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Technology and mathematics as a cognitive component

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Abstract. The objective of the study was to analyze the technological impact and cognitive attributes of technology for the construction of meaningful learning of mathematics students at Universities in Ecuador and Colombia. The sample was non-probability, with the participation of 1124 students. A mixed study of sequential explanatory design was applied. In the quantitative phase, correlational method, were applying a digital questionnaire, the data were analyzed through multiple regression and statistical analysis of nested variance to two variables demonstrating the need to implement mathematical software. In the qualitative phase, the mathematical software Wiris and Geogebra were implemented and results merged by the contrasting method. The conclusions demonstrate the impact of digital connectivity, distinguishing technology as a cognitive component through dynamic knowledge. The method was effective to the development of logical analytic thinking; boosted the activity of the right limbic lobe.

1. Introduction

The formation of critical thinking and the development of creativity are the most common objectives in curricula at all levels, however, methodologies and the teacher's ego sometimes lead them to an interest in neutralizing anarchic or destabilizing individuals from the educational system in the classroom [1]. In mathematics, technology has been used as a tool to encourage motivation or specific interest in learning, and has great intellectual or emotional significance for teachers. Then information and communication technologies (ICT) was considered excellent cognitive component that should be adapted as a didactic resource as soon as possible, taking the classrooms to take advantage of the possibilities offered in different areas and educational levels; teachers have considered that its use allows the mind to initiate tasks, search for and retrieve memories, words, expressions, ideas, events, images, melodies, actively sound out modular devices and integrate their content into a recognizable memory, rich in meaning personal [2]. However, there are other challenges that allow us to understand how the student understands, how he acts and most importantly how his cognitive skills are enhanced; for this reason, the process in mathematics in university, has become in recent years a very complex and principal task, as it presents a fundamental basis in the study curriculum of the degrees offered by the universities under study [3]. To this end, teachers of mathematics and sciences are often faced with changing and innovative teaching needs, which have to have greater attention by those engaged in research in the field of arithmetic and, above all, the development of micro-curricula and rubrics to address subject's mathematics.



Within this order of ideas, the application of resources and strategies ICT in mathematical, plays an important role in the cognitive flexibility's of students [4], since it allowing a greater view problems and weaknesses in attention differently, make connections between executive ability and abstract thinking of students to facilitate the construction of significant; hence the importance of study to promote the use of ICT as an andragogic resource. From this perspective, analyzed series of phenomenological analyses in the students, as well as in analyzing behaviors and observing what activities were empowered in young people by stimulating them.

2. Methodology

The research was mixed [2] incorporate method of the analysis quantitative and qualitative, as well as their integration and joint discussion. The first phase used as instrument a questionnaire [5,6], with Cronbach alpha coefficient = 0.898, *i.e.* high reliability [7]. Survey technique, used to obtain effective information from the student population, which was quantified through selection non-probability type [8], with the participation of 1124 students in San José de Cúcuta and Bucaramanga, Colombia of the “Universidad Francisco de Paula Santander” and “Universidad de Santander”, as well as the “Universidad Internacional del Ecuador” in Quito and “Universidad Nacional de Loja” in Loja, Ecuador.

In the quantitative phase, used a questionnaire, structured by ten key questions subdivided into variables digital connectivity and cognitive influence, which had as answer options “totally in agreement”, “in agreement”, “indecisive”, “in disagreement”, “totally in disagreement; both variables are merged to perform a multiple regression statistical analysis. In the analysis of the variable digital connectivity as a cognitive influence, the results of the first variable defined digital connectivity as cognitive influence. A statistical analysis of multiple regression [8], grouped in units. During the second phase of research of semester A-2018 the version of the Geogebra and Wiris [3] was applied. An open and direct relationship was established between methods, researchers and students when applying technological equipment and programmatic software. As a key instrument for the collection of information during the second phase, was applied the digital participant type observation guide [3], to interpretative analysis, determines families and emerging categories, weighs according to percentage of similarity and determines associations between them from triangulation [9] and results are contrasted [10], analyzing coincidences and differences [11]. The data obtained in the first phase were verified, as well as the qualitative information. The contrast or triangulation was carried out with the theoretical support of several authors, carrying out an exhaustive and explanatory analysis of the results. The observation is compared with Cazau's models [12]. The inter-subjectivity, therefore, as unit segment in research [13]. Meanings in the mathematical software was a cognitive component that facilitates the construction of functional memory and inhibitory control [11] to learning in mathematical and sciences.

