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GeoGebra as Didactic and Technological Mediation in the Learning of Mathematics. An Analysis from the Perceptions of Basic and Secondary Education Students

Cesar Augusto Hernández Suárez[1], Carlos Antonio Pabón Galán[2], Audin Aloiso Gamboa Suarez[3]

[1]*Universidad Francisco de Paula Santander, Colombia*
cesaraugusto@ufps.edu.co
ORCID 0000-0002-7974-5560
[2]*Universidad Francisco de Paula Santander, Colombia*
carlosantoniopg@ufps.edu.co
ORCID 0000-0003-4027-819X
[3]*Universidad Francisco de Paula Santander, Cúcuta, Colombia*
audingamboa@ufps.edu.co
ORCID 0000-0001-9755-6408

Abstract

Educational applications are tools that contribute to the mediation of the learning of the concepts that are acquired in the classroom. For this reason, the objective of this articleis to know the perception of students about the use of Geogebra in the learning of mathematics. To this end, a Likert scale questionnaire was applied to assess motivational aspects, navigability and interface and pedagogical anddidactic aspects, through the use of descriptive statistics to assess perceptions. The findings showed that students' perceptions towards the use of GeoGebra were at a satisfactory level of acceptance. It is concluded that the use of GeoGebra as pedagogical and technological mediation allows to support the learning of mathematics in students of basic and secondary education.

Keywords: Modeling, Simulation, Basic Education.

I. INTRODUCTION

The use of technology is increasingly inseparable from the educational process which is mediated by innovations that seek, among others, to amend the learning difficulties of students, in such a way that to acquire the concepts is actively and constructively, through experimentation, at their own pace and with resources available in their environment. In this line, the learning of mathematics, are constituted as a chain in which each knowledge is linked with the previous ones in a hierarchical way. That is why identifying errors as a result of difficulties in student learning, such as the presence of inadequate cognitive schemes and not as a lack of knowledge (Socas, 2007), trigger a lackof prior knowledge required in it that imply knowing the steps that are carried out during this process (Carrillo, 2009).

Therefore, it is necessary to use strategies that facilitate their approach and motivate the student towards the construction of concepts, in which activities that only remain procedural and mechanical are avoided, which makes it difficult for them to ask questions, analyze and explain the mathematical process (Hernández et al., 2017). In addition, there is evidence thatstudents who have difficulties in learning mathematics, in traditional teaching contexts, have lower academic performance than those who learn using technologies (Costa et al., 2010).

In this sense, the use of mathematical softwarepromotes innovative ways of learning and develops skills in the student, especially in the aspect of motivation and the change of attitudes towards their learning (Gómez, 2010; Ballesteros-Ballesteros et al., 2022) which favors his interest and makes him an active actor in his learning (Candelario-Dorta, 2018), helping him overcome his learning difficulties and obstacles. In this sense, there is a consensus that technology is essential in the teaching and learning ofmathematics (Hohenwarter et al., 2009; Area et al., 2018), in particular, the design of interactive environments that provide learning opportunities that provide the student with mathematical skills and levels of understanding based on the visualization and explanation of mathematical objects and concepts in interactive environments. So experiences with mediations such as GeoGebra that through simulations and visualizations allow an understanding of ideas and concepts (Acosta, 2010; Boaler & Sengupta, 2016).

GeoGebra was chosen because it is an open source software that dynamically integrates geometry, algebra and calculus (Hohenwarter, & Fuchs, 2004), the possibilities of graphical representation with the algebraic expression of graphic objects (Hohenwarter, & Preiner, 2007; Hohenwarter et al., 2009). In addition, it is easy to learn to handle, intuitive and does not require advanced use strategies to use it in the teaching of mathematics, which allows the teacher to propose different learning experiences (Rojas-Bello, 2020), not only as resources that solve and solve problems (Silva & Flores, 2017), but also facilitate the student to follow the process of manipulation of mathematical elements and constructions in the resolution of these (Gamboa & Fonseca, 2014). Also, with GeoGebra you can carry out interactive activities online (Hohenwarter et al., 2009) and on mobile (Martin & Lezcano, 2021).

On the other hand, there are studies that show that one of the factors that allow thepedagogical integration of digital technologies is linked to the beliefs and perspectives that educational actors have about this process (Area et al, 2018). In relation to teachers, they have focused on the didactic use of ICT (Area et al. , 2016), ICT competencies (Hernández et al., 2016; Hernández et al., 2016; Hernández et al., 2022), educational programs and policies (De Pablos, 2015) among others. In addition, it is evident that teachers have positive perceptions about its use as a valid alternative tool in the teaching and learning processes of Mathematics (Zakaria & Lee, 2012).

