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Padowan Graph Tool in Learning Graphs of Functions, in University Students

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Abstract

Objective. To analyze the effect that the Padowan Graph software has on the learning of graphs of functions, it was applied to undergraduate university students in order to improve their levels of learning in mathematics using learning and knowledge technologies (TAC). Method. Type of experimental research with quasi-experimental design, quantitative approach. The study sample was non-probabilistic, 29 students for the experimental group and 29 for the control group, to whom questionnaires such as knowledge tests validated by judges and with the V. Aiken coefficient (0.86) and reliable with the statistical method of two were applied as well with Spearman Brown formula. Results. Favorable averages were evidenced for the experimental group (16.59) compared to the control group (12.69) after applying the Padowan Graph software, for the hypothesis test the non-parametric formula of U. Mann Whitney for independent samples was used obtaining values for the bilateral sig. of (0.00) lower than the value of (0.05). Conclusion. The Padowan Graph Software significantly improves the learning of graphs of functions in a motivated, fast, interactive way In addition, it encourages a more active learning, and promotes the development of mathematical skills.

Keywords: *Learning mathematics; didactic strategy; Function graphs; Padowan Graph.*

INTRODUCTION

Currently, ICT tools are transversal in all areas, this research work was developed in the educational field with the applicability of the Padowan Graph tool that is part of the TAC specifically as a didactic strategy to improve the levels of learning in graphics of important content functions that students must handle in the subject of mathematics (Alvarado, 2022).

The use of ICT favors academic performance in the subject of mathematics at the university level in a significantly and positively way. (Feliciano and Cuevas, 2021).

Nogales et al. (2019) point out that technological tools such as Geograbra, Wiris, Padowan Graph, among others, produce significant changes in the teacher's didactics, promote the development of creativity, discovery, the construction of mathematical knowledge in students. Thus, 72% of University students consider that the use of ICT improves the learning of geometry and their academic performance.

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Under this scenario, the Padowan Graph application is a calculation tool that has the potential to generate and design different graphs taking into account the coordinate systems, from different mathematical functions, whether simple graphs or that require parameter functions.

There are many similar applications that allow you to display graphic representations, some require installation, others are online and most are free license such as GeoGebra, Gnuplo, FooPlot, Evaluator, Graphing Calculator, Graph.tk, Meta-calculator, Mathway, Graph Sketch, Rechner, GraphFree, Graph Plotter, Mafa Function, among others. (PADOWAN, 2022)

Based on the previous support for our research work, we take as background research that applied similar software and that is related to our variable called learning the graph of linear and quadratic functions. In the following paragraphs I present a pertinent conceptual framework.

The Padowan Graph software is a valuable mathematical tool for creating graphs of various mathematical functions in a coordinate system, in a simple and precise way, as well as allowing work with normal and parameterized graphs. (Vera, 2019).

Along the same lines, Sánchez and Borja (2022) in their study reveal the importance of technological tools that allow significantly improving problem solving and their graphic representations of different functions, such as the Padowan, Geogebra and Graphing software, for example. On the other hand, these tools support the teaching and learning process of mathematics.

In this same perspective, Cedeño and Valdez (2022), in their study that aimed to analyze the use of GeoGebra to improve the mathematics learning process that used a quasi-experimental design, had a sample made of thirty eight students who took a test at the beginning and at the end of content comprehension that contained five multiple choice exercises and was carried out through a survey with Google forms, in addition they developed contents of vector and parametric equations of lines in space, reaching the conclusion that if it positively improves the understanding of mathematical content and their attention skills for the experimental group.

On the other hand, Vargas (2020), in his study, analyzed the problem regarding the resolution of application problems in mathematics. For this, he made a theoretical support on the educational theories of constructivism as well as connectivism, he had both E-learning and M-learning as forms of communication. He also explored elements that affect academic performance such as reading comprehension, logical reasoning and abstract thinking. Finally, he implemented various digital tools such as GeoGebra, Mathway, Daypo and Highlight Tool, aimed at developing and strengthening their students' skills in quadratic functions. The results showed a remarkable development in problem-solving skills and an increase in student satisfaction and confidence to approach mathematics using technological tools.

