# EDUCATIONAL SOFTWARE FOR THE TEACHING AND LEARNING OF QUADRILATERALS GENERATED FROM A PROGRAMMING LANGUAGE AND THE DABEJA METHOD.

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**RESUME**

The teaching of math is a process that starts from an early age especially the teaching of geometry through which different representations, constructions, axioms, and theorems among others helps develop the formal thoughts of individuals. This requires not only graphical but demonstrative processes that mentally schemes chords to generate levels of rational thought. Quadrilaterals are part of the components of geometry in the two-dimensional and three-dimensional fields. They possess properties, definitions, classifications, and studies through postulations of parallelism and perpendicularity. Using dynamic strategies and formal processes of knowledge as the Dabeja method to strengthen the teaching of geometry of quadrilaterals through the construction of dynamic courseware, is one of the questions that reveals problems in thought formation.
This is an investigation of a parametric quantitative approach with an experimental design of research aimed at the techno de facto and their relationship with the individual development of a formal thinking. An educational software was developed using the Java programming language to construct quadrilaterals, demonstrate their properties and relationships through the Dabeja method.

**Keywords:** Education, Quadrilaterals, Geometry, Java Educational Software.

## 1. INTRODUCTION

The study of quadrilaterals forms part of the thematic units of math books in all levels of schooling. From the primary stages to the more advanced or secondary stages such as undergraduate studies in the university. Recognition of recent researches such as the Dabeja method (2006) recognized by the academic community teaches us a new way of constructing geometric figures through a language of simple parameterization with simple variables and known algebraic processes [5].
This allows the generation of technological projects that involve adequate knowledge in fundamental mathematics, geometry and other courses with the purpose of application in professional training.
Thus integrating the Dabeja method as a formal development of mathematical modeling in programming languages will allow the generation of quadrilateral educational software as a dynamic tool to strengthen processes of teaching and learning mathematics. Thereby integrating structures, inferential processes and implementation of engineering problems.
This article is a product of a research project undertaken by the faculty of Engineering of the Cooperative University of Colombia situated in Villavicencio using the activities realized by students in math courses. The project is based on the design of geometric software that allows the construction of quadrilaterals employing the Parameterization of the Dabeja method, the programing language and mathematical didactic strategies for teaching and learning.

## 2. LITERATURE REVIEW

Through the renewed curriculum, education in Colombia allows the involvement of dynamic tools in the classroom; nonetheless this proposal has not been able to run fully. Taking into consideration cost and infrastructure that goes with it. This is also due to lack of teaching strategies that should accompany the use of math softwares in the development of mathematical thoughts or equally in the problem of; knowledge of properties, axioms, theorems and postulations that students must know.
In this millennium, changes in the educational revolution and other factors of incidence, allows the deployment of technological resources in the classroom. ‘‘Almeida Bairral 2002’’
‘‘*With the social transformations imposed by society, the great advance in technology and its aftereffect, educational media must be raised and reassessed via new ways of teaching and learning since the teacher's fundamental element in the teaching and learning process will need a constant professional improvement in the quality of educational action’’*. [1].

The interdisciplinarity that exists in the construction of technological resources allows the involvement of system engineering students. These are integrated from their formative stages with adequate knowledge in the design and creation of educational softwares in geometry thereby serving as a didactic resource.
The Dabeja method allows the generation of a geometric software since its formulae are in a parametric language and also has a programming language that allows the generation of mathematical expressions which can be written using any software program. Examples include; Visual Basic 6.0, Macro Media Flash, C++ among others. Thus the integration of mathematics, programming and the design of an educational software.

### A) Definitión of ICT.

Act 1341 of the Republic of Colombia, defines information technology and communication as a a set of resources, tools, equipment, software, applications, network and media that allow the compilation, processing, storage and transmission of information as: voice, data, text and images. Another formal definition of information technology and communication in the Colombian context, ''it may be defined as the set of instruments, tools or means of communications such as telephony, computers, e-mails and the internet that allows communication among individuals or organizations'' [11].

### B) ICT in Education

Currently, educational institutions are confronted with changes created by the new society of information and the place that has the overall system of education is that which aids the involvement in quality processes and extension of coverages that consider the use of technology in education [2].

It must be clearly stated that the sole us of ICT is not enough. It is necessary to analyze if its incorporation is actually producing correct learning. This is one of the troubling elements for most teachers since they need to find a way of evaluating learning that has taken place thankfully through the inclusion of ICT. Teachers don't only want a technological environment but a support service at the University that helps to resolve problems and improves the quality of work.

