays, learning mathematics by using computer technology has been widely practiced. GeoGebra, plays a role in achieving various competencies of students (Azizah, et al., 2021). According to different studies conducted, the results reveal that the software is an effective learning medium (Weinhandl, et al., 2021; Pari, et al., 2020; Azizah, et al., 2021). GeoGebra is not only a tool to support existing methodologies, but a didactic resource to support proposals for new active, dynamic and creative learning methodologies. Moreover, around the software there is an international community organized in International GeoGebra Institutes (IGI) and local institutes. As of 2013 there were more than 120 GeoGebra Institutes. In that perspective has been created in Ecuador, the Ecuadorian GeoGebra Institute at the National University of Education-UNAE, which was constituted in 2018 on the occasion of the celebration of the VI Iberoamerican GeoGebra Day. A non-profit institution that supports teachers and students. Among its activities are the offer of continuing education courses in the use of GeoGebra, organization of Ecuadorian GeoGebra Events, publication of proceedings and repositories of acts, among others.

Materials and Methods

Methods

To achieve the objectives proposed in this research, the study was approached through a mixed method research design (Hernandez, et al., 2010). But not only as a sum of quantitative and qualitative, but as an interactive, complementary and systematic combination that allows us to approach the educational reality that Ecuadorian teachers experience in the classroom (Ramirez & Lugo, 2020). It is framed in the line of educational innovation based on Information and Communication Technologies (ICTs). It is of longitudinal type, of sequential exploratory scope (Ramirez & Lugo, 2020).

Population und Sample

The study population corresponds to 832 Ecuadorian teachers who were trained in the use of GeoGebra (2017-2020) through the training education course "GeoGebra as a didactic resource for teaching and learning mathematics" (GRDEAM) and "Innovating and Transforming Mathematics Teaching with GeoGebra" (ITEMG) (Pari, et al., 2020), offered from the IEG at UNAE. The teachers were selected by the Ministry of Education. The blended and virtual course lasted six months with a load of 150 hours and the facilitators were the authors. The sample was non-probabilistic, made up of 144 (90 men and 54 women) teachers who answered the online questionnaire voluntarily and represent 20 provinces out of the 24 in the country.

Research Instruments

In order to respond to the objectives, a 32-item questionnaire was designed. The first part corresponds to the sociodemographic aspect (12 items), the second part on difficulties (8 items), the third part on the challenges of implementing GeoGebra in the classroom (10 items) and the last part is open-ended questions on the advantages and disadvantages of using GeoGebra in the classroom. The questionnaire was sent by e-mail. The responses are collected using a 5-point Likert scale. The very low option totally disagree (1) "SD", disagree (2) "D", neither disagree nor agree (3) "N", agree (4) "A" and totally agree (5) "SA" (See Table 2). A pilot test was also applied to 20 participants to determine the level of reliability of the instrument. Cronbach's alpha was applied to the instrument for reliability. (Cronbach, 1951). The statistical value was 0.881 according to (Pari, et al., 2020) showing that it is a reliable instrument.

Universidad Nacional de Educación						UNAE
This questionnaire aims to identify the advantages and disadvantages faced by Ecuadorian teachers in the implementation of GeoGebra® software as a didactic resource for the teaching and learning of mathematics in the period of the closure of face-to-face classes and replaced by home schooling due to the COVID-19 pandemic.						
Items	On a scale of 1 to 5, how would you rate the premise 'Difficulties in implementing GeoGebra software in the classroom'?	**Options**				
		1 SD	**2 D**	**3 N**	**4 A**	**5 SA**
1	Creating problems from the student's context.					
2	Lack of technological devices.					
3	Students lack technological devices.					
4	Teachers lack technological devices.					
5	Lack of training in the use of GeoGebra.					
6	Lack of digital competencies in teachers.					
7	Lack of knowledge of integrating GeoGebra in the classroom.					
8	The mathematics curriculum does not allow.					
Items	***On a scale of 1 to 5, how would you rate the premise 'Challenges in implementing GeoGebra® in the classroom?'***	***Options***				
		1 SD	***2 D***	***3 N***	***4 A***	***5 SA***
9	Develop creative thinking.					
10	Demonstrate mathematical concepts in a creative way.					
11	Create innovative activities in GeoGebra.					
12	Develop mathematical reasoning.					
13	Adapt to different learning styles.					
14	Solve problems and make decisions.					
15	Correct use of mathematical language.					
16	Interaction between teacher and student and between them.					
17	Facilitate collaborative learning.					
18	Develop students' self-learning.					

