Webology (ISSN: 1735-188X)
Volume 19, Number 6, 2022

Geogebra As A Learning Tool: A Contextual Assessment From The Pedagogical And Technological Point Of View

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Abstract
The article reports on the evaluation of the Geogebra program to facilitate the learning of the topic of Derivation, through the implementation of a didactic sequence. A quantitative approach with a descriptive level and the survey technique was used to collect information. We worked with a purposive sample of 24 students from a mathematics teacher training programme. The findings point to the ease of access, the simplicity of use of the programme and its pedagogical potential, which makes it a mediation tool for the learning process of mathematics subjects.

Keywords: Geogebra, Valuation, technology, pedagogy, pedagogy.

Introduction

One of the particularities of learning mathematics is that it requires a high degree of abstraction. This limits, in some cases, students in the visualisation and appropriation of the concepts addressed, causing confusion, mismanagement of the subject under study and difficulties in addressing the solution of problematic situations, a situation that transcends the limits of the classroom. Although learning is the learner's own decision, teaching plays a leading role in it, and both (learning and teaching) are inseparable dialectical processes. There is no doubt that mediation facilitated by teachers who are reflective about their practice and by an appropriate strategy makes it possible to achieve meaningful learning (Ausubel et al., 1997; Novak & Gowin, 1988; Díaz-Barriga, 2011).

Currently, universities are issuing policies to incorporate technological tools in the different educational processes, and the teaching and learning of mathematics are not on the sidelines. So the need arises to use educational mathematical software in the didactic act in order to help students understand abstract mathematical concepts of differential calculus such as derivatives, their applications and interpretations. Hence, the incorporation of the symbolic calculation programme such as Geogebra was proposed as a technological tool with the purpose of supporting the teacher's work and facilitating the student's learning of the subject of derivatives.
Favourable results have been found on the use of this application to develop mathematical concepts and to dynamise the student's learning process (Cenas et al., 2021), which point out the advantage of its free access and easy handling, therefore, users (students and teachers) can make use of this tool without investing much time for its proper use.

The focus of the article was the contextualised evaluation of the technical and pedagogical potential of the symbolic calculation application Geogebra, for which a didactic sequence was developed on the subject of derivatives of algebraic functions, which was implemented with the support of a teacher and his group of students of the subject Differential Calculus. It is based on the need to contribute to the initial training of mathematics teachers, on the one hand, to contextually assess the use of this application as a pedagogical mediation where the incorporation of ICT in educational processes is fulfilled and, on the other hand, to provide the teacher in training to promote meaningful learning of this topic in their professional training.

Mathematics requires certain levels of abstraction on the part of the learner. The concepts, their applications and transfers (to other disciplines such as physics, for example) are limited, especially if students are unable to visualise and manage them, which causes difficulties in the search for solutions to problematic situations, both in the university context and later in the workplace. Hence, the use of educational software or applications is increasingly necessary, in view of studies that point to their importance in achieving meaningful learning (Castellano et al., 2012). This is because both the concepts and the operations presented in class can be manipulated and visualised by means of algebraic and graphic representations, which allows a greater understanding of these topics.

In the case of students, in their teacher training process, it is necessary to have innovative ways to facilitate learning the topic of algebraic function derivatives. The use of technological mediations such as Geogebra makes it possible to provide an alternative in which students can consolidate meaningful and contextualised learning of mathematics. By incorporating the use of Geogebra into classroom work, the student will not only be able to achieve significant learning, but also the proper management of an application that the student will be able to use in their academic training, and as a

teacher in their professional practice. Therefore, the objective was to design a didactic sequence for the incorporation and contextual assessment of the symbolic calculation programme Geogebra.

Geogebra as a symbolic calculus program

The existence of various computer programmes that facilitate different mathematical operations such as symbolic, numerical and graphical calculation, among others, allows for greater flexibility in approaching mathematics content. The use of educational programmes or applications in mathematics facilitates the handling of concepts specific to this science, as well as being a motivating element for students (Fernández et al., 2017; Cuicas et al., 2011; Sabino, 2014) that facilitates the teaching and learning processes of mathematics (Sánchez-Balarezo & Borja-Andrade, 2022; Santos, 2021; Pineda et al., 2020).

According to Arteaga et al. (2019), Geogebra is characterised by the fact that it is one of the most user-friendly and useful programmes to support the learning of Mathematics and is an assistant that facilitates symbolic calculation, numerical calculations, the elaboration of graphs, among others, to work with functions, derivatives, limits, integrals, etc. (Porillo et al., 2019). Geogebra, according to Ramírez (2020), allows to achieve different numerical, algebraic and graphical representations, in a dynamic way, that correlate geometric and algebraic, graphing in two and three dimensions among others.

