RESEARCH ARTICLE

The School Garden with the Use of ICT: The Perfect Excuse to Solve Mathematical Problems

La huerta escolar con el uso de las TIC, la excusa perfecta para resolver problemas matemáticos

A horta escolar com o uso das TIC, a desculpa perfeita para resolver problemas matemáticos

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ABSTRACT

The objective of this research is based on solving mathematical problems from the School Garden and the use of ICT with students from third, fourth and fifth grades of the Clavellinas Educational Institution. The qualitative methodology of participatory action research type applied in this study favors an active interaction of the participating agents and subjects. The sample was selected intentionally or by convenience and the data collection instruments used were interviews, surveys, participant observations, and didactic sequence. The applied research demonstrates that the articulation of the school garden as a pedagogical strategy allows significant advances in the development of problem solving in the five areas of thinking: numerical, spatial, metric, random and variational, and also recognizes the importance of acquiring good eating habits with the consumption of vegetables in the diet. The research validates the pedagogical strategy of articulating the school garden to the area of mathematics, since students acquire skills and abilities to formulate and solve mathematical problems in a creative and competent manner in context.

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RESUMO

O objetivo desta pesquisa baseia-se na resolução de problemas matemáticos da Horta Escolar e na utilização das TIC com alunos do terceiro, quarto e quinto anos da Instituição Educacional Clavellinas. A metodologia qualitativa do tipo ação participativa aplicada nesta pesquisa favorece uma interação ativa dos agentes e sujeitos participantes, a amostra é feita intentionalmente ou convenientemente e os instrumentos de coleta de dados usados foram entrevistas, inquéritos, observações participantes e sequência didática. Com a investigação aplicada mostra-se que articular a horta escolar como estratégia pedagógica permite avanços significativos no desenvolvimento da resolução de problemas dos cinco pensamentos: numérico, espacial, métrico, aleatório e variacional, sendo também reconhecida a importância da aquisição de bons hábitos alimentares como o consumo de vegetais na dieta alimentar. A pesquisa valida a estratégia pedagógica de articular a horta escolar à área da matemática à medida que os alunos adquirem competências e aptidões para formular e resolver problemas matemáticos de forma criativa e competente em contexto.

Introduction

Being a teacher in a rural area requires the teacher to leave their comfort zone and face contexts with particular situations that affect the learning processes. However, the goal of training competent students, who acquire a "know-how" to solve the multiple problems they face is constant or indistinct from the area. Therefore, the research presented in this article allows teachers to illustrate and apply in their classrooms a pedagogical strategy that uses a practical and authentic learning space such as the school garden to make their students fall in love with the area of mathematics by studying it in a creative, dynamic and different way. Therefore, applying this strategy in their pedagogical work, teachers will see how it significantly affects the student's ability to analyze and understand a mathematical problem, but at the same time design and propose solutions.

The school garden as a pedagogical strategy has been proposed in various scenarios at the national and international level. These experiences have been developed on an extracurricular basis for the purpose of harvesting take-home food. Others have been conducted for students to learn planting and harvesting techniques and the use of tools. Some experiences have succeeded in incorporating the vegetable garden in the school and with it they have been able to promote learning related to natural sciences, citizenship skills and scientific competencies. However, there are few researches and experiences that show the development of mathematical skills from the school garden. This theoretical body enriches and sustains the proposed research.

This research allows us to analyze the progress of students in numerical, geometric and variational thoughts, while they manage to understand the global part of the mathematical problem and its representation thanks to the understanding of the vocabulary used. As for the analysis of the problem, they acquire skills to perform a logical ordering of the parts of the problem: unknown, they recognize the question they must answer, they organize the data. Regarding the reasoning of the problem, they decide more easily the operations to obtain the result, in short, they acquire mathematical skills in a creative way where the environment, in this case, the school garden becomes another classroom.

This proposal constitutes a pilot to be applied throughout the municipality of Aratoca in order to evaluate its validity as a pedagogical strategy and seek its application at the provincial and then departmental levels.

This research work focuses on the development of mathematical competences, from the strengthening of numerical, geometric and variational thoughts, as well as of the competences or investigative skills (Reyes, 2013): cognitive, personal, methodological, collaborative, computer and epistemic in the fourth and fifth graders of the Clavellinas Educational Institution of the Municipality of Aratoca, Santander, Colombia. As a practical learning scenario, a school garden will be developed with the active participation of parents since in their homes each student practices what they have learned in their family garden.