Table 2: Questionnaire applied to GeoGebra course participants.

The data obtained through the online questionnaire were analyzed descriptively. Based on the results, a second qualitative instrument was added. Participants were asked to freely express their perception of difficulties and challenges they faced in the implementation of GeoGebra in the classroom after their training in the use of GeoGebra.

Processing

The instruments that were developed for the study was the online questionnaire, which was administered to all teachers of the Ecuadorian Educational System who participated in the GeoGebra courses (2017-2020) as a didactic resource and training of trainers. The instrument was sent by email to all participants for voluntary response.

Results and Discussion

Phase - Quantitative

The implementation of technologies in any organization is a complex and multifactorial process of different natures (technological, organizational and cultural) (Area, et al., 2020). However, studies have identified and examined among the main obstacles and grouped into two types of factors: (1) external factors outside the teacher's control such as access to technology, availability of time and technical support, resources, content and training; and (2) internal barriers and factors more at the school level, such as organizational culture, or at the teacher level, such as their beliefs about teaching with technology as well as their degree or capacity for openness to change and innovation (Area, et al., 2020). In this perspective, the quantitative analysis of the data collected through the instruments has been divided into three parts.

The first part related to the demographic information of 144 participants of this study (90 men and 54 women, 62.5% and 37.5% respectively). They represent 20 provinces out of the 24. Their average age is 41 years and the standard deviation is 11.44 years. 85% are tenured teachers and 15% are on occasional contracts. 89% work in public educational units, 9% in Fiscomisional and 2% in private. 75% work in urban areas and 25 percent in rural areas. 60% of them are high school teachers and 30% of them are elementary school teachers. 90 % teach mathematics and 10% teach other subjects such as Physics or Chemistry.

Secondly, the results obtained regarding the difficulties or barriers faced by teachers in the implementation of GeoGebra as a didactic resource for teaching mathematics are shown in Figure 1. The highest average was the option "lack of technological devices" with an average of 52.1% totally agreeing "SA" and 35.4% agreeing "A", which means that 87.5% identified it as one of the difficulties. This lack of technological devices in students corresponds to 78.4% as a result of 45.1% with 33.3%. While the lack of devices in teachers is only 34.7% (11.8% +22.9%). Next, the option "lack or poor training of teachers in the use of GeoGebra" is shown at 79.1% (44.4%+34.7%). This shows that teachers trained in GeoGebra recognize that the software is not only to support traditional methodologies, but it is a help to generate new strategies and implement in the teaching and learning process of mathematics that allows problems from the context of the student and can respond to the learning needs of the 21st century.

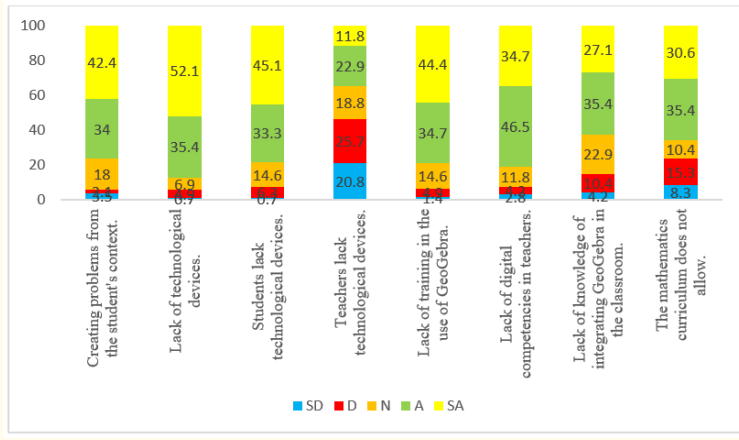

Figure 1: Results of the premise "Difficulties in implementing GeoGebra in the classroom".