Multiple works show this reality in the current education system. The use of technology in education may have the aim of developing the cognitive capabilities of individuals. It also has a focus on the collaborative work and networks the development of participation and citizenship.

The work done by ***Washington Antonio Cevallos Gamboa***, *''Development of a frame of reference for the development, transfer and evaluation of ICT in Universities''*[4], managed to show that not all institutions of higher education will introduce institutional changes consequential to ICT.

The use of technological tools in academic milieus is more common every day and teachers are discovering the benefits of involving them as support for classroom training. Sometimes the quality of the material is poor and as a result learning in such virtual environments demands a lot of work on the part of the teacher. However this can be avoided if a serious evaluation of the employed technology and application is considered.

Other authors like Salina, with his use of flexible models as a response to the society of information in Universities argues that it is necessary to adopt flexible models of teaching and learning that exposes the need to incorporate ICT in higher education as a response to changes in today's society. Likewise, Camargo (2012) with his dominating work "Incorporation of ICT in the mathematics classroom in the basic primary education centers" aims to promote the use of technological tools and recreational materials in the teaching-learning process of mathematics by optimizing academic performance. The author believes that with these tools students will be attracted to a dynamic environment and most strikingly; this will reduce the damaging perception that people apparently have about the difficulty of math.

### C) Role of the Teacher.

At present, the teacher must respond effectively to the changes and the demands of the milieu thereby modifying the way in which he or she carries out the teaching-learning process. It is therefore necessary that the teacher assumes a more active and proactive role with a basic management of technology and additionally possess certain characteristics that would facilitate work with this type of tool in the classroom.

The teacher can participate in the never ending formation of a more participatory and flexible multi-directional learning environment since with the use of technological tools one can point out in both directions that they are attractive and allow access to environments of learning; the personalization of learning, greater flexibility in studies, proximity to the teacher, ample educative instruments, companionship and collaboration.

### D) Software and ICT resources.

Software, technological resources and communication tics are currently means by which students study and have fun relationships. This makes the implementation of software and education evident and offers the possibility of producing modifications to provide the answers and requisite actions with immediacy and fluidity whiles allowing among others, dynamic exploration and a control of a sequence of actions.

With the same construction, it is possible to visualize various situations. For example; building the heights in an acute-angled triangle and then transforming it so that it is obtuse-angled or a rectangle to what happens to the heights. Furthermore, generating circles of different sizes to measure its perimeter, radius and diameter with ''three clicks''.

Multiple forms of representation in the same interactive; textual, graphical, tabular, iconic spatial and spatial hearing. Given that the concepts are materialized through a means of representation and the learning of concepts associated with the development of the ability to translate from one to another type of presentation, dynamic exploration, the passage from one to another and the opportunity to discover information that was implicit or as well force the student to create information to improve precision.

### E) Dynamic Geometry.

The introduction of the geometry software dynamic has revolutionized the teaching of geometry. The concept of dynamic geometry was introduced by Nick Jackiw and Steve Rasmussen (Goldenberg and Cuoco, 1988). This applies to computer programs which allow users to: move certain items by dragging them freely and observe how other elements can dynamically respond to changes in conditions after having done a construction. [12].

These geometry programs were designed for the specific intention of putting at the disposal of pupils an ambience of a micro-type world for the experimental exploration of elementary planimetry. Working with pencils, papers, rules and compasses gives a more or less exact representation though fixed and as a result exploration is limited. Majority of these programs convert the manipulative tools of graphical representation with the capacity of providing informative feedback with proposed activities that are more than ''looking at the screen.

## 3. FORMULAE

From the parameterization proposed by Bejarano (2007) these regular polygons and other figures can be constructed. [5].

**Construction of a Regular polygon with four sides.**

Are $P_1 = (x_1, y_1)$, $0 \leq \theta \leq 360º$ L=a ω= (360/4)=90º With the data you have provided, the 2 remaining points and their corresponding coordinates are found:

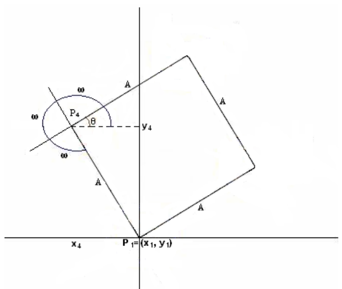


**Figure 1. A four sided regular polygon**

$x_2 = \text{LCos}\,\theta + x_1 \quad y_2 = \text{LSen}\,\theta + y_1$, Ec. (1)