Didactic sequence for learning

The didactic sequence is based on a curriculum design proposed by Gagné et al. (1992) and Dick et al. (2004), among others. These relate to: the students with their characteristics and prior knowledge; the learning objectives, axes of the planning of the learning experiences; the contents with appropriate structuring and sequences. The methodology focused on the didactic strategy, taking into account methods, techniques, procedures and evaluation. It should also focus on the analysis of tasks linked to the learning experiences; didactic resources, these are the materials or technological tools such as educational software. The time and place of the didactic activity are fundamental as they are directly related to the context.

Contextual evaluation of the use of Geogebra

The implementation of resources associated with ICT, including programmes such as Geogebra, and the strategies used with students, being educational innovations, require evaluation processes to determine their impact on the educational process. However, since their incursion into the pedagogical field, various models have been generated for their evaluation depending on the type of software and the context in which it is used. The evaluation of digital education, far from being thought of as a technical action, is not reduced to the insertion of technological systems, but rather to the pedagogical

understanding of their role and impact on educational processes (Barberá-Gregori, & Suárez-Guerrero, 2021). It is interesting to incorporate the contextual aspects of its use that depend on its relationship with users and the curriculum, which makes it a more meaningful evaluation. These should contain aspects specific to the didactic act: learner-educator interaction, objectives, contents, methodology or didactic strategy, didactic resources, time and place, among others (Galbán & Ortega, 2017). These aspects are considered in the didactic sequence.

Method

Approach and design

The study was developed under a quantitative approach, with a descriptive level and field design. Due to the nature of the object of study, the contextual assessment of Geogebra, the quantitative approach is the most appropriate. For the field study, we sought the assessment of the Geogebra programme by the students of a teacher training programme in mathematics. The survey technique was used and the instrument was a questionnair.

Target population

The didactic sequence was applied to a group of 24 students of the teacher training programme in mathematics, during a period of two weeks. The subject where it was implemented was Didactics of Variational Thinking in the topic of Derivation. Given that this is a finite population, since the total number of elements that made up the population was known, and it was possible to access each of them, a census was considered.

Data collection technique and instrument

A survey was used as the data collection technique, and the instrument was a self-administered multiple-choice questionnaire with a Likert-type scale (Nemoto & Beglar, 2014) with options ranging from strongly disagree to strongly agree. Its design was based on theoretical references on educational software evaluation. The questionnaire was an adaptation of these and Geogebra was evaluated based on what was proposed by Barberá-Gregori, & Suárez-Guerrero (2021). The reliability was determined through the Cronbach's alpha reliability index, obtaining a value of 0,81.

Results

The results and the organisation of the data analysis were made according to the dimensions of the evaluations of technological aspects, with their indicators of accessibility, versatility, navigation, suitability for users and audiovisual quality, and of pedagogical aspects with their indicators of content quality, didactic solidity, exercise, feedback, cognitive development and motivation.

Technological aspects

Regarding the dimension of technological aspects, in the indicators in which the Geogebra software was assessed, students agree that the Geogebra software interface is user-friendly (93,8%) and easy to access (95,8%). Regarding the versatility indicator, students agree that Geogebra's calculation speed is fast (97,9%) and that this makes it easier for them to answer exercises that require many operations (95,8%). In the navigation indicator, students indicate that they agree that Geogebra offers them adequate interactivity (95,8%) and easy handling (87,5%) to construct other solution paths to the situations posed (87,5%). For the user-friendliness indicator, 72,9% of the students agree that little time is required for the proper use of Geogebra, and of these, 54,2% say that during the time of interaction with the programme they were encouraged to carry out the assigned activities. Finally, with regard to the audiovisual quality indicator, 93,8% of the students were of the opinion that the graphical visualisation offered by Geogebra favours a better understanding of the topics covered.

