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Implementation of educational technology for the development of computational thinking in fourth grade children in a public educational institution in Colombia

Implementando la tecnología educativa para el desarrollo del pensamiento computacional en niños de grado cuarto en una institución educativa pública de Colombia.

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ABSTRACT

Keywords:	Statistics are becoming more and more important in the teaching of mathematics, being an essential part of the curricula and school environments, for which this project seeks to solve a problem that was detected in the Ciudad Verde educational institution and that is related to the prediction, interpretation and calculation of probabilities in fourth grade students. When carrying out an analysis, it was possible to show that it is necessary to strengthen these probabilistic knowledge that are fundamental in the learning processes of students and that in fact are part of the daily context; therefore, the purpose is to seek that children are able to function in the community and with the skills to take on the challenges of innovation and change demanded by today's society, where information and communication technologies have gained more and more relevance in the training of students. In this way, the project incorporates the tools Schoology, Scratch and the application of computational thinking with a STEAM model, which will support the pedagogical strategy to solve the problem with the students under study of the Educational Institution, the results of the research allow demonstrate the strengthening in problem solving in probability issues using computational thinking through Scratch.
Probability, Random, Computational Thinking, Mathematical Competencies, Scratch, Schoology	

RESUMEN

Palabras clave:	La estadística cada vez cobra más importancia en la enseñanza de las matemáticas siendo parte esencial de los currículos y los ambientes escolares, por lo cual este proyecto busca dar solución a una problemática que se detectó en la institución educativa Ciudad Verde y que está relacionada con la predicción, interpretación y el cálculo de probabilidades en estudiantes de grado cuarto de primaria. Al realizar un análisis se pudo evidenciar que es necesario fortalecer estos conocimientos probabilísticos que son fundamentales en los procesos de aprendizaje de los estudiantes y que de hecho hacen parte del contexto cotidiano; por lo anterior la finalidad es buscar que los niños estén en la capacidad de desenvolverse en la comunidad y con las habilidades para asumir los retos de innovación y cambio que exige la sociedad actual, donde las tecnologías de la información y comunicación han ganado cada vez más relevancia en la formación del estudiantado. De esta forma el proyecto incorpora las herramientas Schoology, Scratch y aplicación del pensamiento computacional con un modelo STEAM, lo cual apoyará la estrategia pedagógica para dar solución a la problemática con los estudiantes objeto de estudio de la Institución Educativa. Los resultados de la investigación permiten evidenciar el fortalecimiento en la resolución de problemas en temas de probabilidades haciendo uso del pensamiento computacional mediante Scratch.
Probabilidad, aleatorio, Pensamiento computacional, competencias matemáticas, Scratch, Schoology	

Introduction

Mathematical and statistical development in daily life is a fundamental part of learning processes and school curricula, because it helps to strengthen the way in which human beings perform calculations and analysis in problem situations, involving statistics as well as the study of probabilities and interpretation, especially in fourth grade students, Likewise, it is evident that education should not be exclusively the acquisition of certain knowledge, but on the contrary, it should focus on the development

of capacities and abilities of students to assume the challenges of innovation and change that today's society demands, to satisfactorily develop in any field, where information and communication technologies are increasingly part of student training; The study of this situation allows them to assume challenges of innovation and change that in turn have an impact on their overall education and teachers must offer safe, clear and relevant learning environments; in this regard Bauca (2019) says "educational innovation is above all commitment, effort, collaboration and reflection"(p. 25). This leads to the search to incorporate technological tools that facilitate learning in computational thinking, that help the student to make meaningful use of them, and that are supported by the pedagogical component; taking into account that ICT must act "as an effective strategy to promote autonomous learning and student motivation by probability" (Buitrago Sanchez & Buitrago Sanchez, 2017, p. 49)

According to the above, in the Ciudad Verde educational institution, which is the object of the study, there is a problem in which it is evident that little depth is given to the topics related to random thinking, especially in the area of prediction, interpretation and calculation of probabilities, This has resulted in the inadequate development of mathematical skills in which students can predict with certainty what may happen in the face of events or possible situations of probability in the subject of statistics, which is caused by traditional classes and the application of strategies and methodologies that are not very interesting and appealing to them. This generates low results in the bimonthly tests, at the same time in external tests and therefore leads to a low quality of education.