The purpose of the research is to obtain information about the strengths and weaknesses of the students in the development of mathematical competencies. Based on this diagnosis, the design of a pedagogical strategy based on the management of the school garden is proposed to promote the development of mathematical skills, especially in problem solving and school research in third, fourth, and fifth grade students. Finally, it is expected to obtain information on the relevance and significance of the strategy designed based on the results obtained by systematically applying it in the classroom.

Methodology

The qualitative methodology of participatory action was used. From the school garden, students and even parents are active participants in the problem researched in order for children to develop mathematical skills to solve problems in the different thoughts of the area. Also, to improve the quality of nutrition in the educational community, where the transversality of the areas of knowledge play a fundamental role from the school and home garden implemented and supported by the use of ICT in the proposed research.

The research is carried out in the Clavellinas Educational Institution, located in the municipality of Aratoca, in the Clavellinas village with nine offices with a total of 450 students (237 of rural postprimary and 213 of primary).

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The population is comprised of students in third, fourth and fifth grades: 69 students among all sites. These grades were chosen because the academic deficiencies, especially in problem-solving thinking, are more noticeable in these grades as evidenced in the results of the external tests (saber tests), which are conducted in the third and fifth grades by the ICFES.

The sample is made up of boys and girls in the third, fourth and fifth grades of elementary school at the Toma de San Carlos and San Ignacio sites, boys and girls between the ages of 8 and 13, a total of 15 boys and 24 girls for a total of 39 students, since they are the closest sites to carry out the work and have the largest number of students, which allows for a smaller margin of error.

Before implementing the pedagogical strategy, a SWOT analysis was carried out: strengths, weaknesses, opportunities and threats at the administrative management level, which made it possible to verify resources and academic management in order to verify the hypotheses and problems raised.

Applied Pedagogical Strategy

The design of the pedagogical strategy was made from the diagnosis made (SWOT) and according to the study plan established in the curriculum of the Institutional Educational Project. Therefore, the following objectives are formulated:

- To recognize, analyze and represent relationships and in particular relationships of order and equivalence.
- To identify the set of natural numbers and in it, carry out the operations and recognize the relationships that correspond to additive, multiplicative and potentiative situations.
- To execute logical, critical and objective recognition skills.
- To distinguish, before concrete problems, those that raise a case of additive, multiplicative or potentiative situation and give them a solution.

Taking into account the previous performances, the pedagogical strategies in ICT to be implemented are proposed, according to the competencies foreseen in the context of the school garden and mathematical problem solving according to the thematic axes of the area.

The following thematic contents are worked on:

- Analyzing our preknowledge.
- Knowing and implementing the school garden.
- Properties of vegetables and benefits in humans.
- Measuring our school garden.
- Shopping from the school garden.
- Interpreting graphs from the school garden.
- Making recipes from the school garden.
- Socializing what we learned in the school garden.

Activities are proposed from the *Hot potatoes* software, where different types of exercises can be created in a simple way. It can be applied with online use or from any off-line computer.

After completing their activities, the students show them in Cuadernia, a very easy tool where the *software* allows them to insert videos, photos, blogs, tasks executed in Word (tables, logs, etc.), without the need for internet.

To carry out the activities, we worked on full days of a "correlation day" class, since the areas of mathematics, language, natural sciences, citizen competences and technology and computer science are transversalized, during periods 1 and 2 of the school year.

The students created new knowledge because they, led by the teacher, developed their activities, which allowed them to participate actively in the proposed research.

> This role of students must go from being 'consumers' of knowledge to creators and innovators. In this sense, students become the center of their own learning and experience, create, make mistakes and obtain results to improve their learning process. 'Learning by Doing' is a methodology based on the acquisition of skills and competences through action processes. According to Borgnakke (2004), we can change and modify learning, but we cannot avoid 'doing'. (Sanchez, 2016)

In this project, the students went from being simple spectators to being a fundamental part of the research process. They were builders of new knowledge from the strategy proposed, from the research seedbed: Children Farm Researchers. They assume their responsibility and leadership in the participation of this, in this way they solve mathematical problems from their approach to their solution.