$x_3 = \text{LCos}\,(\theta + \omega) + x_2 \quad y_3 = \text{LSen}\,(\theta + \omega) + y_2$ Ec. (2)
$x_4 = \text{LCos}\,(\theta + 2\omega) + x_3 \quad y_4 = \text{LSen}\,(\theta + 2\omega) + y_3$ Ec. (3)
$P_2 = (x_2, y_2)$, $P_3 = (x_3, y_3)$ y $P_4 = (x_4, y_4)$ Ec. (4)

**Construction of a rectangle.**

For $P_1 = (x_1, y_1)$, $0 \leq \theta \leq 360º$ $L_{1\,y\,3} = a$ $L_{2\,y\,4} = b$
ω=90º With the data you have provided, the 3 remaining points and their corresponding coordinates are found:

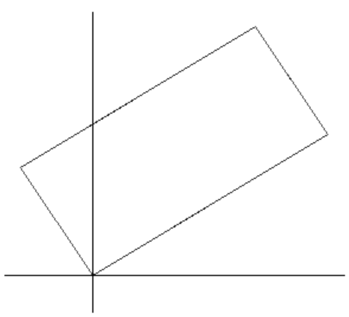

Figure 2. Rectangle

$x_2 = \text{aCos}\,\theta + x_1 \quad y_2 = \text{aSen}\,\theta + y_1$, Ec. (5)
$x_3 = \text{bCos}\,(\theta + \omega) + x_2 \quad y_3 = \text{bSen}\,(\theta + \omega) + y_2$ (Ec. 6)
$x_4 = \text{aCos}\,(\theta + 2\omega) + x_3 \quad y_4 = \text{aSen}\,(\theta + 2\omega) + y_3$ Ec. (7)
$P_2 = (x_2, y_2)$, $P_3 = (x_3, y_3)$ y $P_4 = (x_4, y_4)$ Ec. (8)

**Construction of a Rhomboid**.

With the following data, $P_1 = (x_1, y_1)$, $0 \leq \theta \leq 360º$
$L_{1\,y\,3} = a$ $L_{2\,y\,4} = b$ 0<ω<180º ω≠90º and ω+ω´=180º you can find the three remaining points in order to generate whatever rhomboid with the coordinates:

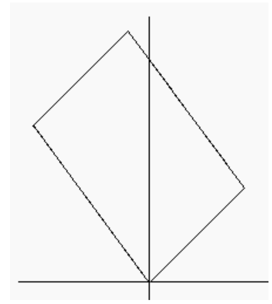

Figura 3- Rhomboid

$x_2 = \text{aCos}\,\theta + x_1 \quad y_2 = \text{aSen}\,\theta + y_1$, Ec (9)
$x_3 = \text{bCos}\,(\theta + \omega) + x_2 \quad y_3 = \text{bSen}\,(\theta + \omega) + y_2$ Ec. (10)
$x_4 = \text{aCos}\,(\theta + \omega + \omega') + x_3 \quad y_4 = \text{aSen}\,(\theta + \omega + \omega') + y_3$ Ec. (11)

**Construction of a Rhombus**.

Are $P_1 = (x_1, y_1)$, $0 \leq \theta \leq 360º$ L= a 0<ω<180º ω≠90º ω+ω´=180º. With the data you have provided, the 3 remaining points and their corresponding coordinates are found:

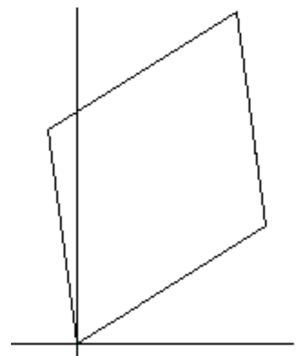

Figura 4. Rombus

$x_2 = \text{aCos}\,\theta + x_1 \quad y_2 = \text{aSen}\,\theta + y_1$, Ec.(12)
$x_3 = \text{aCos}\,(\theta + \omega) + x_2 \quad y_3 = \text{aSen}\,(\theta + \omega) + y_2$ Ec. (13)
$x_4 = \text{aCos}\,(\theta + \omega + \omega') + x_3 \quad y_4 = \text{aSen}\,(\theta + \omega + \omega') + y_3$ Ec. (14)

**Construction of an Isosceles Trapezium**.

Are $P_1 = (x_1, y_1)$, $0 \leq \theta \leq 360º$ $L_1 = a$ $L_{2\,y\,4} = b$. $L_1 = c$
A≠C, ω≠90º 0<ω<180º