The results obtained on the opportunities or advantages in the implementation of GeoGebra as a didactic resource for teaching mathematics in times of Covid-19 as shown in Figure 2. This includes recognizing the place of mathematics among the sciences and ensuring that the subject is accessible not as a memorization of formulas and accounts to then repeat decontextualized exercises for students, but as a resource to facilitate interactive, dynamic, creative learning that allows developing the necessary skills for learning in the 21st century.

The results of each item were averaged through the arithmetic mean, the highest average was the option "totally agree" with 65.97%. In second place was the option "agree" with 29.58%, followed by the option "neutral" with 3.01%, the option "disagree" with 1.28% and the option "totally disagree" with 0.7%. All items exceed with more than 60% of "strongly agree". Furthermore, these results are interactively and systematically complemented by the qualitative analysis. Many of the teachers reflected on the basis of their experience as learners of the GeoGebra course, that at the beginning it was difficult to differentiate between objects drawn and constructed in GeoGebra. The former do not keep their properties while the latter maintain invariance in the face of transformations and dynamic movement of some elements. In addition, teachers perceive that GeoGebra facilitates addressing social distancing challenges presented by the COVID-19 pandemic. (See Figure 2)

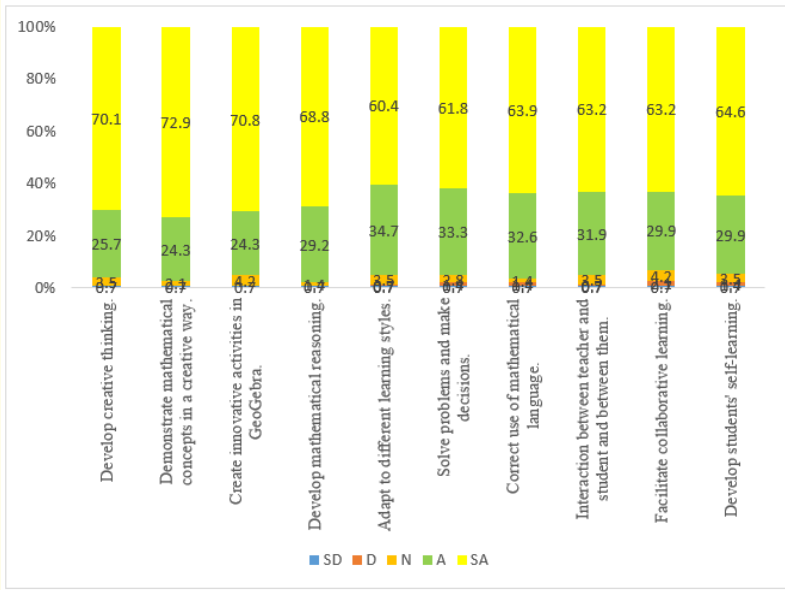

Figure 2: Results of the premise "Challenges for the implementation of GeoGebra in the classroom".