Nuñez (2021), in his research work, aimed to use ICT to promote the development of mathematical skills in teachers and students, a type of qualitative basic research with an interpretative hermeneutic design with an empirical and interpretive level. He used the interview for data collection, and concluded that the intensive use of technological tools for mathematics allow instant, interactive accessibility to information and overcomes all kinds of barriers. In that sense, our research paper on Padowan Graph software has similar characteristics.

Besides, Romero, et al. (2022) aimed to determine the effectiveness of the Geogebra software in learning graphs of functions and transformations of functions in university students. The research work was experimental with a quasi-experimental design. The sample was of thirty five students for each group and descriptive statistics and the T-student test for independent samples were used, concluding that the use of GeoGebra as a

didactic strategy favors meaningful learning in the topics of graphs and transformations of functions.

For their part, Bermeo and Marilin (2022) investigated the incidence of the use of mathematical tools such as GeoGebra and Liveworksheets in the teaching of quadratic functions, a type of documentary research through records and institutional codes, bibliographic. They collected the information through a probabilistic sample of 268 students. The results were favorable for the experimental group with an average of 6.38, unlike the control group 4.93. The conclusion showed that GeoGebra and Liveworksheets have a significant impact when using quadratic functions in the teaching and learning process.

In this same perspective, Ruiz et al (2022) in their research on the use of the computer tools MS-Excel and GeoGebra as didactic resources for learning the calculation of roots of nonlinear equations through the Newton Raphson method, the sample was made up of 8 students specializing in mathematics. The research was descriptive with a qualitative approach, ex post facto method. The results showed that the students were able to experience and visualize each of the proposed interactions through the tools in a motivated, interactive, easy-to-use and understand way.

On the other hand, Ibarra (2022) reveals the use of the GeoGebra software through the disk method to find the sum of the volumes and approximate the volume of solids, in addition to using the software it becomes more didactic, motivated volume calculations by Riemann sums and definite integrals under this method.

Along the same lines, Rodríguez and Suarez (2022) mention that when students carry out mathematical processes on quadratic functions and supported by the Geogebra software, they are able to experiment, verify, visualize conjectures with a high motivation supported by their type of experimental research with a mixed approach using the CEAP-48 inventory, additionally and through a focus group interview. They conclude that by using the TACs specifically, the GeoGebra software stimulates students to be highly motivated.

According to Navarrete et al. (2022) in their research work, the use of GeoGebra software as a didactic tool in learning mathematics is a type of qualitative documentary research extracted from Google Scholar; Dialnet and Redalyc with thirteen articles that present the use of technology for learning mathematics and can make graphic representations quickly and easily. He concludes that by using the GeoGebra software it helps to learn different calculations, in addition, students develop new concepts, create new knowledge, through the development of two-dimensional graphics, three-dimensional dynamics and analytical calculation.

Arteaga (2023), who investigated the benefits of technological tools in teaching mathematics, a type of mixed research with a non-experimental design, concludes that the use of active methodologies with the application of ICT in different environments and Mathematics learning contexts have direct relationships with attitudes, culture and interest of the teacher guide, and it also significantly and positively impacts their innovation when using technology in the teaching process.

Bravo and García (2023) aimed to implement technological resources to strengthen the skills of teachers who teach mathematics at the University of Manta. The type of study is descriptive, with a quantitative approach. The results showed that 88% of teachers stated that they do not use technological resources to teach mathematics, and 78% stated that they did not suggest activities through technological tools either. They conclude that the use of technological resources does allow the strengthening of mathematical competencies and also helps to provide solutions to various mathematical problems and that students show a significant improvement in their knowledge and skills.

For Martinez et al. (2021) in their research work with a quasi-experimental design that analyzed the incidence of technological tools, more specifically augmented reality in the learning of mathematical functions, conclude that the students of the experimental group showed better results, that is, in the various processes on mathematical functions. They obtained better and higher averages compared to the control group that were not applied technological tools.

Also, Sandoval et al. (2022) use a strategy through an educational method to graph Piecewise-type functions using windows and it has an advantage for both students and teachers, the results were positive joining several functions and it can be applied in precalculus subjects as a useful graphing tool.