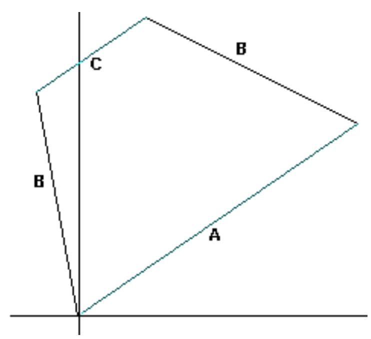


Figura 5. Isosceles Trapezium

$x_2 = \text{aCos}\,\theta + x_1 \quad y_2 = \text{aSen}\,\theta + y_1$, Ec. (15)
$x_3 = \text{bCos}\,(\theta + \omega) + x_2 \quad y_3 = \text{bSen}\,(\theta + \omega) + y_2$ (Ec. 16)
$x_4 = \text{bCos}\,(\theta + \omega') + x_1 \quad y_4 = \text{bSen}\,(\theta + \omega') + y_1$ (Ec. 17)

## 4. METHODOLOGY

This is an applied research with technological features, mediated through the methodology of research focusing on the quantitative approach. It is structured on a profound theory and is determined through technological knowledge. This allows the development of the technofacto mathematical application in the field of geometry, construction of quadrilaterals, demonstrating properties and relationships through the Dabeja Method and teaching strategies.
The project requires a population of students of the Faculty of Engineering, who possess expertise in geometry and mathematical applications in the first five semesters of civil engineering and systems. The sample is taken at a rate of 5% of the population that ranges between 25 and 30 students randomly chosen and possess basic knowledge in geometry.
The methodological process that arises is a sequence of consecutive step:
First, the application design which is a diagnostic to identifying problems and defining the types of software that should be designed. It identifies the characteristics and requirements of users and generates and inventory of the necessary pedagogic and didactic resources and further proposes the graphical representation.
The next step involves; programming, development of the application, and the adaptation to the hardware and software environment. This is achieved through the realization and revision of bibliographic materials in order to obtain the current subject-matter under discussion in engineering programs or courses. It creates the navigation map, adjusts the equipment, installs the software and builds the programming language together with graphs and movements necessary for the operation of the software and other multimedia tools.
In the third and final step the implementation of the application is realized. This leads to the installation of the prototype application and its development and testing processes with instruments of validation according to the criteria defined for the formation of thoughts in mathematics and the elaboration of manuals (user, installation and didactic guide). It also involves the training of users and the installation of the software. For the development of the software, the construction of prototypes methodology is used.

## 5. RESULTS

The software is designed in Java with a version compatible with the most available platforms. The abstraction of the problem was realized from the functional mathematical point of view with the main objective of breaking down the it's constituent and to parameterize the main equation. Thereby obtaining the following distribution of primary objects; Rectangle, Regular Polygon, Rhombus, Rhomboid, Scalene and Rectangular Trapezium.

**Graphical Mode**
The graphic mode is designed using 2D graphics offered by JAVA. The drawing methods and the main cycles are optimized for the selected drawing of geometric elements using time rendering methods and low consumption of computational resources. The calculation of the scales of the graph variables is related to the movement of the wheel of the mouse using a log based system based on the maximum lengths of the existing polygons to compute proportions of necessary scale measures and for it's visualization.

**Diagrams**
This case diagram represents the functions the educational software carries out.

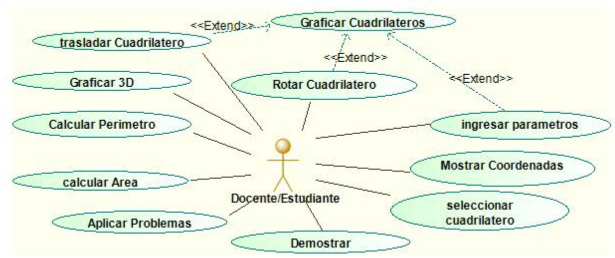

Figure 6. Case Diagrams of usages

Specific kinds of; Rectangles, Rhombuses, Rhomboids and Trapeziums inherit their methods and main attributes depending on their classes. Thereby, obtaining access to all the methods and attributes of this and extending them with their own specifics necessary for functioning.

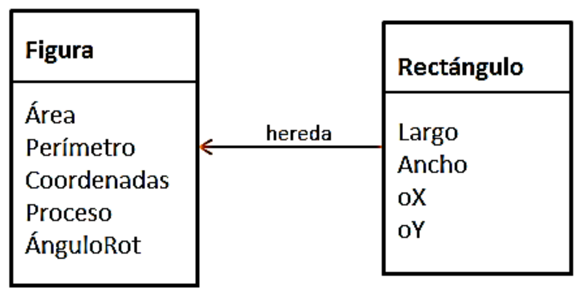

Figure 7 Inherited Diagrams.