Pedagogical Aspects

Regarding the dimension of pedagogical aspects, in the indicators in which the Geogebra software was evaluated, we find the quality of the contents where the students indicate that they agree that Geogebra facilitated the conceptual handling of the subject (95,8%), as well as allowing them to clarify the concepts of the slope of a tangent line and the geometric interpretation of the derivative (94,8%) and to learn topics of the subject of derivatives that were not understood (91,7%). They also agreed that the calculation routines were reduced (87,5%) and that the Geogebra activities strengthened their previous concepts (95.8%). Regarding the didactic strength indicator, (95,9%) of the students agreed that they were protagonists in the activities carried out with Geogebra. In addition, the students considered that it allowed them to learn according to their needs (93,8%), this made it easier for them to overcome difficulties (85,4%) and to be autonomous in their learning (95,8%). For their part, in the exercise indicator, the students agreed that Geogebra allowed them to clearly distinguish the solution followed in the development of the exercises (97,9%), to advance from simple exercises to those of greater complexity (97,9%), which facilitated the development of the exercises and that, therefore, what is worked on in Geogebra corresponds to what was taught (95,8%). For the feedback indicator, students agree that the use of Geogebra makes it easier for them to verify what they have worked on paper (97,9%) and to know how much they are learning (93,8%). Likewise, in terms of cognitive development, students agree that Geogebra makes them curious about the handling of mathematical concepts and facilitates the correct interpretation of the results (93,8), appropriation of the different concepts of derivatives (91,7%) and that after their experience with Geogebra they feel able to apply what they have learnt (93.8%). Finally, regarding the motivation indicator, students agreed that their motivation to learn improved (97,9%), they enjoyed it (93,8%), and their attitude towards mathematics improved with the use of Geogebra (84,4%).

Discussion

The Geogebra programme is an easily accessible programme with a user-friendly interface. In this sense, the technical quality of a programme in terms of interface and usability facilitates the strengthening of mathematical competences, as users prefer intuitive elements in its handling (Mosquera & Vivas, 2017). In addition, it is easy to use and offers students adequate interactivity. This is similar to Pineda et al. (2020), who state that this type of programme allows easy movement between symbolic, numerical, graphical and analytical representation systems, which promotes well-founded meaning processes. In addition, the graphical visualisation offered by Geogebra facilitates a better understanding of the problem (Tenorio, & Martín, 2015), in this case the derivation process.

In the area of derivation, Geogebra streamlined the calculations, made it possible to respond to exercises that require a large number of operations and facilitated the construction of new ways of solving the problem situations posed. As it performs routine calculations, this reduces the time spent on them and allows the student to use it to experiment with new situations or parameters (Coronel et al., 2018), clarify and consolidate the concepts already addressed, and facilitates the learning of those that have not been assimilated. This provides a learning environment where they work at their own pace (Vitabar, 2013) to learn according to their needs and overcome the difficulties presented in their development. Therefore, with the use of technology it is possible to make the student an active and autonomous participant (Castillo, & Jiménez, 2019).

The use of Geogebra makes it easier for the student to follow the solution of an exercise, to progress from less complex exercises to more complex ones, and to maintain the level of demand between what has been worked on in the programme and what has been taught. Therefore, using GeoGebra software to show step by step the solution of a problem (Barrena et al., 2011), verify what has been done on pencil and paper, and keep track of learning progress, improves the operational skills needed to solve exercises and problem situations, and a better performance is obtained in their evaluations (Pineda et al., 2020) because there is an appropriate interpretation of the results in the exercises, in addition to the appropriation of concepts addressed and the ability to apply what has been learned.

Finally, the use of Geogebra allows improving the attitude towards mathematics, in this case the topic of derivation, improving motivation to learn and enjoy learning mathematics. In this sense, Cenas et al. (2021), in relation to the use of Geogebra, state that students are motivated towards the learning of mathematics.

Conclusions

The didactic sequence was appropriate, and this allowed the contextual assessment of Geogebra in the technological and pedagogical dimensions and the achievement of positive results in the learning of mathematical topics such as derivation through the incorporation of technological mediations as support. This aspect is evidenced in the results obtained from the opinion of the students surveyed.

Regarding the technological aspects, the analysis reveals that Geogebra is a suitable programme as a support tool for student learning, because it is easy to access and simple for students to use, with adequate interactivity and a user-friendly interface. It speeds up calculations, makes it possible to respond to exercises that require a large number of operations, facilitates the construction of the solution to problematic situations posed and comprehension thanks to the graphical visualisation it offers.

The pedagogical aspects analysed show that the incorporation of Geogebra as mediation facilitated the learning of the topics of derivation, as its use favours an adequate handling of the concepts, as it helps to strengthen previous preconceptions and consolidation of new concepts. It also allows the student to experiment with new parameters in the problem, developing greater autonomy, learning according to their needs and overcoming the difficulties presented in a better way. It also allows the student to follow the solution of an exercise, to advance to more complex exercises, to verify what has been done on pencil and paper, to maintain what has been worked on in the programme and what has been taught, which gives them control of the progress in learning the subject. Finally, it enables the interpretation of the results obtained, the appropriation of the concepts addressed and the ability to apply what has been learned, and this allows them to improve their attitude towards mathematics and increase their motivation to learn mathematics..

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