Phase - Qualitative

Figure 3 shows the analysis of the qualitative information regarding the open-ended questions on the advantages and disadvantages of using GeoGebra in times of Covid-19 and the new educational reality. This was done with the qualitative analysis software Atlas.ti version 9. In the case of the advantages of using GeoGebra, the categories developed were: development of creative thinking; development of logical-mathematical thinking; creation of mathematical objects and verification of mathematical concepts; dynamic, innovative and interactive tool; motivation to learn mathematics; time savings in the development of virtual classes, among others that link the potential of GeoGebra in the learning of mathematics. (See Figure 3)

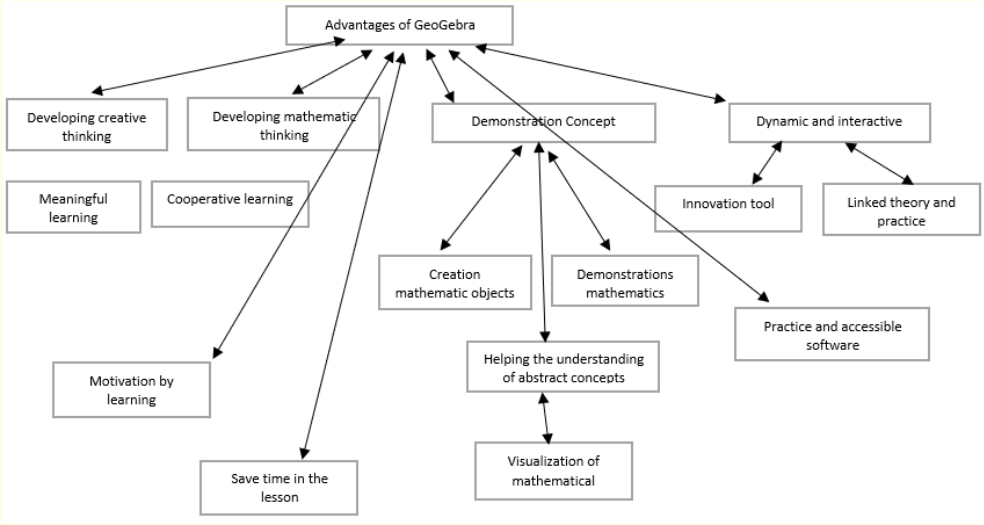

Figure 3: Analysis map of the potentialities of GeoGebra in the teaching and learning process of mathematics.

With respect to the development of creative and logical-mathematical thinking, the participants identified by Q_i of the study indicated "The use in classes has been very useful especially in creativity" (Q1), "development of creative thinking, ease of assimilation of content" (Q2), "It allows me especially to awaken curiosity in students, which allows them to have a voluntary attitude towards learning" (Q3), "it puts more interest in learning because they feel creative, and eager to explore every day, so the student is in constant unknowns to do" (Q4), "It has allowed my students to learn mathematics in a more creative way, it has helped me a lot to demonstrate theories. The students are not bored and want to know more" (Q5).

On the other hand, with respect to mathematical proofs, creation of mathematical objects, visualization and motivation to learn, the participants pointed out: "Very interesting, the student has more attention in the proofs of the exercises and proofs" (Q6), "it improves the grades since they can understand the different forms of representation of mathematical concepts" (Q7), "It increases attention, improves participation, facilitates understanding. Better analysis, processes are better visualized" (Q8), "the graphic response is immediate, expectation is generated in students as a different and attractive medium" (Q9), "students become interested in mathematics classes; be able to speak correctly mathematical terms; understand basic concepts in different areas" (Q10), "demonstrate mathematical concepts through its graphic environment and has allowed the implementation of new strategies with its use. In virtual classes it has been a strength since students are connected to a screen either by Smartphone, Laptop" (Q11), "students have visualized graphically what cannot be done in face-to-face class due to the lack of a screen and projector" (Q12).