3. Results

The implementation of the Wiris system and Geogebra was motivating and didactic tool, students showed high percentage (90%) optimism, indicated motivate in the use of mathematical software but is necessary investigation and simulation of the events to appropriations and think development; the 50% considered technological equipment's as an intellectual distraction, but when requested by the teacher in all research, it is considered by the student body in a participatory, appropriate and understandable way. An 80% indicated that worked in virtual groups in mathematics classes. In administrative and research performance, every teacher appreciated that when students join or form a research group, they can transmit knowledge. Attaining level medium as the rest of the team, educational competencies are formed associate concepts of limit, variances and geometric analytic in 2D and 3D. The application of language math and solved problems with interaction virtual from structuring ideas, reintroduced, opening up to self-evaluation, hetero-evaluation and student group co-evaluation. Analyzing the results, 90% of the university students reported that they fully agreed to perceive a virtual link to networking, turning advance collectively towards the acquisition of the competencies researched. Digital activities increased the possibilities of complementing and improving teaching and learning processes, ICT allowed the creation of new online learning.

Virtual environments provided from cognitive structure student's centered used of models and optimization. ICT reconfigured practices of teachers, item associated demonstrates the interest of applying a digitized mathematical, improves design, perspectives in dimensions, inclusion of time as a representative variable, where the majority (80%) agreeing completely were considered digital natives, adding up to 10% who agreed and 10% feeling undecided, interest for games, red, twit, live video. Student and teacher, as soon as directors, just like university students, considering that they feel better evaluated through the on-line digital system. According to the questionnaire the 80% of the students totally agree when they say they are enthusiastic, visualizing that their teacher is updated with the technology, the 20% of respondents can interact and think in math conceptions and they have better reception of data.

Analysis of the variable development of mathematical thinking through software, showed that the learning acquired by mathematics students analyzed as a unique subject or excluding area, isolated from the other areas of university education, with a weighting of 10% that reveals to be undecided, plus 80% of those surveyed who claim to disagree and finally, 10% who disagree totally. The mastery of this science facilitates the way in which human organize results from formal or post-formal thinking according to their level of development. In this way, working in teams, they were agile and dynamic, facilitating a suitable climate for working. Therefore, students alone do not feel comfortable developing mathematical thinking, through digital networks. Researchers pointed out that the classroom derives from logic, where it was necessary to group or subdivide students. It should be noted that the results indicated that 90% of respondents fully agree some software in geometry, topology and analysis math. This demonstrates the need for the university to establish significant practices, as soon as, tool construction as software.

Assume this work in and out scenery educative was inferred, in order to, quality in the teaching of mathematics, the computer should be applied as didactic material to every institution in order to obtain significant learning. The students are interested in studying mathematics, especially with sequence didactic, experimental, when they see different methods of study and is permitted think lowly. Since to 60% considered the classes were not passive, and under this quality it is allowed to intervene voluntarily in the oriented activities. On the other hand, the evaluations, contrary to exposit [10] what conducted by assessors have high level, the techniques with used technology caused interest. The residual value was 4.279 (Table 1), considered positive, being the value closest to the highest index [13]. It does determine whether there is an objective interrelationship, where the dependent variable digital connectivity as cognitive influence presented a continuous measurement level.

Table 1. Bi-directional statistical data.

	Sum of squares (N=1124, df=1)	Middle square (N=1124, df=1)	F (N=1124, df=1)	P
Regression	5.149	5.149	55.350	0.000
Residual	4.279	0.093		
Total	9.428			

The data established in a parametric way, raise the assumption that variables were depends, when distributed sequentially, analysis of variance (ANOVA) also assumed the homogeneity of the variance [14], which means that the variance between the two groups (variables) were of equality, *i.e.*, directed to the same objective of study. In other hand, the correlation between syntax and logical questions is high ($r = 0.75$), and between syntax and logical relationships, which allows inferring that syntax is an element to solve logical (everyday) questions in program, but in order to establish logical relationships (relate logical concepts to basic mathematical operations). There is a correlation between the syntax and the logical problems $r = 0.69$, it can be inferred that at the time of abstract and classify information for the solution of logical problems the syntax if it has incidence. The correlation that exists between semantics and each of the sections of the mathematics questionnaire is low [15], which would allow us to affirm that the meaning of the words is not relevant to the performance of the questions. The existing

correlation between pragmatics and the logical relations when being of $r = 0.71$ is high, it is considered a moderate relation between the pragmatics with logical problems and pragmatics with logical relationships by obtaining a correlation coefficient of $r = 0.61$ and $r = 0.63$ respectively which shows the influence that the reading using tic has on the mentioned components. There is a linear regression between digital connectivity and cognitive influence, residues showed a linear trend in which it can be concluded that the assumption of normality has not been violated [16]. The line correctly describes the distribution of the waste and therefore concludes that it does not violate the assumption of normality. Logarithmic and curvilinear exponential analysis were also considered. The regression analysis adjusted to these two mathematical functions of the calibration data indicates that the linear equation is statistically significant because it has its central point of intersection above value 4, or above value 3 appreciated as the mean value of the questionnaire response scale.

