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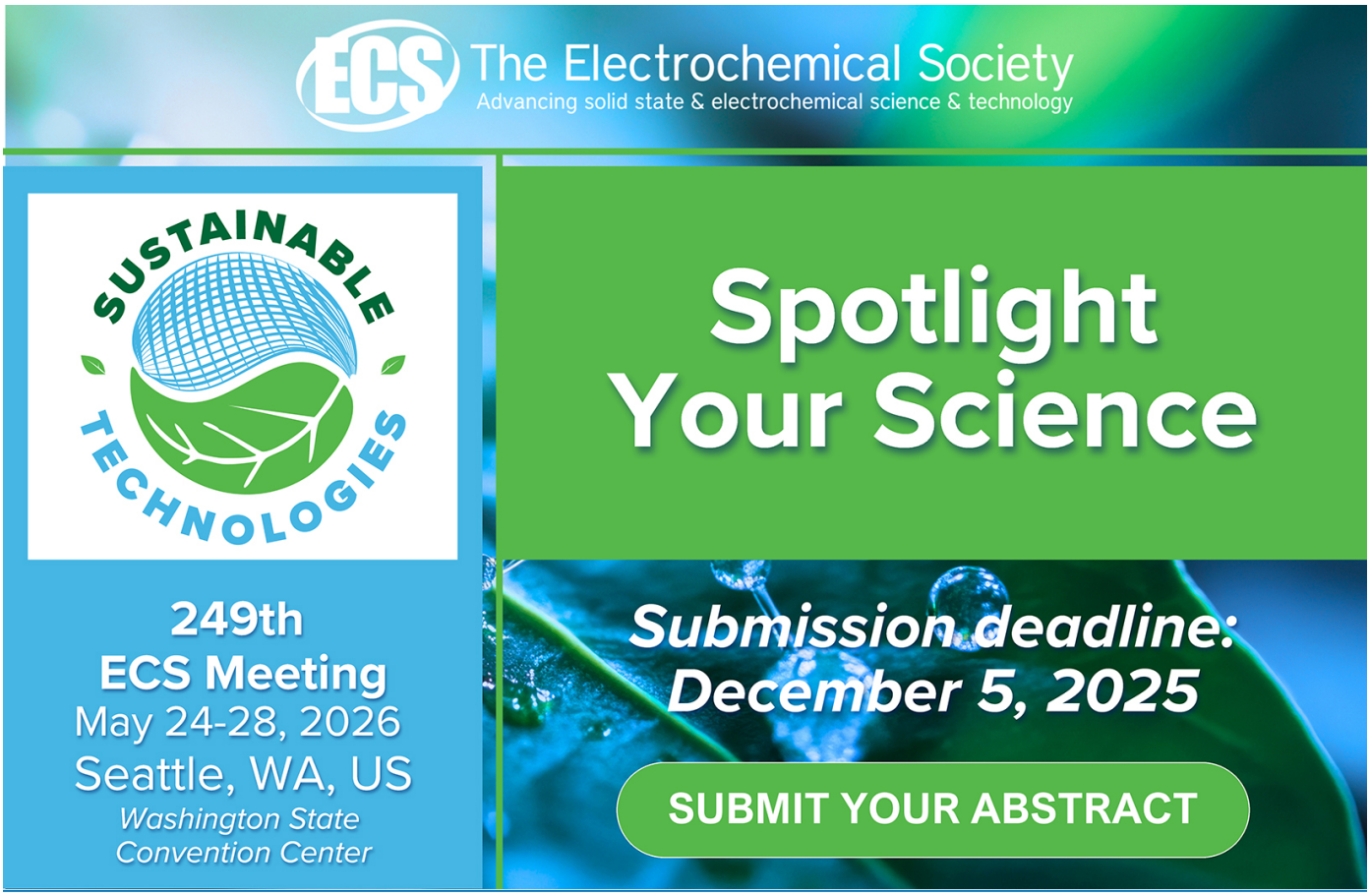
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Case studies: learning strategy incorporating Lego Education in the seventh-grade math course at the school

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Abstract. This article presents reflections on the use of case studies that revolve around the student's environment to use it as an input in the development of the mathematics course in the seventh grades at the "Isidro Caballero Delgado" school in Floridablanca, Santander, Colombia. With this experience, it can be determined that the use of robotics prototypes in mathematics is a support tool as a pedagogical strategy in the student's learning process, strengthening not only the academic but also their comprehensive training. That is why students use the construction of the prototypes not only to learn mathematical concepts for better understanding, analysis, and critical reasoning but also to develop technical language in an empirical way giving answers to the laws of physics in the prototype or its function. This work is part of doctoral research where 60 students of the experimental group participated. The structure of the document contains a first section with the introduction, second section where the methodology and the applied strategy are detailed; in section third the results obtained are mentioned; and finally, in fourth section, the conclusions and possible recommendations are presented.