It is worthy to mention that Vera et al. (2022) analyzed in their study that multiple media such as Geogebra, Podawangrap Kahoot, Quizizz, tutorials, videos and among other media improve significant teaching-learning processes when they have difficulties mainly in topics related to mathematics, how quadratics work.

Along the same lines, Chacín et al. (2022) investigated the effectiveness of the GeoGebra tool as a strategy in learning graphs and transformations of functions at the university level. He used an experimental research with a quasi-experimental design and concluded that technological tools such as GeoGebra significantly favor the learning of graphs and transformations of domain and range functions.

According to Granados and Padilla (2021), their study indicates strengthening the geometric modeling of the tangent line using a digital tool such as the GeoGebra qualitative research software through a didactic proposal. They conclude that by interacting with the students they improved their geometric thinking skills specifically in graphing functions and other topics related to mathematics.

For our study, the Padowan Graph is a powerful software like GeoGebra. Both can be downloaded for free from the website http://www.padowan.dk to be able to apply during the development of the experiment of the experimental group and compare with the control group that was taught in a traditional way without the support of technology.

OBJECTIVE

The general objective of our study was to analyze the effect of using the Padowan Graph tool on learning graphs of functions. As specific objectives, it was to establish differences in the level of learning of function graphs in the control and experimental groups before and after applying the Padowan Graph tool in its graphic dimensions of linear functions and quadratic functions.

METHODOLOGY

This study is experimental and it seeks to compare two methods of teaching mathematics, the first called New Method where the learning sessions were applied and developed with the support of the Padowan Graph software and the second method called Traditional without the application of mathematical software. The work was based on a quantitative approach with a quasi-experimental design. The sample was determined using the non-probabilistic method in an intentional and arbitrary manner to form the 29 students for the experimental group (EG) and 29 for the control group (CG), all of them from Jaime Bausate y Meza University which took the same subject, developed the same contents and the same academic cycle, that is, these groups were intact and were formed as such. (See Table 1).

Every instrument must be measured through validity and reliability processes (Posso and Lorenzo, 2020), in that sense, for our research work, the validity and reliability of the

instruments called knowledge tests were determined in the following way: first we carried out the content validity by evaluating the judgment of experts in the subject of study, we then used the V. Aiken coefficient to demonstrate the adequacy of the items. In other words, if they were valid or we would have to reformulate them. Finally, the results showed a similar value for Pretest and Posttest of 0.86, this meant that the instruments were valid, addressing main criteria such as clarity, congruence, context and domain. (See Table 2).

Then we carried out the reliability that was determined using the Spearman Brown formula of two halves method with a pilot sample, the results showed values of 0.94 and 0.97 respectively for the Pretest and Posttest. In other words, these coefficients obtained indicated high reliability and were immediately applied to the first groups before applying the Padowan Graph software in order to know their level of achievement of the students in graphs of functions, then the mathematics subject was developed for an entire academic cycle with the support of the Graph software for the EG and without the Graph software for the GC. That is, teaching in a traditional way. During the process we also use evaluation instruments to know the level of progress such as rubrics and checklists. Once the experiment is finished, we administer the second instrument called Postest to both groups and compare results in averages and median scores to determine the effect that Padowan Graph software had on function graph learning. (See Table 3)

The values in Table 3 show the pilot sample of 16 students. The number of items was 20 for each instrument. The coefficients for the Pretest (0.94) and for the Posttest (0.97) indicated that our instruments that we applied were reliable with a high degree of consistency and coherence. We then applied it to the entire study sample by groups and the following results were obtained.

RESULTS

According to the proposed methodology, the results of two aspects are presented. The first at a descriptive level where a data analysis at a quantitative level of the dimension's graph of linear functions and graph of quadratic functions is revealed. And in the second aspect, the distribution of the data is known using the Shapiro Wilk numerical method for samples less than 50. Finally, the hypotheses are tested with the non-parametric U. Mann Whitney formula. Below are details of the procedures supported by the SPSS statistical software through tables, figures and interpretations.