In the qualitative phase, the students were more original and independent, leaders in their group, innovative and creative, risky, they liked the unexpected and were willing to make new experiences, they looked for other types of software to support themselves and make 3D visualizations. When faced with a problem, they were amazed by their ability to retain the essential and propose multiple solutions. Some often proposed interesting and innovative rules and actions. They were more relaxed and inattentive when the matter seemed too prosaic. At times imprecise, disordered, their exhibitions initially lacked rigor and prefer to make fantastic plans to solve everyday problems, they expressed displeasure at being forced to follow instructions or reflect with limits. The varied classes, with concrete graphic interruptions, games, imaginative works empowered them the capacity to create, to expose ideas and to try to innovate, *i.e.*, a pedagogy based on the imagination, openness, the breakthrough. Therefore. the use of the operating systems Wiris and applications in architecture, engineering, biology from field data analysis on population growth and its correlation [17] at universities for 16 weeks, distributed over two hours per week, was observed to provide a high environment intellectual expressed in the social environment and climate in a natural way. In the study, the identity crisis, was eliminated as a belief that aberrant, extravagant behavior is part of adolescent confusion or that depression makes one of the many vicissitudes of adolescence reactive. The student goes through an existential process that forces him or her to compose several images of himself, as a friend, youth, student, leader, man or woman. Under the incursion of the mathematical software, observed personal development's, established rules, to redefine and to put to test the reliability and affirmation of itself, in the encounter of the own identity, cornerstone in the construction of the being. The students verified their constructs, conceptions in math and geometry, through their exercises searching among their equivalent peers for the solutions of their activity. ICT as a tool of current development, allowed students to interact with functions, concepts in math, they established roles to resolving problem, procedures, short routes from process optimization, work with matrices, graphs, adjustments and correlation of functions. the programming allows them to develop their creativity, and move to higher level stages to make inferences, generalize, establish rules and propositions.

In addition, the distance mathematics curriculums changes, was an open scenario of motivation. The mathematical problems raised by the researchers in the activities created critics compartment, recovery of past experiences, allowing them to understand formulations, through images and graphics, and then look for solutions to build meaningful thinking, analyzed that almost 60% of the total number of messages reduced the evidence of indicators of cognitive interaction, allowing to process effectively yours developed. The formative value of academic peer mediation was evident, between technology and mathematics learn observed. Most of the exercises [18], were offered with the opportunity to be chosen. For the students it was comfort to design action plans, to organize the necessary resources (cognitive, material, documentary, technological) available to carry out the task of making decisions. In general, it was considered to privilege teamwork, since it not only allowed the development of cognitive skills, but is also a very effective way to learn and thus be able to conceive the qualities that the Wiris and Geogebra programs grant to advance significantly in mathematical logical reasoning, through communication with other students.

According to the triangulation of the data obtained in the quantitative and qualitative phase of the research, the praxeology family is constructed defined by Chevallard as an entity of operative and discursive practice systems [19], in this family, emerging categories were signs, symbols, mathematical language, pragmatic comprehension, role-playing in teamwork, semiosis; another family that emerged was the epistemology associated with categories context, practice, roles, research; the family conceptual entity associated with programming, propositions, procedures, argumentation, validity, mathematical models, functions; personal meanings with categories of motivation, proposition, creativity, emotional.

4. Conclusions

Tic was effective to the development of logical analytic thinking; boosted the activity of the right limbic lobe, students characterized more original and independent, leaders in their group, innovative and creative, risky. family emergent was the praxeology with operative and discursive practice systems; another family that emerged was the epistemology associated with categories context, practice, roles, research; the family conceptual entity associated with programming, propositions, procedures, argumentation, validity, mathematical models, functions; personal meanings with categories of motivation, proposition, creativity emotional.

The correlation between syntax and logical questions were high and between syntax, logical relationships, time of abstract and classify information for the solution of logical problems. There was a linear regression between digital connectivity and cognitive influence. The syntax had incidence with logical problems and pragmatics.

Mathematical software stimulates the development of logical-rational thinking as a constructive process. Its function is to provide a guide that facilitates exploration and discovery. The digital environment provides a state of freedom and support among students.

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