However, studies on perceptions, assessments and expectations about technologies and their integration by students are incipient (Area et al., 2018) especially in the learning of mathematics (Cruz-Huertas, 2016; Pari & Auccahuallpa, 2019). So this study, I seek to explore the perceptions that the students themselves have about the motivational aspects, navigability and interface and the pedagogical and didactic aspects that GeoGebra has in its training that were introduced during a workshop related to the topic of functions, which facilitates the processes of abstraction showing the construction of e a relationship between a geometric and algebraic model of a real-life situation, which allows to find solutions not only Mathematics, but also visual, which represent the solution of a certain problem.

2. MATERIALS AND METHODS

2.1 Enfoque

The focus of this study is quantitative of descriptive type in which it seeks to explore the perceptions of students about the use of GeoGebra as didactic and technological mediation in the learning of mathematics. Descriptive statistics were used to assess students' perceptions.

2.2 Population and sample

The study population is the students of the last three grades of basic and secondary education of an educational institution located in the department of Norte de Santander, Colombia. The sample is not probabilistic because it corresponds to 165 students who answered the online questionnaire (73 female and 92 male). By grades, 58 students correspond to ninth, 66 to tenth and 41 to eleventh.

2.3 Collection instrument and technique

The collection technique is a survey to measure the perception of students, which was applied once GeoGebra was implemented as a mediation in the learning of mathematics. The instrumento was modified and adapted from the work carried out by Cruz-Huertas (2015) and Hernández et al. (2022), to assess the use of GeoGebra by students in motivational aspects (2 items), related to motivation and attitude; navigation and interface (2 items), which includes the design of the environment in terms of color, size and visualization; the pedagogical and didactic aspects (5 items), related to the construction of concepts that are deepened are their use, related to the applicationof mathematics, for a total of 9 items valued on a Likert scale ranging from strongly disagree (1) to strongly agree (5).

As a first step, the reliability of the instrument was verified using Cronbach's Alpha statistic (Table 1), values that are above 0.7, the acceptable threshold suggested by Celina & Campo-Arias (2005) and Vanegas, Gamboa and Gómez (2022) which showsthat the instrument has internal consistency and coherence between the different items. For data collection, it relied on Google Forms.

Table 1

Coefficient of reliability of the dimensions of the questionnaire.

Dimensions	Alpha de Cronbach
Motivational aspects	0,93
Navigability and interface	0,92
Pedagogical and didactic aspects	0,95

2.4 Data processing

The information obtained was statistically processed in the statistical software IBM SPSS Statistics 24, with a descriptive statistic of central tendency and cross tables, accompanied by their analysis and interpretation. Next, the non-rmalidad of the data is checked to apply the corresponding hypothesis test to check if there are significant differences between the students of the different grades under study

3. RESULTS

The results obtained on theperceptions on the use of GeoGebra as didactic mediation for the learning of mathematics of the students who answered the questionnaire are presented.

Table 2

Descriptive statistics on the perception of the use of GeoGebra as didactic and technological mediation by dimensions.

		Statistical	
Dimensions	Items	Media	Standard deviation

Motivational Aspects	The dynamic environment with GeoGebra, drives you to actively participate in your academic process	3,7	0,61
	The dynamic environment with GeoGebra presents information in a pleasant way that motivates and interests you		
Navigability and interface	The design of the dynamic environment with GeoGebra facilitates navigation and interaction.	3,8	0,66
	The colors, sizes and fonts in the dynamic environment of GeoGebra provide an adequate visual environment		
Pedagogical and didactic aspects	The organization of the contents, the tools and activities, fulfill their pedagogical and didactic functions	3,9	0,76
	The theme has been developed in depth.		
	Resources such as tables, graphs, and interactive simulations expand the understanding of the concepts seen.		
	GeoGebra is an innovative educational mediation		
	It is important that the teacher uses GeoGebra to guide observation and analysis processes.		
Total		3,8	0,73

The average survey score is 3.8/5.00; The highest average score is given in the pedagogical and didactic aspects, followed by navigability and interface and finally the motivational aspects. However, the difference is minimal, so thecorrelation between the dimensions is studied below using the Pearson statistic (see Table 3):

Table 3

Correlation between dimensions.

		Motivational Aspects	**Navigability and interface**	**Pedagogical and didactic aspects**
Motivational Aspects	Pearson correlation	1,00	0,62**	0,63**
	Sig. (bilateral)		0,00	0,00
Navigability and interface	Pearson correlation	0,62**	1,00	0,73**
	Sig. (bilateral)	0,00		0,00
	Pearson correlation	0,63**	0,73**	1,00

Pedagogical and didactic aspects	Sig. (bilateral)	0,00	0,00

According to Table 3, it is evident that there is a strong correlation between motivational aspects and navigability and interface, which have a value of 0.62; Among the motivations aspects and pedagogical and didactic aspects the value is 0.63; in addition, the correlation between navigability and interface with pedagogical and didactic aspects is 0.73.

On the other hand, Table 4 presents the descriptive statistics on the perception of the use of GeoGebra as didactic and technological mediation by dimensions and by degree.