The data shown in Table 4 and Figure 1 show the results of the graphical dimension of linear functions at the time of the Pretest. The control group had an average of 11.00 and the experimental group had 12.00, apparently with a small advantage for the CG. Then, after applying the Padowan Graph tool, the average and median scores increased in favor of the experimental group (EG) by a score of 16.59, that is, 50% of the students had lower and equal averages 17 and the rest higher than 17. Unlike the CG that obtained an average of 12.69 and a median of 12, these results gave us initial certainty that the mathematical software Padowan Graph showed a positive effect on the learning of mathematics in the linear functions dimension in the students from Jaime Bausate y Meza University, Lima.

Table 4 and Figure 2 show the average and median scores for the control and experimental groups in their two moments: Pretest and Posttest. For the Pretest, before the experiment the control group obtained an average of 12.00 while the experimental group obtained an average of 11.28. The latter is apparently lower, however, after applying the Padowan Graph tool the averages were better and higher for the experimental group (16.55). On the other hand, concerning the median for the Posttest GE, 50% of the total group of students obtained averages lower than and equal to 17 and the rest, the other 50%, higher than 17. These results indicated to us that the application

of the Padowan Graph tool does have a preponderant effect on learning quadratic functions.

Before submitting to contrast our proposed hypotheses, we demonstrated that our data did not have a normal distribution with Shapiro Wilk's numerical method where the results showed for the Pretest and Posttest values for the P-value of (0.00) lower than the (0.05) level of significance. Based on such, we conclude that our collected data came from free distribution. Consequently, we used the nonparametric test statistic U. Mann Whitney then mentioned his equation (e).

$$z = \frac{U - \left(\frac{n_1 n_2}{2}\right)}{\sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}} \quad \text{(e)}$$

U= minimum U value. Mann Whitney

Z= calculated value

n1 = GE sample

n2= GC sample

Regarding the statement of the true general hypothesis, there is a positive effect when applying the Padowan Graph tool in learning graphs of functions. As a false denial, it was estimated at the 95% confidence level and 5% significance level and with the support of the software SPSS statistics processed the data and the results are shown below (see Table 6).

The data seen in Table 6 show the results of the general hypothesis test, with the U. Mann Whitney value being (89,500), the rank sum for the new teaching method, that is, using the Padowan Graph tool, was (1186.50) and for the traditional method, without using the mathematical tool, it was (524.50). On the other hand, the statistical value of the Mann Whitney z-calculated was (5.219) taken in absolute value, being greater than the critical z value (1.96), and it is also evident that the following value is lower than the level of significance (0.05). That is why we decided to reject the null hypothesis and accept the alternative hypothesis concluding that it is statistically inferred that the Padowan Graph tool has a predominant positive effect on the learning of function graphs in university students.

In the same way, the specific hypotheses were tested using the same formula. For specific hypothesis 1, which was raised as a true hypothesis, there is a significant effect of the Padowan Graph tool in the learning of linear functions and its denial as a null hypothesis. It was also estimated at 95% confidence and 5% significance.

The results showed a z-calculated value of (4.956) greater than the z-table value (1.96) and according to these results, the null hypothesis was rejected and the true hypothesis was accepted, concluding that there is a positive and significant effect. of the mathematical tool in learning graphs of dimension linear functions. Finally, for specific hypothesis 2, values lower than the significance value (0.05) were obtained. The false hypothesis was also rejected, concluding that the mathematical tool Padowan Graph has a very significant effect on the learning of graphs of quadratic functions in first-year university students in the mathematics course of the same semester.

DISCUSSION

According to our quasi-experimental research design, we required two groups. An experimental group (EG) where we would apply our mathematical tool Padowan Graph

and another group called Control (CG) without the mathematical tool, that is, compare two teaching methods, one using the Padowan Graph tool and the other without the Padowan Graph tool in a traditional way without use CT scans. Regarding the validity of the research instruments, first of all we carried out content validity through the qualification of expert judges in the field and their adequacy of the items taking into account certain criteria with the V. Aiken coefficient. We also determined their reliability using the two-half method with the Spearman Brown formula applied to instruments with dichotomous as well as polytomous responses and our instruments meet these characteristics. Once their reliability and validity have been demonstrated, we apply it to the entire study sample of 29 students in the EG group and 29 in the control group (CG).