**Main interface operation**
To gain access each of the functions that the software offers, a primary interface was realized by means of which the different modules can be seen.

Figura 8. Main Interface

On having chosen one of the options, the system redirects the user to the interface that corresponds to the selection in which the user can enter the required values to start the simulation of the geometrical model selected. See Figure 9 to 11

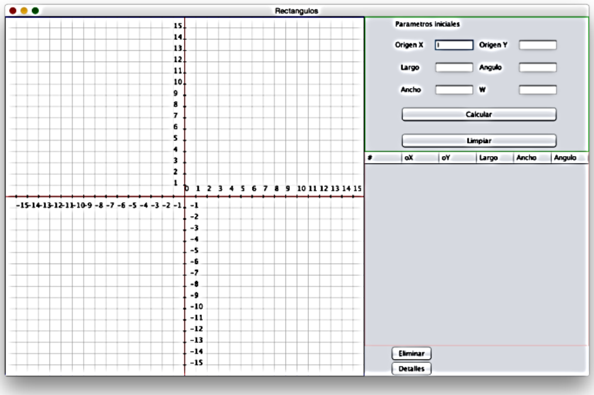


Figura 9. Rectangle no data interface.

The user enters the requested information and chooses the option ‘’Calculate’’

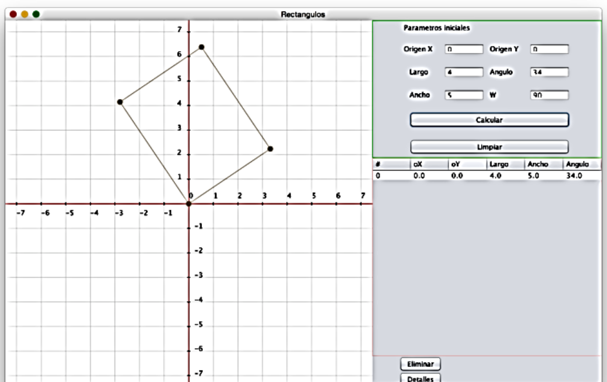


Figura 10. Rectagle interface with data and figures.

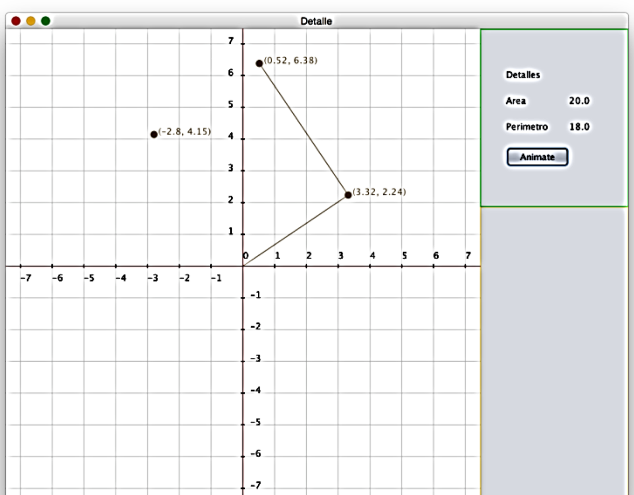


Figura 11. Rectangle with animation.

**Application**

Together with the software, students are allowed to identify other ways to construct quadrilaterals other than traditionally used methods. It is possible to see the state of learning of the proper components of every figure which initially was not taken into account under the traditional definitions of quadrilaterals and furthermore facilitates conceptual understanding.

This dynamic development in the classroom also allows students to have further arguments to resolve problems related to the construction of four-sided figures. The dynamic view of the software is a conceptual and operative tool where the component of each figure manages to differentiate and take into account the resolution of problems.

## 6. CONCLUSIONS

The parametrization of geometric figures allows the modelling of the programing language, the bi-dimensionality of educative resources that strengthen diverse mental structures and representational visualization that possess dynamic movements, transformations in the plane and identification of its structures.

It comprises the processes of construction and inference by using diverse resources for the design per the 2D Graphics offered by JAVA. Time used when drawing geometric elements by students is optimized and better programming is achieved in depth. Dynamic representation of mathematical figures that is supported with computer interfaces that accelerate the understanding of dimensional transformation from its components.

The use of the components of each figure from the parameters of the Dabeja method to differentiate one figure from another and offers high level arguments for the solving of complex problems.

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