1. Introduction

Around the whole process of teaching and learning and the vocation that teachers of any institution should have, it is important to determine what are the different mechanisms that they should know and handle to always offer an adequate education to each situation that is presented in their academic environment, as well as to guarantee that it is not only a traditional transfer of knowledge to the student but that it stimulates him to analyze, interpret and understand that information that he is receiving from them. With all of the above, it is indispensable that the educator has a broad knowledge in their respective areas and must also have the skills to apply it in solving problems in everyday situations.

The "Isidro Caballero Delgado" school has a differentiating context in its academic environment, due to its location in the Zapamanga neighborhood of the Floridablanca municipality, belonging to the department of Santander in Colombia. In this area, there is a predominantly vulnerable population with different factors of coexistence and security that impact the academic community where robberies, gangs, robberies, murders, consumption and trafficking of drugs and alcoholic beverages, domestic violence, low purchasing power of the families and all this makes the student see the academy as something without relevance. It is common that the process of teaching and study of any area of knowledge is sometimes complex and more so if it is mathematics. For this reason, it is necessary that the actors of the academic community, especially the teachers, start to know different methodologies of teaching and learning with the application of practical cases that can explain in a more practical and real

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way some subjects that are difficult to understand by the students. It is also important to take into account the incorporation of the use of new information technologies in this process, thus generating an adaptation to cultural and social changes and especially to the new expectations and needs of the different interest groups, thus generating an increase in their skills to solve any problem from the social, economic or cultural point of view in a society that is increasingly multicultural, more connected, universal and interconnected.

It is very important for the student the use of these practical cases for their learning process since through them they acquire or reinforce all the knowledge integrally from the disciplinary area to later apply it when solving the different problems that they can identify in their daily life or real situations through constructivism [1], having as support the construction of a model or prototypes with the Lego Education or Fischer Technik kits, traditional teaching with only masterclasses is left aside as an exclusive methodology for the educational environment; Instead, they invite the student to be critical, thus promoting his or her logical reasoning. Also, with the construction of these prototypes, it is possible to make an imitation of an "object" in the environment with Lego cards and thus implicitly explain its properties, parts that make it up and functionality, the relationship between the parts and physical phenomena that are related as in real life, such as a car, a boat and others that are in the environment of the student With the use of different tools and equipment of the new information technologies where the construction of different prototypes is made applying practical cases identifying a real context in the area of mathematics. It is related that this robotics equipment has provided the teacher with great support in their training processes, generating better critical reasoning in the student [2,3]. Different strategies are implemented, such as collaborative work [4-6], and project-based learning [7], among others. The intervention of students is actively sought, breaking down possible barriers that may interfere with the educational process, regardless of gender, race, color, religion, or beliefs [8]. For all of the above, different work activities are generated and, with the Lego Education or Fischer Technik kits, a daily life situation is described in a practical case to appropriate the knowledge or reinforce the subject in the context that both teachers and students experience.

With the experience that teachers have and according to the math work plan, contemplating the areas that integrate math and their respective topics according to the established schedule, different class activities are developed, fulfilling not only the requirements and needs of the course but also the expectations that students may have regarding the knowledge they receive from the diverse contexts and social situations, which are evident in the daily practices of teachers involved in this process. The article is a product of doctoral research "use of Lego cards to strengthen math learning in seventh-grade students at “Isidro Caballero Delgado" school, from the education sciences program being studied with the Universidad de Cuauhtémoc, Mexico, and applied in the city of Bucaramanga, Colombia. There are different phases in the development of each one of the practical cases, such as the identification of the context or real situation and the possible relation with the subject to be dealt with in the course, according to the area to be worked on (geometry, arithmetic or statistics); the planning of these activities; the execution and the evaluation/reflection period. Results are obtained according to the respective analysis of the work to reach conclusions by answering some research questions such as (a) is there a clear relationship between a practical case with a real context? (b) does the learning of the students solving practical cases generate a better experience in their academic process? (c) does using practical cases encourage each of the students to be more responsible as members of collaborative work? (d) having a case study prototyped with robotics and related to the topic helps the teacher to give the student a more integral knowledge; (e) the use of case studies using prototypes generates in the student's improvement of their cognitive skills, competences, and critical thinking.