> The teacher, as a mediator, is responsible for introducing the students to the world of scientists, seeking to reach an understanding of the world and scientific language. The conception that the teacher has of science linked to pedagogy generates fields of knowledge. This entails a change in the idea of the teacher and his/her role. (Duque ,2016).

For the project to have more validity with regard to the school garden, the parents are integrated, since in each home they must carry out a home garden with the same characteristics of the pilot that are established in each participating headquarters. In this way, it will be easier for the children to carry out the activities of the area of mathematics and natural such as observing, analyzing, deepening and performing a follow-up of the processes that are observed and then in the institution to translate them into the technological resources that are used, such as Cuadernia, Word files where they carry their learning logs and blog of the proposed project, but above all they will have the support of their parents in their training process and better results will be achieved than those researched.

Results

After applying the pedagogical strategy, there was great satisfaction, the type of participatory action research allowed students, parents and teachers to take ownership of the project by responding to the problems and hypotheses.

The SWOT analysis in the development of mathematical competence managed to meet the objective of identifying the strengths and weaknesses of the students. For this activity, it was considered: the report cards of the mathematics area where the performances of each period are evaluated, the result of Tuesday tests applied in the institution, the results of external tests of the last three years, and the structure at the computer level, since this affects the educational quality.

The following is the SWOT that was reached after analyzing each aspect from two steps of the institutional educational project:

Administrative management

Strengths

Disposition by government entities.

The disposition of the teachers and knowledge of application of this *software*. The attitude of children to

work in groups to learn.

Weaknesses

There are not the necessary resources to invest in the technological requirements.

Internet access is only available in some locations.

The low number of computers at each headquarters hinders the teaching-learning process.

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Opportunities

Management by the directives to obtain resources for technological requirements. Apply *free* education software that does not require the use of the internet: *Bookcase, Hot potatoes.*

Increase in staffing as requested from the ICT secretariat.

Threats

The theft of computers that has already occurred at our headquarters is why we have so few.

Academic management

Strengths

They know the basic operations with their proper process. Skilled in random thinking.

Weaknesses

According to the external tests applied to students, they are weak in the Numerical-variational component.

Weakness in the geometric-metric component, representation and modeling.

With respect to the evaluations that are carried out in the classroom, students present low performance in a large percentage in problem solving, that is, when they are placed in exercises where they apply the basic operations.

Opportunities

The change of class methodology making use of ICT with the use of the Notebook consisting of a digital book.

Apply a pedagogical strategy with the use of the free software Cuadernia and hot potatoes.

Math workshops from the school garden.

Despite the few computers, their use in the application of the topics seen.

Threats

That no academic improvement is observed even with the change in traditional methodology.

That they continue like this and there is no improvement in the external tests.

The second objective: to design and apply pedagogical strategies for school research in the proper management of the school garden and the resolution of mathematical problems using free software, allowed to see the following results from the participating agents:

Parents

- Parents have taken on the responsibility of building the garden in their homes, which has allowed them to strengthen their ties as a family by supporting their children with their homework from the school garden.
- Through the home garden, they have discovered that consuming organic vegetables, that is, without chemicals, is healthier and improves their quality of life.
- Parents have found that having a home garden saves money because they do not have to buy it, but it is taken directly from their home, thus benefiting the family budget.

- They recognize that it is important for their children to use technological tools that at first as we observed in data collection were reluctant to use them, they have even requested that through the parent school they be offered training workshops on computer use.

Students

Another fundamental participant is the students who, through the research seedbed "Children Farm Researchers" (NIDECAM), actively participate in the proposed research project." Meaningful learning, according to Ausubel is when students take new knowledge and relate or integrate it with what they already have, it can be from their familiar environment or acquired in their teaching site, readjusts it and reconstruct a new knowledge" (Suárez, 2015) and it could be evidenced in the following:

- Awareness of a healthy diet through vegetables since the children at the time of the survey only ate mostly carbohidrates and sugars.
- Correlation or transversalization with other areas of knowledge in this case the areas of natural sciences, mathematics, physical education, social (citizenship skills) and computer science and technology that allow the student to acquire knowledge in a comprehensive manner.
- The use of the free *software* where problem solving exercises can be applied makes the class more enjoyable which fosters the student's love and interest in the areas of knowledge.
- It is important to highlight the change in attitude towards the area of mathematics. They are fascinated by the day of correlation, they work with pleasure and great interest, which has allowed a strengthening of learning with greater ease.
- When carrying out the evaluations of this period especially in terms of problem solving, an improvement has been observed. Even in the last simulation test it is observed that it was passed from low to medium performance, and several satisfactory or advanced.
- The project continues to strengthen the value of field research, and the children have already proposed a new problem question to work on next year with another area of knowledge: Spanish. Do we learn reading skills in the school garden?