On the other hand, in recent years a considerable effort has been made to establish, from a conceptual, operational and practical point of view, how to teach mathematics and statistics from a technological point of view. Another point is that there are children who lack guidance at home, either due to lack of time or the accompaniment of their parents or some family member, or due to lack of knowledge about the use of technological tools, good study practices are sought, and this is how the proposal begins to take shape and a mixed qualitative and quantitative research methodology is adopted, with a participatory action approach to evidence the progress of students, initially taking into account the adaptation of the Likert type scale, which "is an additive scale with an ordinal level (Namakforoosh, 2000), made up of a series of items to which the subject's reaction is requested. The respondent indicates his or her degree of agreement or disagreement with each item, proposal, or statement related to the subject studied; a favorable or unfavorable score is given to each possible response" (Fabila Echauri & Izquierdo Sandoval, 2013, p. 33).

According to the information that was obtained, it allowed thinking about giving solution to the problem with the students object of study of the mentioned educational Institution, a characterization of the population is given, determining the difficulties that they present in the subject of statistics constituted by a series of items, making an analysis from the international context, national, local, and institutional, in order to justify the relevance of addressing the problem and to promote the search for a solution that strengthens skills related to probability calculation, hand in hand with the use of ICTs and according to the initial diagnosis in the collection of data measured numerically and compared both quantitatively and qualitatively.

According to the above, the pedagogical strategy is proposed and implemented considering that probability is a fundamental issue in teaching and especially in this research project, since it is related to several fields and is used in many occasions to make decisions and estimates both in science and in daily life, and integrating the development of computer thinking skills, taking into account one of the contributions of (Zapata-Ros, 2015) who refers to "that there is a specific way of thinking, of organizing ideas and representations, which is

propitious and which favors computer skills. It is a way of thinking that favors the analysis and relation of ideas for the organization and the logical representation of procedures" (page 3).

Consequently, once the intervention was completed, it was evident that the students had advanced in the competencies associated with probability and computational thinking; This is supported by the fulfillment of the proposed objectives and therefore the strengthening of mathematical skills in problem solving associated with prediction, interpretation and calculation of probabilities, through Schoology, Scratch and computational thinking based on the STEAM model, highlighting that significant learning is achieved based on the contributions of (Moreira, 2017), who states from the theory of Ausubel that "to learn significantly one must not discover but give meaning to the content to be learned" (p. 3).

Materials and Methods

In order to fulfill the objectives and to solve the proposed problem, a set of procedures and techniques was carried out that allowed to order and to analyze the data obtained for the good development of the planned investigation, this granted validity and scientific rigor to the results in the process of study and analysis. In the same way, the project exposed and described decisions and necessary activities that allowed structuring a classroom intervention and later making a final test that measured the level of advance reached by students in the competences associated to probability and computational thinking. It was also elaborated, defined and systematized the set of qualitative and quantitative data adopting a mixed methodology within the research process to approach the study topic from a scientific, social and humanistic point of view, directing and supporting the development of the work with valid arguments that allowed clarifying the reason of the decisions taken.

In order to reflect the results of the research process within the variables that determine the execution of each one of the activities to fulfill the proposed objectives, the strengthening of the mathematical competences associated to the interpretation, prediction and calculation of probabilities and the development of competences of computational thinking as dependent variables, the application of the technological tools Schoology and Scratch as support to the pedagogic strategy to strengthen the interpretation, the prediction, the calculation of probabilities and the development of the computational thinking as independent variable were proposed.

In this sense, the aim was to capture the reality of the fourth grade students of the afternoon session at the Ciudad Verde Educational Institution in the municipality of Soacha, in relation to the knowledge and strategies for calculating probabilities, that is, to systematically explore the knowledge they share in the educational context, from which the necessary information was obtained to develop each of the stages of this research, according to the applications of Scratch, AVA Schoology, and the incorporation of the STEAM model, in an interactive way, through the game, the interpretation, practical interaction, allowing the student not to feel obliged, but to be more a taste that helps to develop other skills, strengthening him emotionally because he feels capable of reaching proposed achievements.

This research was framed in an action-participation approach, since the authors of the document, as researchers, also intervened directly in the teaching-learning process as the teachers who guided the implementation of each of the activities to be developed with the students, through interactive games and animations, where the children worked in an easy and fun way using operators and variables as shown in Figure 1.
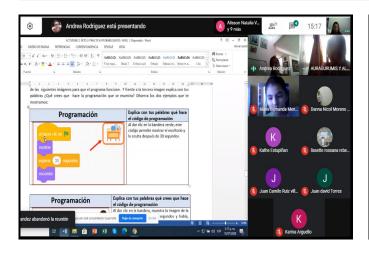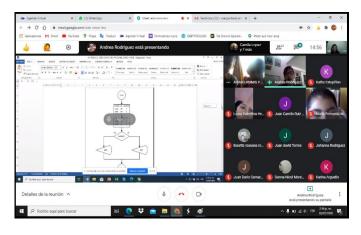
Figure 1 Class via Meet where students are explained through a guide, basic handling of Scratch.Source: own creation

With the use of technological tools, the aim was for the students to understand programming concepts that would lead them to the solution of problems, that would allow them to think about the computational logical process in order to carry out their own probability exercises, applying what they have learned in a playful way as shown in illustrations 2 and 3.