In general, the potentialities that the use of GeoGebra allows in the teaching and learning of mathematics are linked as a dynamic, innovative, interactive and user-friendly tool. Figure 4 shows the disadvantages of the use of GeoGebra in the teaching and learning process of mathematics in Covid-19 times. The categories that have been developed from the open questions of the online questionnaire were: lack of technological resources, the digital gap, limited internet access, lack of training in GeoGebra, education modality (virtual-presently), urban versus rural areas, lack of time, Ecuadorian mathematics curriculum, and lack of resources and tools in GeoGebra. (See figure 4)

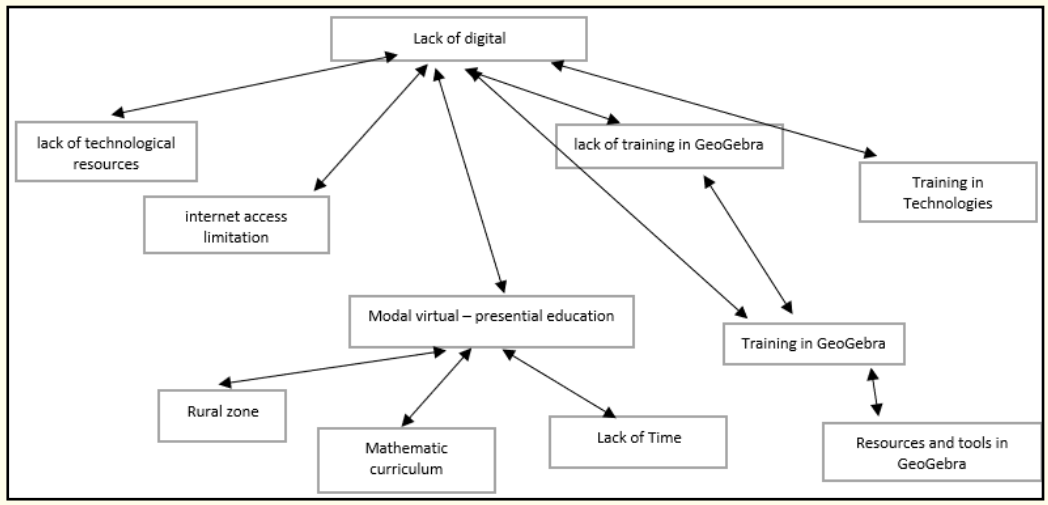

Figure 4: Analysis map of the disadvantages of the use GeoGebra in the teaching-learning process of mathematics.

Regarding the lack of technological resources, Internet access and the digital gap, the participants identified by P_i pointed out "The disadvantage is that most of the students do not have fixed Internet" (P1), "the technological equipment of the students is deficient and they cannot resolve doubts in the use of GeoGebra because being in this virtual mode makes it difficult to help them with the doubts that each individual has" (P2), "In a rural sector and do not have fixed Internet or smart devices" (P3), "Connectivity in the virtual classroom is sometimes not always good and the program does not open for some students" (P4), "students do not have the proper tools to develop the activities proposed, therefore a number of children are left without learning the use of GeoGebra" (P5).

On the other hand, regarding the lack of time, training in GeoGebra and the curriculum, the participants stated: "Lack of time and space in the curriculum to train students" (P6), "Some classes have become complex" (P7), "Lack of knowledge of the students" (P8), "That students lack training in its use" (P9), "Lack of time and space in the curriculum to train students" (P9), "Lack of time and space in the curriculum to train students" (P9), "Lack of time given by the curriculum to mathematics and physics subjects" (P10).

Finally, some pointed out that there are no disadvantages in the use of GeoGebra, as mentioned "the disadvantages are not a product of the GeoGebra program, they are a product of the poor connectivity that exists" (P11).

Analysis of the Research

This article contributes with a new perspective of the 21st century education on the challenges that the contemporary teacher presents in the implementation of GeoGebra for the teaching and learning of mathematics. Although previous work in the literature has developed the 21st century competencies that teachers should possess (Pamungkas, et al., 2020), they still require tools and methodological strategies to achieve the 4Cs set out in the theoretical framework.

