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Computational Thinking in Geometric Concept Construction Using Geogebra Software

Abstract: - The knowledge era has allowed new ways of interacting with peers and socially, which allows the promotion of social skills and abilities associating the components of computer science, in order to manage the use of Technology and Information and Communication Technology (ICT) in the resolution of geometric situations in the practice of construction, elaboration and interaction with geometric prototypes detected in reality and simulated by GeoGebra software in university students. For this purpose, a non-experimental design of comparative descriptive level was applied, in which sessions with interaction of geometric contents and indicators of computational thinking were developed during seven weeks of classes. The development of the experimental activities allowed the resolution of practical situations detected in the process of: design of plans, organization of analytical components of data through abstraction, solutions of specific and complex situations through the heuristic and algorithmic method, in the challenge of creating new geometric prototypes, exploring new ways of learning geometry, creating challenging situations in producing figures through the software under the basic and fundamental principles of the software leading to the development of computational thinking of the students under observation.

Keywords: Computational thinking, Geometric concept, GeoGebra, Information and Communication Technology.

I. INTRODUCTION

In principle, computational thinking (CP) arises approximately 2006 from the positions of Computer Science (CC) [1] emphasized in the (ACM), Association for Computing Machinery of USA,, [2], it arises as a proposal of a skills to solve complex problems necessary for people [3], PC is also understood as a skill oriented to abstraction, selection, generalization, compliance with algorithmic rules, decomposition to understand the object of study, who carry and decide how to solve the problem with the support of technology.

On the other hand, [4]. Computational thinking is understood as a sequence of higher and lower cognitive processes not necessarily the use of technology, under this premise, it is considered as a unique requirement to a person who computes, to [4] mentally process mental tools to deal with computational problems, i.e. problems that is solved computationally. [5] the PC today, is fundamental to expand mental capabilities, for its part [6] refers to the skills involved in learning and the manifestation of adaptive behavior to adverse situations, allowing the management of complexity and automate personal tasks and face complex tasks.

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Under these arguments, [7]–[9] teacher training students, present challenges to face the technological world, where society and those who conform it present computational skills, besides making use of superior mental processors who are supported with computational tools. The experts according to [7] computers and other computational devices are the ones that allow achieving the PC, claiming that the relevance of computational thinking is precisely that computers can execute our computational thoughts and that computers begin to be our partners and collaborators in our discoveries.

[6], Computational thinking is a type of analytical thinking, Computational thinking is a set of knowledge in STEM (Science, Technology, Engineering and athematics) areas introduced in educational programs for the student to understand the use of digital media and tools, such that they influence the economy, culture, communication and social relations rescuing analogical educational practices and local cultural traditions. [9], Computational Thinking is involved in formulating problems and finding their solutions so that the solutions are represented by an agent that processes information, [8], the goal of PC is to permanently develop critical thinking and problem solving skills based on the concepts of computing, such as abstraction, algorithms, programming, simulation, among others; [8] allowing us to recognize the computational benefits of the world around us, and the application of computer science tools and techniques to understand and reason about natural and artificial systems and processes.

In the arguments of [1], The PC presents as a premise within university institutions, where students can use own skills in the field of computing for problem solving in other similar fields, since problem solving is one of the necessary skills of the XXI century. While [3], PC is one of the necessary skills in literacy for the 21st century, since it is the influence of robotics in the learning process in different areas of knowledge, [2] argues that PC and creative are related, since the loop component related to repeated actions allows creative thinking and fluency, originality and flexibility stimulating heuristics in the student.

Geometric thinking, [10] demands the acquisition of geometric knowledge thanks to the concrete visualization of abstract concepts, even more so when dealing with the application of software such as GeoGebra and Cabri II Plus, since being visible shows genuine and committed participation in the construction of geometric figures. [11], the enrichment with the use of virtual environments for learning and the strengthening of the didactics of geometry with the use of digital resources allow dynamizing the formative processes of geometric knowledge.

The study focused on the validation of the GeoGebra software as a relevant tool to reinforce the learning of the concept of geometry and detect the conceptual evolution from undefined concepts to the abstract strengthening the spatial thinking of teacher training students. [12], [13], it has been detected that in classrooms, constructions with ruler and compass are being abandoned, that is, geometric work is being abandoned, although this is a good way to learn to analyze geometric properties and to promote argumentation allowing the development of thinking.