Educational Institution

The pedagogical strategy applied allowed the Institution to improve in a quality training; the researcher in education Isabel Segovia supports and gives it validity when she says that it is necessary:

> To develop in children and young people skills, knowledge and values that allow them to understand, transform and interact with the world in which they live. This implies moving from content learning and memoristic and encyclopedic training to relevant education connected with the country and the world. Likewise, to conceive of education as a process that is not exhausted in the educational system, but is developed permanently in interaction with the world (Segovia, 2010).

Discussion

From its origins one of the fundamental activities of Escuela Nueva (New School) is the implementation of school gardens where the child builds new knowledge through meaningful learning and constructivism, and in the case of the area of mathematics learns to solve problems in context:

> Knowledge will be effective to the extent that it rests on the testimony of experience; the school must therefore create the conditions to facilitate manipulation and experimentation by students. The child thus becomes the fundamental element of educational processes, and both programmes and methods will have to be based on his or her needs, motivations and interests. (Zubiria, 2006).

The use of the school garden in school as fieldwork or research facilitates the development of mathematical skills in a more practical and pleasant way for students when applying their knowledge in daily activities, this allows the Ministry of Education in Colombia to respond, when it expresses the following:

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> Mathematical competencies are not achieved by spontaneous generation, but require learning environments enriched by significant and comprehensive problem situations, which make it possible to advance to more and more complex levels of competence. (MEN, 2004)

In addition, it specifies in the guidelines and standards in mathematics the three fundamental aspects to develop: Approach and problem solving; mathematical reasoning (formulation, argumentation, demonstration) and mathematical communication; and consolidation of the way of thinking (coherent, clear, precise).

The school vegetable garden is the teaching-learning environment where the teacher, along with the students, carries out projects related to the cultivation of herbs and vegetables, which develops in them the skills of observation, exploration and research towards new knowledge.

Constructivist postulates are applicable to any area of knowledge and mathematics is one of them.

> All knowledge is constructed. Mathematical knowledge is constructed, at least in part, through a process of reflective abstraction. There are cognitive structures that are activated in the construction processes. Cognitive structures are in continuous development and purposeful activity induces transformation in existing structures (Kilpatrick, Gómez y Rico, 1995).

School gardens also make it possible to be an innovative instrument of sustainability where knowledge is offered in a transversal way. It strengthens the teaching-learning process where the values of responsibility, solidarity, perseverance, cooperation, and commitment allow the student to collaborate with the care of the environment while acquiring and producing new knowledge responding to the objectives set out in the 2030 agenda.

The school garden "*Pedagogical space for the implementation of a proposal for curricular integration from the agricultural training* " of the Agricultural Rural Educational Institution of the municipality of San Jerónimo, is a project with two lines of research: pedagogical and technical. It allows to dynamize the teaching and learning processes, a curricular mesh is created from the different areas of knowledge in a transversal way that allows teaching, creating and sharing knowledge in the different members of the educational community, the value of collaborative work is enhanced (Méndez, A., Jiménez, 2016).

The research project "*Towards an ecological praxis from the school garden, a study from pedagogy*" uses a qualitative methodology where an interdisciplinary learning is developed through social cartography and the sandbox. It allows to improve learning from the Waldorf pedagogy where free and collaborative environments allow better knowledge processes (Bolaños, Cifuentes, Figueroa, 2017). This project gives relevance to transversality in the different areas of knowledge, where the school garden is presented as the environment outside the classroom so that the student learns new knowledge from practice using the environment with which they live, the role of the teacher here is fundamental for transversality to be made in a concrete way, that is, it shares the definition of science as social construction and knowledge as a tool for interpreting reality linked to the social practice in which it is generated (Velásquez , 2009).