From the qualitative and quantitative results, we can point out that the contemporary mathematics teacher from the Covid-19 pandemic and the new educational reality presents challenges such as: (1) the digital gap, this makes the teaching-learning process impossible by integrating ICT in the virtual modality (Hurtado, 2020). (2) the lack of access to technological resources in the 21st century is emerging for the knowledge society, since until 2019, only 45.5% of the population had access to wireless internet, however, by 2020, 89% of the Ecuadorian population is connected to a cell phone. (3) Lack of training in GeoGebra. Despite the efforts of the Ecuadorian Institute of GeoGebra at the UNAE, training in the use of the software for teaching mathematics is urgent and fundamental for Ecuadorian teachers, as they manage to develop mathematical content in a dynamic, interactive, creative and innovative way (Pari, et al., 2020; Vera & Yañez, 2021).

In addition, the challenge for teachers in the face-to-face modality was to integrate and comply with the curriculum during the school year. This, in the current teaching modality (virtual) has been more complex for teachers, since the mathematics curriculum has three large curricular blocks and the time available to teachers in the synchronous session is 2 hours on average per week. This would show the difference that exists in face-to-face versus virtual education and the challenge that the teacher has in the integration of ICTs, more so, the use of GeoGebra (Hurtado, 2020).

Conclusion

Based on the results we reach the following conclusions: the review of the available literature reveals that in recent decades there have been great advances in the use of technology and distance or virtual teaching in all disciplines and particularly in mathematics. Consequently, the GeoGebra program has become an essential tool not only to cope with the virtual teaching and learning resulting from the COVID-19 pandemic, but also to facilitate innovative, flexible and complementary proposals that respond to the needs of 21st century learning.

Among the difficulties identified by teachers trained in the use of GeoGebra, the first is the lack of technological devices, especially for students, which coincides with international research, the need for more teacher training both in the use of the software, as well as disciplinary and active learning methodologies.

Regarding the advantages and opportunities there is a high consensus that the software allows demonstration, verification, and creative discovery of mathematical concepts. In addition, the development of the GeoGebra course as a didactic resource for teaching mathematics in a bimodal way (face-to-face - virtual), was already a test for the new virtual reality. Like the implementation of interactive methodologies, as described by (Pari, et al., 2020), teachers found it difficult to differentiate between drawn and constructed objects. They even instituted the facilitator to explain how to do so that they could repeat. It was not an easy task for the facilitators to make them understand that creative learning and self-learning was needed.

Finally, based on the experience of having developed the GeoGebra course for mathematics teachers and the results on difficulties and challenges faced by Ecuadorian teachers for the implementation of GeoGebra in mathematics teaching are transferable to the integration of ICT in different disciplines. Therefore, it is necessary that the Ecuadorian Institute of GeoGebra at UNAE continues with the organization of the Ecuadorian GeoGebra Events and expands the offer of training and updating courses on the use of GeoGebra as a didactic resource for the teaching of mathematics at different educational levels.

References

1. Agabus IS. “Factors influencing the use of Information and Communication Technology (ICT)”. Teaching and Learning Computer Studies in Ohaukwu Local Government Area of Ebonyi State-Nigeria. Journal of Education and Practice 6.7 (2015): 71-86.
2. Area M, Santana PJ and Sanabria AL. “The transformation of schools. Obstacles and resistances”. Digital Education Review 37 (2020): 15-31.
3. Arteaga Valdés E, Medina Mendieta JF and Del Sol Martínez JL. “The GeoGebra: a technological tool to learn mathematics in Basic High School by doing mathematics”. Conrado Magazine 15.70 (2019): 102-108.
4. Astudillo M, Chavez F and Figueroa J. “ICTs as generators of social exclusion in educational practices”. Educational Contexts 27 (2021): 205-221.
5. Azizah AN, Kusmayadi TA and Fitriana L. “The Effectiveness of Software GeoGebra to Improve Visual Representation Ability”. Journal of Physics: Conference Series (2021): 1-6.
6. Barrantes G Casas L and Luengo R. “Perceived obstacles to the implementation of ICT by Infant and Primary teachers in Extremadura”. Pixel-Bit. Media and Education Magazine 38 (2011): 83-94.
7. Berry B. The Teachers of 2030: Creating A Student-Centered Profession for the 21st Century (Washington DC: MetLife Foundation) (2010).
8. Bialik M and Charles F. “Skills for the 21st Century: What Should Students Learn? Center for Curriculum Redesign Boston”.