2. Methodology

It can be mentioned that the case studies are one of the active methodologies that teachers can use in their classrooms for their entire academic process since they have an infinite number of real contexts. They can assimilate and redirect according to their area to make a subject known or reinforce one if

necessary, making this process a transforming and enriching space for students through experiences and aspects of their environment.

The teacher must generate an approach that formally involves real or ideal situations that are similar to reality, which can be in the student's environment through the writing of a story with different problems that exist or may arise. This invites the student to solve the problem individually or through collaborative work [4-6], applying the topics seen in the course in their different areas such as geometry, arithmetic, or statistics supported by the construction of the prototype thus improving their critical thinking in that solution. The practical case also helps the teacher to evaluate the knowledge acquired. With this interaction, the student will acquire experience in the application of mathematics in different environments that can be presented in the future in community settings such as at home, on the street, or in later grades.

With the use of a case study it helps you to relate the possible changes that exist in nature, to be able to understand the daily world that surrounds them and possible natural phenomena that influence; to understand an object or real thing its interactions and operation.

It is interesting to use the practical cases for the acquisition of knowledge and its level of complexity will depend on the objectives proposed by the teacher according to the topic to be presented or deepened, this will also influence with the design of the respective prototype to be built to support with its solution. It is also interesting that the use of the practical cases can be implemented with different learning strategies independently or together, among which we can find case study based learning [9,10], collaborative work [4-6]; gamification [11], task-based learning [12], project-based learning [7], 4C Lego methodology [13], and game-based learning. The case studies may have interesting resources among which are the change of scenarios and also the change of roles in each of them by the students.

As for the implementation of the practical cases in the educational environment, especially in our research, the teacher must guide the student as he or she should proceed in this type of activity, guiding him or her to do different readings and consultations on the subject, make his or her interpretation and a basic analysis of that whole preliminary process. Therefore, teachers in this area should design a course in which they stimulate students to their responsibility, improve their behavior and commit them in a good sense to spaces that call their attention and in this way, they can attend school, generate in them that "intrigue" of reading before class and be able to relate the subject to the construction of prototypes. Then, they can search for characteristics or for the correct functioning of those models (real-life objectives) that are used to prototype, for examples such as a car, a scale among many others, and from their perspective they can identify what information can be useful to them to solve the problem presented in those practical cases.

To fulfill the objective of implementing the practical cases as learning strategies, it is necessary to take into account, in the first place, all the institutional guidelines for our case, the Institutional Educational Project (PEI), the pedagogical model [14], and the work plan for the area of mathematics established by the teaching group, since they give the indications regarding the topics that each teacher must work on to fulfill the respective objectives according to the thematic axes. The design of each case study is generally carried out in two general phases integrating also other learning strategies [15,16]. In the first phase or planning phase is where the specific topic to be developed in each session is identified according to the programming determined in the work plan of the mathematics area and the strategy is established prioritizing the objectives to be met. The strategy of practical cases is identified taking advantage of the situations that are found in the environment of the academic community as an alternative for the development of the theme which can be implemented in a group or individual way, be supported with other learning strategies and with the construction of a prototype related to the theme [17,18].

In this phase we determine how the development of the class will be done, the implementation of the strategies, we establish the number of groups, the students that integrate it, and the roles that they can have within their respective collaborative workgroups which generally are those established in a 4c methodology as a specialist in materials, constructor, reporter, and the project leader but in our case, we add the role of secretary and alerts which are not fixed by each student but rotate for each session. Also,

the subject of equipment, tools, material, or inputs that may be required is identified, such as television, video beam, scissors, and other scales, according to the subject to be worked on. Likewise, the object that can be determined from the real context and that can be prototyped according to the topic to be worked on is identified, such as a scale, a cart, a boat, scissors, among many others.

The use of physics at the time of prototyping an object is very important because it helps us understand how the selected object works, designs and elements that make it up (type, form, function, etc.), and others. For example, a boat, we must know what it is, understands why it floats in the water because its design is concave and elongated; its purpose and how it works; identify its parts and how they interact; with this, we can relate the prototype to the theme of the mathematics course we will be working on (we used the boat to see themes such as reflection and refraction of objects). Once the prototype has been identified, the step-by-step construction process is designed, as shown in Figure 1. If the steps for its construction are not available, or if there is an established model, the primer is used, such as an object that can be prototyped and that may have been proposed.