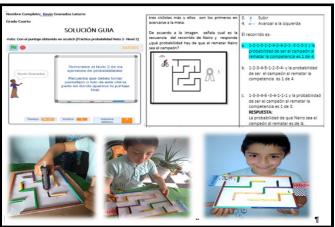**Figure 2** Class at Meet. Explanation of Decision-Making Diagram for Development of Computer Thinking

Figure 3 Practical exercise using Scratch, Decision Making and Art

The research teachers sought to understand and characterize the problem, and were also active agents in the solution of this, becoming a training process that brought into play the intellectual baggage and heritage on the issues, contemplating a deep relationship between reflection, action and educational practice. It is worth mentioning that all of this was supported by selected ICT tools (Schoology and Scratch) as a pretext to develop computational thinking where the interaction with students, technologies and the virtual environment was evident.

In this process, an initial phase was started with a survey to determine the main characteristics of the students' socio-technological environment. Therefore, from data collection to data analysis, we planned to reflect on the reality that surrounds the educational and academic context of fourth grade students in relation to the research issues, in order to draw up favorable strategies that would lead to an improvement in their learning process and help strengthen their practices in primary school.

For the collection of data within the above-mentioned context after gathering information through different techniques, observation was a fundamental part of the research as a technique to determine students' behaviors and attitudes with respect to probability calculation. All the above allowed directing a second phase with the planning

and design of the pedagogic strategy in the classroom, from the knowledge about the technological tools and capacities of the parents to guide their children's tasks in the significant, computational and probabilistic learning.

In the same way, this led to the implementation of a didactic sequence that allowed addressing the topics of probability, computer thinking skills and integration of a STEAM model. Other elements developed were the diagnostic test and the evaluation rubrics as samples of very concrete answers that show varied and wide results, allowing to sustain the knowledge that is generated in a descriptive and numerical way, where correct decisions were determined to achieve satisfactory results according to the proposed objectives.

On the other hand, in a last phase of validation, the implementation of the final test to fourth grade students was applied with the purpose of contrasting results with the diagnostic test to evidence the progress in terms of the topics covered and competencies worked on in the pedagogical strategy on probability and computational thinking, considering that, in order to advance in a process, all phases must be observed and verify if in fact its applicability is viable.

Likewise, as a fundamental element, a survey was applied to the students in order to know the perception of the strategy and ICT tools used with the purpose of evaluating if these resources contributed to the strengthening of the proposed mathematical and computational competences, denoting that at the end all of them showed a high degree of satisfaction with the usefulness and pertinence of these digital tools to facilitate learning.

Results and Discussion

The initial results show that most families belong to a stratum 3 and have more than 3 digital tools such as smartphones and computers, in terms of form of connectivity at home is 88%, which is used for consultation of tasks in times exceeding 5 hours per week and something very positive is that all students have school accompaniment, In some cases the parent with some knowledge of the Internet, also highlights the WhatsApp and e-mails as the most used networks and platforms, just as parents are 100% in agreement with the allocation of virtual activities, however as for the technological tools AVA Schoology, Scratch or the term computer thinking students mostly say they do not know, as shown in Table I.

Table I. Defined results obtained

RESULTADOS DEFINIDOS OBTENIDOS	
Estrato Socioeconómico	Tres
Conectividad	muy buena
Conectividad en internet, uso predominante	Para consulta de tareas
Acompañamiento escolar	Si hay acompañamiento
Herramientas computacionales	No hay conocimineto
Acuerdo de actividades virtuales	Muy deacuerdo
Redes y plataformas mas utilizadas	Whatssaapp y correo electronico
Herramientas digitales predominantes	Smartphone y computador