Massachusetts (2015).

9. Bruno C and Canina M. "Creativity 4.0. Empowering creativity in the digital era". Paper presented at the Proceedings of the 21st International Conference on Engineering and Product Design Education: Towards a New Innovation Landscape, E and PDE (2019).
10. Cabero J and Barroso J. "Technological scenarios in Augmented Reality (AR): educational possibilities in university studies". Open Classroom 47.3 (2018): 327-336.
11. Campuzano JG, Pazmiño MF and San Andrés EM. "Mobile devices and their influence on the learning of Mathematics". Domain of Sciences Scientific Journal 7.1 (2021): 648-662.
12. Chusni M., et al. "Review of critical thinking skill in Indonesia: Preparation of the 21st century learner". Journal of Critical Reviews 7.9 (2020): 1230-1235.
13. Cronbach LJ. "Coefficient alpha and the internal structure of test". Psychometrika 16 (1951): 297-334.
14. Griffin P, Care E and McGaw B. "The changing role of education and schools". In Griffin, P., McGaw, B., Care, E. (Eds.) Assessment and teaching of 21st century skills, Dordrecht: Springer (2021): 1-16.
15. Hernández R, Fernández C and Baptista P. "Research methodology. McGraw Hill, Mexico". Hohenwarter, M. & Fuchs, K. (2004). Combination of dynamic geometry, algebra and calculus in the GeoGebra system. In Mathematics Teaching conference (2010).
16. Hurtado Talavera FJ. "Education in times of pandemic: The challenges of the 21st century school". Venezuelan Science and Technology Magazines REVENCYT 44 (2020): 176-187.
17. Marchesi A, Tedesco JC and Coll C. "Quality, equity and reforms in education. Educational goals". Santillana Foundation (2021).
18. Pari A, Mendoza D. and Auccahuallpa R. "GeoGebra as a Technological Tool in the Process of Teaching and Learning Geometry". In: Rodríguez, G., Fonseca, C., Salgado, J. Pérez, P. Orellana, M. and Berrezueta, S. (eds) Information and Communication Technology. TICEC2020. Communication in Computer and Information Science 1307 (2020): 258-271.
19. Pamungkas SF., et al. "21st century learning: Experiential learning to enhance critical thinking in vocational education". Universal Journal of Educational Research 8.4 (2020): 1345-1355.
20. Ramírez A. and Lugo J. "Systematic review of mixed methods in the Educational Innovation Framework". Scientific Journal of Educommunication 5 (2020): 9-20.
21. UNESCO. "Supporting teachers with mobile Technology. Lesson drawn frounesco projects in Mexico, Nigeria, Pakistan and Senegal". Paris. UNESCO (2019).
22. UNESCO. "Incheon Declaration and Framework for Action". Towards inclusive and equitable quality education and lifelong learning for all (2016).
23. Wasriep MF and Lajium D. "21st century learning in primary science subject via flipped classroom method: A teacher's perspective". International Journal of Recent Technology and Engineering 8.2-9 (2019): 952-959.
24. Weinhandl R., et al. "A look over students' shoulders when learning mathematics in home schooling". International of Mathematical Education in Science and Technology (2021): 1-24.
25. Widya Rifandi R and Laila Rahmi Y. "STEM education to fulfill the 21st century demand: A literature review". Journal of Physics: Conference Series 13171. (2019).
26. Zetriuslita Nofriyandi and Endang Istikpmah. "The Increasing Self-Efficacy through GeoGebra Based Teaching reviewed from Initial Mathematical Ability (IMA) Level". International Journal of Instruction 14.1 (2021): 587-598.