II. EXPERIMENTAL

A. materials

According to the arguments and didactic sequences, the study was framed within the non-experimental design of longitudinal comparative descriptive level according to [14], the studies under this modality allow to describe comparatively the visible indicators between two or more study samples with common characteristics. For this purpose, we have assumed students from two universities that share geometric contents in the curriculum, who were treated during 2 months of class for a total of 32 teaching hours. The study samples were students from a public university with 26 students and a private university with 49 students.

B. Experimental sexuality

The application of GeoGebra software was developed in the students of both institutions, which were applied the didactic sequences; where they have the geometric contents associated with the components of computational thinking according to [15].

C. Component identification

The sequence, according to [2], is composed of conceptual manifestations, in this regard the procedures have been set during the construction of the elements of geometry such as: parallel lines, perpendicular lines, bisector and bisector, to the effect spaces were generated for the student to process, analyze, detect conceptual internal sequences for the generation of geometric traces, to then access the GeoGebra for the construction putting in evidence their previous planning and the actions ordered for the requested sentence.

In the sequence of conditionals, as for [4], it is assumed to the processes of controlling the flows of ideals and the use of computer tools, with respect to the detection of this aspect, students conceptually detected the sequence of construction and the use of GeoGebra during the various traces sequences from geometric points. With respect to the functions component, ([16], it refers to the actions that involve the commitment to execute and carry out the tasks through the fluidity of ideas accompanied by the use of tools. In reference to the planned ideas of the student put in evidence during the use of GeoGebra tools, who repeat the task until the detection of the requested sentence.

Regarding the loop component, [17] states that the repeated processes by way of practice of a requested action, covers the slogans making use of mental competences accompanied with the use of tools, in this regard the student for the achievement of the construction of geometric figures, they achieve the slogan by the repeated times they surface their concepts and assume with responsibility the software tools. Regarding the event component, [18], understood as the events that trigger the sequences for the achievement of the sentences, who assume their ideals generated and matured by the conceptual interactions to then put them in evidence during the geometric constructions.

As for the dimension of operators, [19] it consists of the use of symbols during the arithmetic operations associated with the interactions of geometric thinking, in this regard during the constructions with GeoGebra, the student evidences the need to use symbols for the elaboration of the requested sentences, who assume with logical sequences. Finally, the component of the variables, [15] are assumed as that the events show diverse values that are systematized in symbols with susceptible quantities in comparison, in this respect the student shows diverse nomenclatures that in his cognition of the student internalizes a value, that this is materialized during the elaboration of the geometric figures in a reasonable way keeping equity and posture during his geometric construction through the use of GeoGebra.

III. RESULTS

According to the components of computational thinking and the distribution of the research sample, the following are the results in: concepts, practices and computational perspectives associated with the use of GeoGebra software as a support for the study.

The data shown in the tables correspond to the research database and were prepared by the researchers, which are shown and detailed below.

TABLE 1. Description of geometric concepts by the use of GeoGebra software according to computational thinking capabilities

Capability/ components	Public University (n=32)		Private University (n=42)		Statistic	Significance	
	Mean	Deviation	Mean	Deviation	U Mann Whitney	p_value	sig.
Sequences	1.97	1.062	1.64	0.932	1442.0	0.129	n.s.
Conditional	1.59	1.188	1.357	1.165	1501.5	0.407	n.s.
Functions	2.03	0.897	1.40	1.369	1371.0	0.021	p*
Events	2.16	1.081	1.55	1.041	1352.0	0.011	p**
Loop	2.06	0.948	1.26	0.912	1283.5	0.001	p**
Operators	2.13	0.751	1.40	1.191	1336.5	0.007	p**
Variables	2.09	1.088	1.29	0.995	1292.0	0.001	p**
Conceptual	14.03	3.090	9.85	2.541	211.0	0.000	p**

Source: Authors data base, own elaboration.

The results shown in the table show the comparative statistics of the geometric concept capabilities through the use of GeoGebra. Regarding the sequences component, the students of both institutions were able to develop computational procedures associated to their creativity, confidence, data organization; detecting the statistics of (mean, deviation) (1.97; 1.062) and (1.64; 0.932) of the students of a public and private university respectively with p_value>0.05 and sig. n.s. (not significant). Likewise, we have the conditional ability, which includes tolerance, the ability to liar and resolve the conflict in front of the use of the tools during the elaboration of geometric figures, detecting (1.59; 1.188) and (1.357; 1.165), also p_value>0.05, we affirm that the students achieved the initiative to generate computational thinking through the use of GeoGebra in the construction of the geometric concept.