The findings denote that it is valuable to implement new technologies in the way of teaching and learning, allowing learning to be established in a playful, creative and innovative way, and thus strengthening through digital elements the skills related to the solution of random situations and analysis, obtaining significant learning, where ICT tools are required to implement the project and to work together with students, giving valid contributions and optimal results. Therefore, connectivity is fundamental in this process since it was carried out in the framework of confinement by the pandemic. In this way, it can be seen in figure 1 the use they give to the internet in their homes, which became a strength to support the design of the pedagogical strategy to incorporate the development of computer thinking with Scratch, mathematical and statistical topics related to probability, determining that it is viable because of the good connectivity and

because the population has a good perception about the use of these technological resources, achieving in this way to strengthen the competences mentioned above and promoting significant learning.
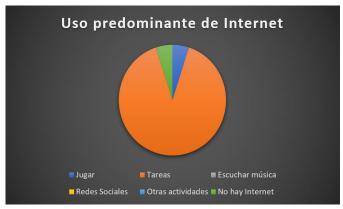

Figure 4. Internet use by students at home

The results allow an analysis on the diagnosis and characterization of the target population, since according to the application, the implementation of the methodological strategy on probability and on computer thinking is determined as a strength and it can be determined as a weakness that the students require a more personalized accompaniment due to their initial lack of knowledge on the use and management of ICT. However, this becomes an opportunity since at the end of the intervention, 100% of the students manage to appropriate the tools and technological equipment used.

When carrying out the evaluation in the mathematical competences in resolution of problems related to the prediction, interpretation and calculation of probabilities, as well as development of the computational thought, with the final test a significant advance is determined what allows to execute everything proposed by the good acceptance and motivation of the students, as it is demonstrated in the illustrations 5 and 6

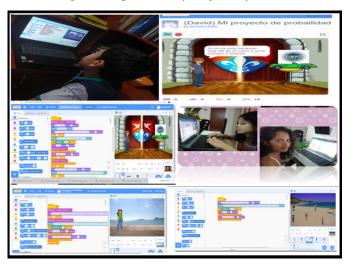**Figure 5.** Management and analysis of probability exercises

Figure 6. Exploring and Managing Probability Exercises

At the end of the activities it is evident that by using an LSM (Learning Management System) it was possible to organize in a satisfactory and understandable way each of the proposed contents, since 100% of the students satisfactorily delivered the evidence of each activity through this means. The above corroborates the contributions of (Romero, 2015, p. 4) adding that the use of Virtual Learning Environments, strengthens and dynamizes scenarios in which it is possible to teach and learn with the support of the Internet.

Thus, as shown in table No. II, the results of five implemented activities show that students reached a percentage higher than 80% in their performance,

highlighting that 94% reached a high performance compared to 4% who had a medium performance. Thus, with the resolution of the activities, the basic standards of competencies for random thinking in the fourth grade were met, since students were able to understand and put into practice the basic concepts of probability.

Table II. Results achieved in the activities

Actividad/ Desempeño	Bajo	Medio	Alto	Porcentaje Actividad
Actividad 1	0%	8%	92%	20%
Actividad 2	0%	4%	96%	20%
Actividad 3	0%	0%	100%	20%
Actividad 4	0%	0%	100%	20%
Actividad 5	0%	16%	84%	20%
Promedio	**0%**	**6%**	**94%**	**100%**

Likewise, through this implementation, students developed computer thinking skills since they required to collect information and make analyses to respond to different probability problems, relating this to daily life and understanding that in most situations they require programming and following instructions to obtain an outcome.

The application of a final test allowed a comparison with the results of the initial test showing that it involved the development and strengthening of computer and mathematical skills integrating the resolution of everyday problems related to random thinking, as shown in Figure No. 7. Consequently, the panorama is positive, since in the final test, which had a greater level of difficulty in the questions, a significant advance is observed that on average is equal to 90%. In this way, as shown in the graph, in all the questions there is a tendency towards improvement at the end of the project in relation to the beginning of it.
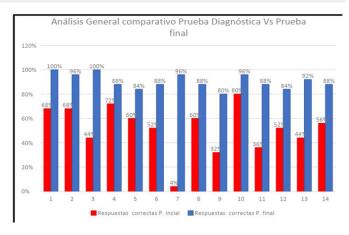

Figure 7. General comparative analysis Diagnostic test Vs final test

It is considered important to emphasize that innovation within the pedagogical task must be constantly involved allowing education to be more active and students to show satisfactory results being authors of a new culture by involving technological tools in the school environment.

It is necessary to implement research on computer thinking since there are few of them, it is necessary to deepen the thinking phases where the respective competences can be strengthened, likewise when implementing the use of ICT in the classroom it should be a responsibility of the teachers since by creating new learning environments, it allows an emotional and intellectual development in the students who finally are the authors who generate future change in society and show a new innovative and creative culture; an opportune selection of the VPA and the programming tool should be made, since the success of the implementation of the pedagogical strategy depends on it. In this sense, it ensures the strengthening of the skills of random thinking through the resolution of everyday problems and the appropriate use of the selected digital tools.