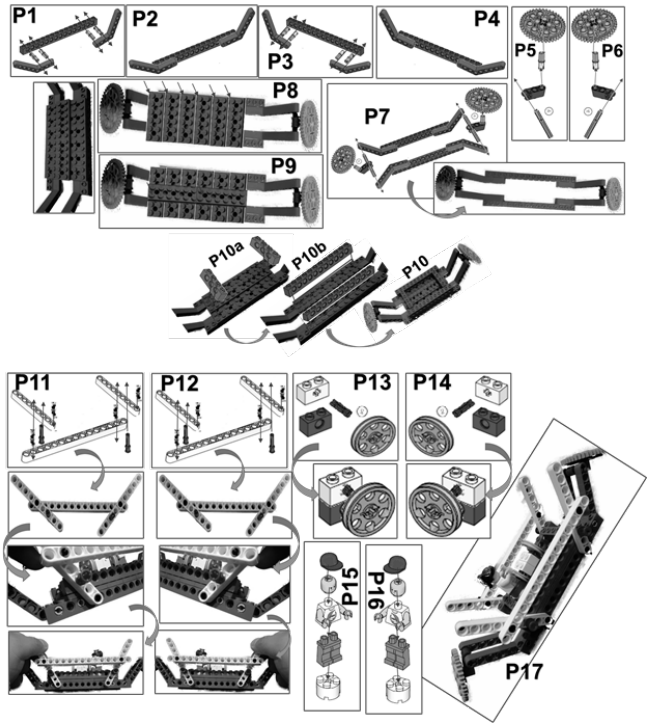


Figure 1. Construction guide for the boat.

The second phase, the implementation through moments established in the 4c Lego methodology such as connecting, constructing, contemplating, and continuing to create an environment in the student of experimentation through constructivism [1], exploration, and construction [15]. At the moment of connecting, different audiovisual supports are used such as a video, a photo, or audio to give an introduction of the subject to be worked on or a content of integral formation through a space of interaction and reflection. In the second moment, which is the construction, the practical case is read, the guide that must be developed according to that practical case is presented and explained in a general way the prototype to be constructed, the Lego Education or Fischer Technik teams and their respective step-by-step documents for its construction or any element are handed over. Then the groups are distributed with their respective students who integrate them with the materials that will be used in the worksite. Once the moment of construction is finished, the moment of contemplation is passed in which the respective reflections are made, the connections between the acquired knowledge, the armed prototype, the practical case with the real situations evaluating as such the learning and the progress of the students. Finally, there is the moment to continue which is presented at the moment of requesting

new possible solutions inspiring the student always in new challenges and construction challenges identifying new competences in the student with the model and prototype already built.

In the construction phase, we have the manipulation of the respective cards with it should determine its form, its composition, identify the use within the prototype, compare the cards with it helps the student to better management of the space that is to say how they should be assembled and identify the form as it is going to be planned the construction of the prototype.

3. Results

It is determined that with the use of different practical cases designed and implemented integrally with contextualized learning strategies and with the support of different prototypes built with Lego Education or Fischer Technik kits [19-22], to introduce or deepen a subject in the mathematics course in any of the areas that integrate it such as geometry, arithmetic or statistics in seventh-grade children, very interesting results have been reached among which are:

- With the implementation of a well-designed case study where different spaces, roles come to pay attention to those real problems posed analyze them from different perspectives by students according to their roles.
- The use of this type of integrated case study with different learning strategies shows a gradual improvement in the final test scores of students in the experimental group 7-3 and 7-5 compared to the control group 7-1-7-2 in the 2019 school year, as shown in Figure 2.