While the results the ability of the organization and logical analysis function, the automation of solutions and identification of possible solutions with the to achieve the effective combinations of computational thinking, of have detected significant differences between the scores, since the p_value <0. 05, it implies that the achievements address the tasks of geometric construction by means of the software, under this same direction, we have to the results of the component of the events, in this aspect, the students managed to conceptualize the sequence for the construction of the geometric figures, nevertheless there exists significant difference since the students of the one diversity publishes internalized in better level the sequences of the elaboration and the functionalities of the software since p_value<0.05 representing p**.

With respect to the capacity of repetitive executions of the loop, the students demonstrated metacognitive processes, reflective of their actions during the geometric construction activities using patterns associated with technology in geometric construction, these actions demonstrated that p_< 0.05 and p** detecting significant comparison. While in the ability of the use of operators, which allowed the analysis of possible solutions through algorithmic sequences led to logical solutions, detecting difference between groups according to the statistics in the table and that p_value <0.05,. Finally, as for the capacity of the recognition of the variables that are observable part within the abstract thinking and the symbolic representation of the data allowed the use of the geometric concepts for the elaborations of the figures and to associate them to the information system by means of the use of the software, in addition difference is shown between the groups of study _value<0.05, p**.

Finally, in the component of the geometric concepts by the use of the GeoGebra software according to the component of the computational thinking of the students, significant difference of comparison have been detected, since the students of the public institution managed to identify and assume the commitment of the theoretical information for the geometric construction and strengthening the computational thinking so as it is appreciated at p_<0.05 and p** demonstrating high comparative statistical significance between the study groups.

TABLE 2. Description of the practices in the construction of geometric figures by the use of GeoGebra software according to the computational thinking skills

Capability/ components	Public University (n=32)		Private University (n=42)		Statistic	Significance	
	Mean	Deviation	Mean	Deviation	U Mann Whitney	p_value	sig.
Sequencies	2.09	0.995	1.71	0.918	511.5	0.067	n.s.
Conditionals	1.91	0.963	1.738	1.127	625.5	0.596	n.s.
Functions	2.22	0.792	1.71	1.088	502.0	0.051	n.s.
Events	2.47	0.803	1.86	0.899	407.0	0.002	p**
Buckle	2.38	0.833	1.60	0.885	350.5	0.000	p**
Operators	2.25	0.718	1.74	1.106	504.5	0.055	n.s.
Variables	2.50	0.672	1.57	0.966	310.0	0.000	p**
Practice	15.81	1.920	11.880	2.520	149.5	0.000	p**

Source: Authors data base, own elaboration.

In reference to the practical actions in the use of GeoGebra in the construction of geometric figures, we have the abilities that show no significant difference, p_value>0.05. With respect to the ability of the sequentially of the practical processes in the construction of geometric figures prior organization of the ideas and simulations of the processes in the presentation of geometric figures, while, in the conditional ability, they detected sequence to bring out complex thinking, likewise, we have the abilities detached during the use of the functions of the software tools in the construction of geometric figures, while in the abilities of the use of the operators, who allowed the processes of problem solving prior implementation of the conceptually elaborated algorithmic plans.

As for the capacities that showed significant difference p_value< 0.05, we have the events, which allowed the development of the elaboration of sequences during the practical executions in the geometric constructions, likewise we have the capacity of repeated executions known as the loop, detecting repeated actions of the patterns with logical and sequential reasoning. And with respect to the characteristics detected with different changes assuming different behaviors with respect to tolerance, ambiguity, the capacity of the automations in different resolutive processes, it is thanks to the information processing with the support of the software during the constructions of the geometric elements.

The statistical result in reference to the practical actions during the construction of geometric figures by the use of GeoGebra software and the emergence of abstract mental thinking reflected from reality during the construction of geometric figures, appreciating a significant difference of comparison between the detected scores.

TABLE 3. Description of computational perspectives on the construction of geometric figures by the use of GeoGebra software according to computational thinking capabilities

Capability/ components	Public University (n=32)		Private University (n=42)		Statistic	Significance	
	Mean	Deviation	Mean	Deviation	U Mann Whitney	p_value	sig.
Sequencies	2.22	1.008	2.57	0.859	411.0	0.233	n. s
Conditionals	2.22	0.975	2.23	1.078	345.0	0.162	n. s
Functions	2.41	0.665	2.31	1.115	303.5	0.071	n. s
Events	2.56	0.669	1.50	1.018	282.5	0.000	p**
Buckle	2.50	0.718	1.21	0.871	198.0	0.000	p**
Operators	2.44	0.619	2.12	0.993	208.0	0.101	n. s
Variables	2.56	0.679	1.35	0.512	189.0	0.000	p**
Perspective	16.91	2.530	9.07	2.161	18.0	0.000	p**

Source: Authors data base, own elaboration.