Significant learning according to the good application of technological tools must integrate several disciplines: science, technology, engineering, art and mathematics; in this way, students are an active and progressive part of their teaching and

learning process showing a continuous change and progress.

Conclusions

From a broad viewpoint in terms of the development of strategies that allow for improved learning, the possibility of strengthening the tools offered by the institutions and the educational context is seen from a more innovative and motivating approach, which gave rise to a model applicable to a certain population according to favorable results obtained from a type of research, participation that allows for the achievement of set objectives and the solution of the problem. How can mathematical competencies be strengthened in the resolution of problems associated with the prediction, interpretation and calculation of probabilities, through digital technologies and the development of computerized thinking in fourth grade students at the Ciudad Verde educational institution? This led to the implementation of a pedagogical strategy that gave satisfactory results in the resolution of random problems related to probability from a daily context and the fulfillment of the main objective, since at the end of the execution process more than 80% of the students achieved the expected performance, promoting not only the development of mathematical skills, but also computational and technological skills where everyone was directly involved in the process and was a builder of their knowledge, taking a very important step from the educational institution and where the community of this institution, especially students and teachers, played a very active role.

The contributions to the field of study allowed to address very important aspects that contributed to develop skills of computational thinking and the inclusion of a STEAM model, which yielded satisfactory results and according to that allowed the construction of theoretical bases and historical background that determine main concepts for the understanding that frames the pedagogical development as meaningful learning, understood as the way in which information is associated and restructured with the arrival of new knowledge; addressing constructivism as a dynamic form and learning process; and computational thinking as innovation to be at the forefront. Likewise, during the process in which the implementation of the pedagogical strategy was carried out, a high level was observed during the development of each of the activities developed. In the same way, in the final test, an important advance was perceived in terms of strengthening the proposed competencies, corresponding to 90% of correct answers; which allowed the fulfillment of the initial hypothesis related to strengthening the mathematical competencies in the resolution of problems associated with the prediction, interpretation and calculation of probabilities, through the incorporation of the tools Schoology, Scratch and the application of computer thinking with a STEAM model in the fourth grade students of the Ciudad Verde Educational Institution.

With the development of the research proposal of mixed methodology linking the quantitative and the qualitative and the focus of action participation, it was evident the advance of the students in the competences associated to probability and computational thinking, the strengthening of the management of programs such as Word and the construction of different elements with materials of the context until the creation of their own projects in Scratch, evidencing the applicability of logical operators, diagrams, variables, achieving the involvement of art, science, technology, creativity and of course mathematics by understanding the basic concepts of probability, allowing them not only to give solutions to different problems but to pose their own using basic commands and putting into practice what they have learned in a logical way, which ultimately allowed them to be protagonists of their learning and led to 94% reaching a high average by consolidating the results of the activities proposed in this pedagogical strategy.

Therefore, the design, implementation and validation of the strategy promotes the change of

traditional methodologies by strengthening and providing answers to new challenges of today's education, ensuring more didactic, effective and practical learning processes in complex skills such as critical thinking, communication, collaboration, probability and problem solving, as explained by special education teacher Celestino Arteta, author of Educación Tecnológica, "this is a new and powerful strategy to influence and motivate groups of people through techniques to encourage people to perform tasks that are normally considered boring"; Therefore, it can be stated that initially it was noticed from the point of view of computer thinking, that most of the students did not follow, did not gather an ordered set of steps, there was no analysis and interpretation of information in a logical way to find an outcome, which allowed to start working on these difficulties including initially more innovative educational methods, use the AVA Schoology to host activities with a STEAM and Scratch model for the development of computer skills, focused on problem and challenge based learning to help students' critical thinking from playing, experimenting and solving questions, strengthening educational practices and having satisfactory results when seeing the performance achieved by students as they progressively advance.

As for the difficulties encountered in the process of the Project, the emergence of the national confinement on behalf of the covid-19, forced to move from a face-to-face implementation to a purely virtual making parents more involved in the formation of their children, opening spaces that favored collaborative work within the process.

According to the positive results it is important to determine that one should contribute with the execution of technological tools in all areas through the use of ICT, the implementation of digital tools, especially in primary school students so that learning is more attractive and day by day the school context increases the synthetic index of quality, and become an image of an innovative practice that awakens the interest in learning in a thousand ways, opening field to knowledge and being at the forefront of a changing world.

Acknowledgements

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