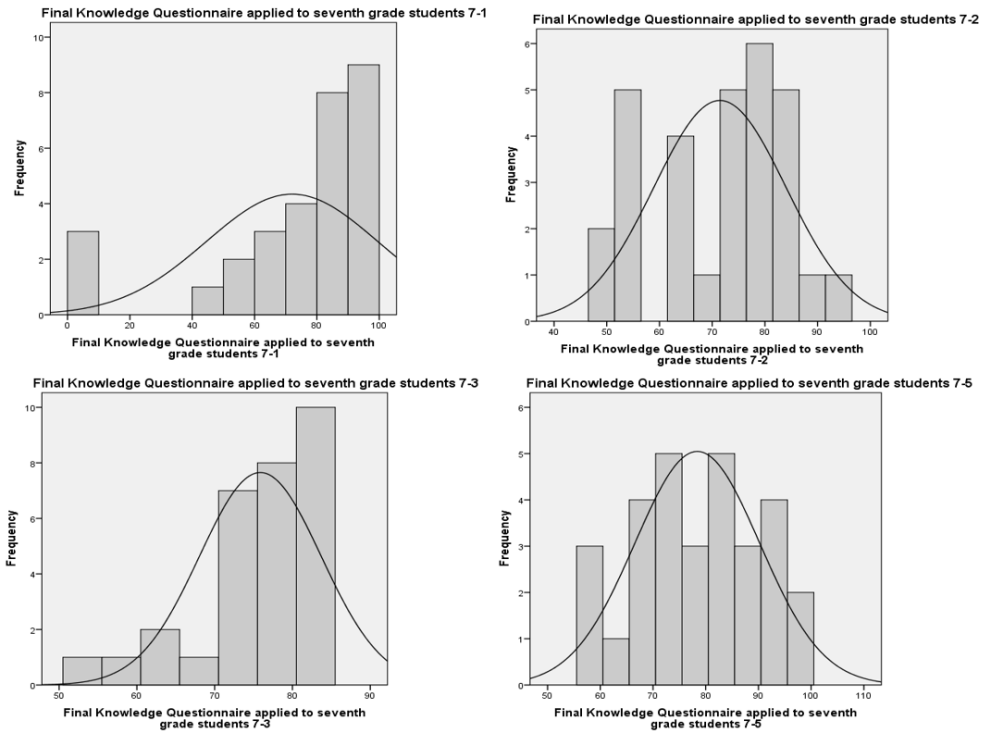


Figure 2: Comparison histogram: final assessments of the experimental and control groups in the 2019 school year.

By working collaboratively and developing the situations presented in the case study, the creation of different solutions is stimulated creatively with the support of the construction of the prototype that contextualizes in a very similar way the situation that is presented.

- The construction of a prototype indicates different ways of interpreting and finding solutions to the same problem according to the reasoning of each student. Also, it generates spaces where the

comparisons of these solutions are made, looking for the student's interest in seeking the justifications of the answers of their peers, understanding in this way that there is no single way to reach a solution, developing in this way his mathematical thinking.

- This kind of tool makes the students acquire motor skills by manipulating different cards since they identify the characteristics of each card, such as how to assemble it and implicitly they must be handling the units they require, thus strengthening mathematical operations and location in space
- At the moment of constructing a prototype, for example, the boat, the student obtains some basic concepts related to physics, such as the handling of space, the use of time, force, speed, and mass, among others, and incorporates them implicitly to strengthen its construction and relates it to the basic theme of mathematics that is being developed.
- It is identified that all the groups carried out the assembly in different ways following the step by step, others divided those phases and were building parts of that prototype and at the end, they assembled everything

4. Conclusions

The area of mathematics can be connected more easily to a real situation and therefore have connections related to the daily activities of the different actors in the academic community. Also, incorporating the experience that the teacher may have and redirecting it to the topics that are established in the area of mathematics makes the students assimilate the respective topics in a better way. Educational institutions and teachers must converge their actions and responsibilities so that different learning strategies are well accepted by students, and that there is a better connection between the classroom and real situations to foster increased student participation in the classroom. In any process of teaching and learning, it is clear that using some learning strategies frequently, such as case studies, does not prevent some mathematics subjects that are more complex from being explained with a more traditional class

It should be noted that the use of case studies in teaching is supported by a strong knowledge of aspects and themes of the area of mathematics as well as a good pedagogical experience to be able to approach them by proposing situations to be solved and argued by the students. In the teaching of seventh-grade students in the area of mathematics, it is important to generate academic spaces in which they are supported more frequently with active methodologies, as is the case in this article.

The results of this experience in the seventh grade of the institution allow us to evaluate the practical case as an effective learning strategy for the development of skills and competencies in both students and teachers. The use of case studies will always be related to physics, since when identifying the real-life object, many factors and elements must be considered, such as how it works, its elements, and what impact it has on its environment when used. Physics and mathematics are sciences that are very well combined since at the moment of construction one has the logical reasoning for the construction and the study of the properties and characteristics of the object. These types of activities must be implemented in other courses using different learning strategies as well as replicating them in the different grades of the school.

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