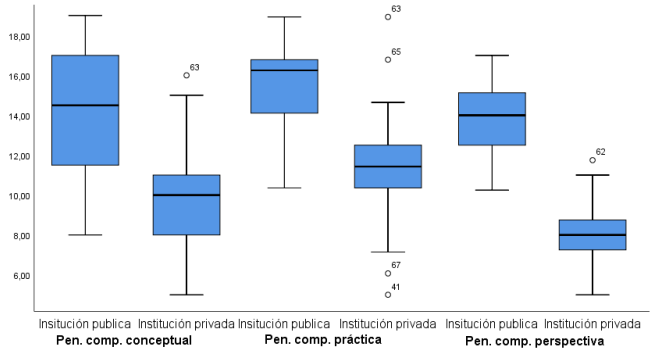
With respect to the computational perspectives in the elaboration of geometric figures through the use of the software. With respect to the sequential component, conditionals, functions and operators, the students as a whole

managed to detach the sequences, to the effect, the participants managed to generate mental prototypes that with the support of the software consolidated their ideas, no difference was evidenced between the groups since p_value<0.05. With respect to the events component, the students of the public modality, detached diverse practices of perspective character with the purpose of consolidating the computational thought, in the same way in the actions of the loop significant difference has been detected, being based on repeated and recurrent actions of the prototypes of the perspectives until the achievement of the sentences. Finally, in the component of the variables, significant differences were detected between the scores in comparison p_value<0.05, observing that the students detected varied values and characteristics during the perspective process in the idealization of the geometric construction.

In reference to the component of perceptions to the development of mental prototypes in terms of geometric construction through the use of GeoGebra software, students demonstrated significant difference in a comparative way, since p_value<0.05, moreover it is significant in a comparative way p***.

A. FIGURE 1. Thought comparison diagram.

The development of the diagram was based on the data detected by the researchers and prepared by them



Source: Authors data base, own elaboration.

IV. DISCUSSION OF RESULTS

The results show that the components of computational thinking: concepts, practices and computational perspectives associated with the use of GeoGebra software, allow the traits to be evidenced, for this purpose they have been experimented in two university institutions detecting significant differences in: events, loops and variables in the three computational thoughts, for the differentiated detection or equivalent in the sample, experiments were put on the thematic contents of the subject of Geometry, by its nature of the course, sequences of inductive processes are detected and were embodied in the construction and elaboration of geometric figures making use of the software tools.

In the study of [1], the PC is a skill to solve complex problems, who is shown in the prototype of geometric figures in instance of mental to then translate into concrete by means of the software, this same perspective is addressed by [3], who adds processes of abstraction, selection, generalization, compliance as part of the PC, to this he shares the arguments of [4], who points to higher and lower cognitive processes as a unique requirement to a person who computes.

Under these arguments, the didactic sequence has allowed to develop the sequences of the idealization of geometric construction linking with the conditions for the presentation in a concrete way thanks to the previous work mentally in the concretion with the later support of the sofware, [7]–[9] the students present challenges to face the technological world, that this premise puts closer the student to access computational and mental processes for

the computational performance within the educational to do.

In addition in the components of the functions that has allowed associating and linking mental ideas in a concrete object as are the sheets with geometric representations thanks to the events repeatedly, in many opportunities as own processes of their interest to conceptualize and capture the mental prototypes in a sheet of geometric figures, in reference to [9], Computational Thinking is involved in formulating problems and finding their solutions so that the solutions. Within the practice of software management, the functions of the tools are indispensable, who allows the solidity and the presentation of the planned objects in an objective and evident way thanks to computational thinking, on the other hand [10], demands the acquisition of geometric knowledge thanks to the concrete visualization of abstract concepts, even more so when dealing with the application of software such as GeoGebra that were developed throughout the experience.

V. CONCLUSION

The development of the experimental activities during the learning of the construction of geometric figures with the support of GeoGebra software, has allowed the resolution of practical situations detected in the process, as in: design of plans, organization of analytical components of data through the abstraction of concepts and geometric relationships, solutions of specific and complex situations through the heuristic method; in terms of the innate way of organizing a geometric and algorithmic creative resolution through the use of expressions and theorems, in the challenge of creating new geometric prototypes, exploring new ways of learning geometry, creating challenging situations in producing figures through the software under the basic and fundamental principles of computer science has led to the development of computational thinking of students in observation.

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