The significant experience *"How fun it is to learn mathematics by cultivating the land!"* takes advantage of the resources of the region and transversalizes mathematics with the agricultural activities of sowing and harvesting, using ancestral and current measures to investigate the cost of food, therefore, specific numerical thinking is developed. (Álvarez, Domicó, 2016). It offers to the research the importance of using adequate practices on sowing and harvesting, that allow to enhance the love for mathematics, generate habits of good health and thus, contribute to social transformation, improving the academic aspect, nutrition and disease prevention since it was not only learning numbers, it was also essential to value the rural space they possess and take advantage of it from their farm and undoubtedly the family work allowed them to work together.

The school garden as a mathematics laboratory "*Learning of positive rational numbers*" (Research thesis presented as a partial requirement to qualify for the degree of: Master in Teaching of Exact and Natural Sciences) of the National University of Colombia confirms what was raised in this project when it states "There are multiple occasions in which they will have to use and relate the numbers and the different

operations and forms of expression and mathematical reasoning, in the tasks included in the school garden. For example: ground plan, calculation of surfaces, areas and volumes, various measurements; height of plants, diameters; measurements, estimation and calculations of magnitudes, organization of information, graphs and statistics." (Cuenca, 2014). This allows them to acquire meaningful learning from the context, the human mechanism, par excellence, to acquire and store the immense amount of ideas and information represented in any field of knowledge. (Ausubel, 1963).

The garden, a transversal classroom. Ecological group El Germinado. Blog Agricultura Social, Lavapiés, Madrid, Spain. It is a seedbed where they work from the school gardens in a transversal way that allows participatory, democratic and above all experiential actions that break with the traditional way of teaching.
It also makes it possible to continuously evolve and transform the teaching-learning process (Torres, 2015). The valuable and interesting thing about working with the school vegetable garden is that it gives spaces to carry out teaching and learning processes from the articulation of different areas, which allows to ratify meaningful learning since the experience from the real context gives more credibility to the student of the knowledge that he or she is acquiring, taking advantage of each space of the garden. It is the perfect excuse to teach: "when vegetables are harvested, the basic operations are explained, proportional distributions, estimation of measurements, measurement of areas, estimation of number of seeds, ancestral concepts, study of the ground plan, vegetable registration, weight, dimensions, measure of the growth of plants and their parts, economic control of the garden, budget, expenses" (Álvarez, Domicó, 2016). This gives a different meaning to mathematics and not only do they look at it as the development of logical thinking, but a different functionality is given to it.

Financial mathematics, where children along with their parents and teachers manage to feel that having a vegetable garden is not only the laboratory to acquire an apprenticeship, but that having it decreases their expenses or can be loaned to form a microenterprise in the future.

In this study, we observe the development of numerical, geometric and variational thoughts. Students interpret statistical graphs, and at the same time develop argumentative competence by creating new tables with simple application exercises at the level of knowledge required in the area of mathematics.

This project is innovative as it presents the area of mathematics in a playful way where the transversality of the areas is fundamental. It is possible to impact both students and parents and without having such an important resource as the Internet, the school garden is the perfect excuse to solve mathematical problems from the different thoughts of the mathematics area.

This project allows the students to leave the classroom and turn their environment into the best learning laboratory, where the garden of their home, serves as feedback by applying the theoretical knowledge learned in the classroom and become an active agent of change in their community in the company of their family and teacher.

Conclusions

Students through the mainstreaming of the areas of knowledge acquire academic processes in a more pleasant way, thus allowing them to improve their performance at the level of mathematical competences. The development of geometric thinking is much more practical as the
students find an applicability when measuring the real gardens and then when doing it on the computer it is much easier. It can be evidenced that the problem solving of both natural and fractional numbers becomes a pedagogical game where they create buying and selling problems that are applied in their daily life. Also, the application of *Hot potatoes Software* or Cuadernia gives the student new methodologies or strategies to reach knowledge in a more creative way. Regarding the school garden, they have learned to eat healthily by recognizing the vitamins and minerals of vegetables.

The participation of parents in the accompaniment of their children developed the work of co-responsibility between parents and the Educational Institution. Finally, research projects like this can renew and resignify the Institutional Educational Project to achieve changes in the environment and in the same agents that participate in them.

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The Educational Institution formally received the project to its satisfaction. The rector, after reading and analyzing it, stated that he will use it as a reference for other areas.

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