Based on the data collected, we carried out a statistical analysis at a descriptive level to know the scores in both averages and medians by groups and their score in each dimension, that is, the dimensions of the mathematics learning variable such as: linear functions and the functional quadratics dimension also called Pretest and Posttest. Once the results were obtained, they were discussed and interpreted, then we performed an analysis at an inferential level with a normality test using the Shapiro Wilk formula (n<=50) to know if our data came from a normal distribution. Consequently, after the test it was determined that our data did not have a normal distribution, then according to the design and the free distribution of the data we chose the most appropriate non-parametric statistic called U. Mann Whitney to test our hypothesis and coincidentally in all tests the null hypotheses were rejected.

Unlike Vera's study, which aimed to know the importance of the Padowan Graph software, in creating graphs of many mathematical functions in a simple and precise way as well as working with normal and parameterized graphs, our study aimed to analyze the effect that the Padowan Graph tool has in learning graphs of linear and quadratic functions at the university level through a quasi-experimental design with two groups. That means comparing two forms of teaching, one traditional and the new one, applying the Podawan Graph tool. Our results showed that it did have a positive and significant effect on the teaching and learning process of mathematics.

CONCLUSIONS

It is concluded at a 95% confidence level and a 5% significance level that the use of the Padown Graph tool did have a positive and significant effect on the learning of graphs of functions in the students of the first semester in Maths at Jaime Bausate y Meza University of Lima. For the teachers, this favors their didactic development with high motivation and easily provides solutions to various mathematical problems. Students also feel motivated, it allows interactivity, speed in solving problems on graphs of functions, they feel more autonomous and it encourages collaboration between classmates. In addition, they improve their development of mathematical skills and learning becomes more active.

Regarding the new teaching method, the mathematical tool called Padowan Graph, the experimental group was better because the students had higher averages (16.57) when solving various problems on graphs of linear and quadratic functions, compared to the traditional method that did not use the Padowan Graph. Thus, the Podowan Graph tool has a significant effect on improving the learning of linear functions and quadratic functions in university students, corroborated with the hypothesis contrast where the values of the p-value (0.00) were lower than the level of significance (0.05).

Finally, I conclude that technologies for learning and knowledge of mathematics undoubtedly improve teaching processes and have positive effects on education.

References

Alvarado, L. (2022) Conoce qué son las TIC. Colombia. Edit. Web virtual poli verso. https://www.poli.edu.co/blog/poliverso/que-son-las-tic

Arteaga, M. (2023). Uso de herramientas tecnológicas y metodologías innovadoras para la enseñanza de las matemáticas, estudio de grado. Editorial Univerisdad Murcia. http://hdl.handle.net/10201/127303

Bravo, M. y Garcia, G. (2023), uso de los recursos tecnológicos para el fortalececiemiento de las competencias en los docentes de Matemáticas nivel Superior. Revista MQR Multidisciplinaria Arbitrada de investigación científica. https://doi.org/10.56048/mqr20225.7.1.2023.1566-1591

Bermeo, F. y Marilin, A. (2022) . Incidencia del uso de las herramientas tecnológicas GeoGebra y Liveworksheets en el proceso de enseñanza aprendizaje de funciones cuadráticas, tesis de grado. http://www.dspace.uce.edu.ec/handle/25000/29069

Cedeño-Menéndez, R. R., y Valdez-Trejo, V. (2022). El uso de la Geogebra como herramienta para el mejoramiento del rendimiento académico en estudiantes de Bachillerato. Revista Polo del Conocimiento, 7(2). https://doi.10.23857/pc.v7i2.3776

Chacín, L., Colmenares, R., Contreras, R., Arenas, A. y Parra, M. (2022) Uso del GeoGebra como estrategia de aprendizaje significativo en el estudio de las gráficas y transformaciones de funciones. Revista de Educación Mediática y TIC. http://doi.org/10.21071/edmetic.v11i1.13345

Feliciano, A., y Cuevas, R. (2021). Uso de las TIC en el aprendizaje de las matemáticas en el nivel superior. Revista Iberoamericana para la Investigación y el Desarrollo Educativo, 12(23).1-18 https://doi.org/10.23913/ride.v12i23.1023