Table 4

Descriptive statistics on the perception of the use of GeoGebra as didactic and technological mediation by dimensions and by degree.

	Degree					
Dimensions	**Ninth**		**Tenth**		**Eleventh**	
Statistical	**Media**	**D.S**	**Media**	**D.S**	**Media**	**D.S**
Motivational Aspects	3,8	0,94	3,4	0,56	3,6	0,77
Navigability and interface	3,9	0,86	3,6	0,56	4,0	0,72
Pedagogical and didactic aspects	4,1	0,79	3,7	0,92	4,0	0,72
Total	3,9	0,77	3,6	0,77	3,8	0,94

In the dimension of motivational aspects, ninth grade students had the best average with a value of 3.9; In the dimension of navigability and interface and the pedagogical and didactic aspects had a better average with a value of 4.0 forthe students of the eleventh grade.

In addition, it is observed in Table 4, the average values range between 3 and 4 points, so we want to verify if there are significant differences between the dimensions and the degrees. In this case, the Kolmogorov Smirnov normality test was carried out for when the sample size is greater than 50 (ninth and tenth grade) and Shapiro-Wilks, for when it is less than or equal to 50 (eleventh degree), to know the distribution of the data and apply the relevant statistical test.

Table 5

Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) normality test.

	Kolmogorov-Smirnov	**Shapiro-Wilk**

Dimension	Degree	Statistical	Gl	Itself.	Statistical	Gl	Itself.
Motivational Aspects	Ninth	0,18	58	0			
	Tenth	0,15	66	0			
	Eleventh				0,94	41	0
Navigability and interface	Ninth	0,22	58	0			
	Tenth	0,16	66	0			
	Eleventh				0,86	41	0
Pedagogical and didactic aspects	Ninth	0,14	58	0			
	Tenth	0,12	66	0			
	Eleventh				0,87	41	0

The normality test reflects in all cases a p-value less than 0.05, which shows that the data do not follow a normal distribution, therefore, the hypothesis test that was applied is the non-parametric Kruskal-Wallis test.

Table 6

Hypothesis testing between the perception of the use of GeoGebra as didactic and technological mediation by dimensions and degree.

	Chi-square	Gl	Sig. asintótica
Motivational Aspects	3,38	2	0,18
Navigability and interface	5	2	0,08
Pedagogical and didactic aspects	9,14	2	0,01

The hypothesis test reflects that there is a sig. value less than 0.01 in the pedagogical and didactic aspects, therefore, it is interpreted that it is the only dimension that presents significant differences related to the perception of the students the differentdegrees.

4. DISCUSSION

The use of GeoGebra and its environment is a didactic and technological mediation, it is characterized by ease of access with a friendly interface, simplicity of use of the software and its high pedagogical potentialities (Hernández et al., 2022), which facilitates the strengthening of concepts and mathematical competences due to the intuitive elements in its handling (Mosquera & Vivas, 2017), which offers students adequate interactivity (Pineda et al., 2020). In addition, the graphical visualization offered by Geogebra facilitates a better understanding of the problem (Tenorio & Martín, 2015). Likewise, the

simulations that are generated in the dynamic environment of GeoGebra are applied by the teacher when building a new concept and at the same time making feedback because they allow analysis and better interpretation, since visualization helps to internalize them better (Gutiérrez et al., 2017; Cenas et al., 2021). This provides a learning environmentwhere they work at their own pace (Vitabar, 2013) to learn according to their needs and overcome the difficulties presented in their development, allowing them to improve the attitude towards mathematics, improve motivation to learn mathematics(Cenas et al., 2021).

Finally, this work joins other works related to perceptions, valuations, expectations, visions, beliefs, opinions, among others, on the use of technological mediations, in this case of GeoGebra, by studentslike those developed by (Hernández et al., 2022; Garcia et al., 2020; Pari & Auccahuallpa, 2019; Area et al., 2018; Cruz-Huertas, 2015; 2016).

5. CONCLUSIONS

According to the perceptions of the students, the use of GeoGebra as a didactic and technological mediation in the learning of mathematics, has a satisfactory level of acceptance; having a better performance in the pedagogical and didactic aspects,followed by navigability and interface, and finally, that related to motivational aspects, in addition, to show that these dimensions are correlated with each other and influenced by each other. Also, significant differences were found with the pedagogical and didactic aspects with the grade; being the highest average in the students of the eleventh year, followed by those of ninth and finally by those of tenth. In short, through this discussion it can be concluded that studentsare linked to technology, that it is motivated and that it demands its educational use, which influences their perceptions and assessments of these mediations.

Finally, it is suggested to deepen this research with qualitative studies. Thequantitative and qualitative studies complement each other, which will allow us to understand how students perceive and value their experiences with technological mediations, which continue to promote pedagogical innovation. Also, it is recommended to develop studies in other contexts and educational levels and grades, taking as reference this work, in order to improve it, where GeoGebra is used as a means to take advantage of the potential of students in the learning of mathematics.

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