Granados, C. y Padilla, I. (2021), el aprendizaje gráfico de la recta tangente a través de la modelación de las secciones cónicas utilizando GeoGebra. Revista científica, (40), 118-132. https://doi.org/10.14483/23448350.16137

Ibarra, L. (2022). Sólidos de Revolución y suma de Riemann en GeoGebra. Revista Digital: Matemática,Educación e Internet, 22(2),1-20. bit.ly/3lhZ6Tj

Martínez, M., Mejía, E., Ramírez, R. y Rodríguez, D. (2021). Incidencia de la realidad aumentada en los procesos de aprendizaje de las funciones matemáticas. Información tecnológica, 32(3), 3-14. http://dx.doi.org/10.4067/S0718-07642021000300003

Nogales, M., Gusñay, C., Sevilla, E., y Ortega, R. (2019). Geogebra como herramienta didáctica en el proceso de enseñanza aprendizaje de la matemática. Revista ED. Explorador digital, 3(3.1), 204-223. https://doi.org/10.33262/exploradordigital.v3i3.1.881

Núñez Cheng, J. (2021). Tecnologías de la información y comunicación en las competencias matemáticas: análisis de la educación virtual en estudiantes universitarios. https://hdl.handle.net/20.500.12692/71513

Navarrete, M., Merino, P., Estupiñán, B. y Caicedo, J. (2022). Geogebra as a technological-didactic tool in learning integral calculus. Sapienza: International Journal of Interdisciplinary Studies, 3(1), 902–910. https://doi.org/10.51798/sijis.v3i1.271

PADOWAN (2022) grafico de Padowan https://padowan-graph.softag.com/

Posso, R. y Lorenzo, E.(2020) Validez y confiabilidad del instrumento, articulo revista Educare ISSN:2244-7296. https://doi.org/10.46498/reduipb.v24i3.1410

Rodriguez, R., y Suárez, J. (2022). La motivación y el estudio de la función cuadrática con GeoGebra. Educación y Humanismo, 24(42). https://doi.org/10.17081/eduhum.24.42.4864

Romero Chacín, J. L., Romero Colmenares, J., Reyes Contreras, R., Barboza Arenas, L. A., y Romero Parra, R. M. (2022). Uso del GeoGebra como estrategia de aprendizaje significativo en el estudio de las gráficas y transformaciones de funciones.http://hdl.handle.net/10396/24185

Ruiz, O., Palma, E. y Mendoza, C. (2022). Excel y GeoGebra para el cálculo de raíces de ecuaciones no lineales mediante el método de Newton-Raphson. Revista Científica Tecnológica, 5(2),38–47 bit.ly/40mK7pO

Sánchez-Balarezo, R. W., y Borja-Andrade, A. M. (2022). Geogebra en el proceso de Enseñanza-Aprendizaje de las Matemáticas. Domino de las Ciencias, 8(2), 33-52. https://doi.org/10.23857/dc.v8i2.2737

Sandoval, M., Vázquez,H., Huerta, J., Castro,F. y Filobello, U. (2022). Didáctica del graficado de funciones: el caso de las funciones piecewise. RIDE. Revista Iberoamericana para la Investigación y el Desarrollo Educativo, 12(24) https://doi.org/10.23913/ride.v12i24.1197

Vera, V. (2019) Enseñanza del concepto de derivada con Geogebra. Una guía didáctica desde el aula de clase. Revista Internacional de Aprendizaje en Ciencia, Matemáticas y Tecnología, ISSN 2386-8791 © Global Knowledge Academics. bit.ly/3H1n1gw

Vera, A., Figueroa, R., Ponce, R. y González, M. (2022). Multimedios en el proceso de enseñanza-aprendizaje de matemáticas. Ciencia Latina. Revista Científica Multidisciplinar. https://doi.org/10.37811/cl_rcm.v6i6.4310

Vargas-Fajardo, A. O. (2020). Resolución de problemas de función cuadrática y uso de aplicaciones móviles en estudiantes de décimo año del Liceo Naval de Guayaquil (Master's thesis, Universidad Casa Grande. Departamento de Posgrado). bit.ly/42KpUwv