



# CONTEXTUALIZED CONCEPTUAL CARTOONS IN THE INITIAL TRAINING OF ENVIRONMENTAL ENGINEERS

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**ABSTRACT-** This article presents the results of the research entitled Comics in the teaching of science developed at the Francisco José de Caldas District University, which consisted of the design and production of didactic material for the teaching of science called contextualized conceptual comic strips. The methodology was based on a qualitative perspective of the design and validation process of the CC comics supported by the review of experts and researchers, as well as the content analysis of the academic productions of the students. Some of the results are evident in the cartoon called "El Trasteo" and the questions, reflections and experimental proposals of Environmental Engineering students in a mechanical physics course. The conclusions emphasize the didactic possibilities or potentials of Contextualized Conceptual Comics.

**Key Words:** Contextualized Concept Cartoons, Science Education, Physics Education, Kinds of energy

## I. INTRODUCTION

This document presents the main findings of research, to the implement as a teaching strategy in teaching physics a Contextualized Conceptual cartoon (CCC) called "el trasteo". This didactic tool consists of a set of cartoons in comic format that addresses a phenomenological situation, in the case of the displacement of loads in a move. It should be noted that this work is articulated with the research developments in conceptual comics proposed, among others, by Naylor & McMurdo, (1990); Peacock, (1995); Naylor and Keogh, (2000, 2013), Samková, L., (2020). However, in the INVESTUD-CN research group institutionalized at the Research and Scientist Development Center of the Francisco José de Caldas District University, progress is made in this line of inquiry by adding the contextual character to the conceptual comics (Reyes y Romero, 2017); Reyes, Romero & Bustos, (2018, 2019, 2020); (Cely, G., Reyes, J., & Bustos, E., 2018; Porras & Reyes (2019).

In this sense, the use of contextualized conceptual comics is associated with the idea of constructing alternative narratives, which emerge in a situated phenomenological investigation, and which allow students to re-signify their understandings of phenomena explained by science. Aspects that also position the necessary connections between the world of people's lives and the world of science, which, through an investigative process, energize new meanings and raise questions and experimental plans to test specific hypotheses. Thus, the objective of the research was to establish a characterization of the questions, and experimental proposals of the students (engineers in training) of the Mechanical Physics course formulated and developed when interacting with an CCC.

## II. METHODOLOGY

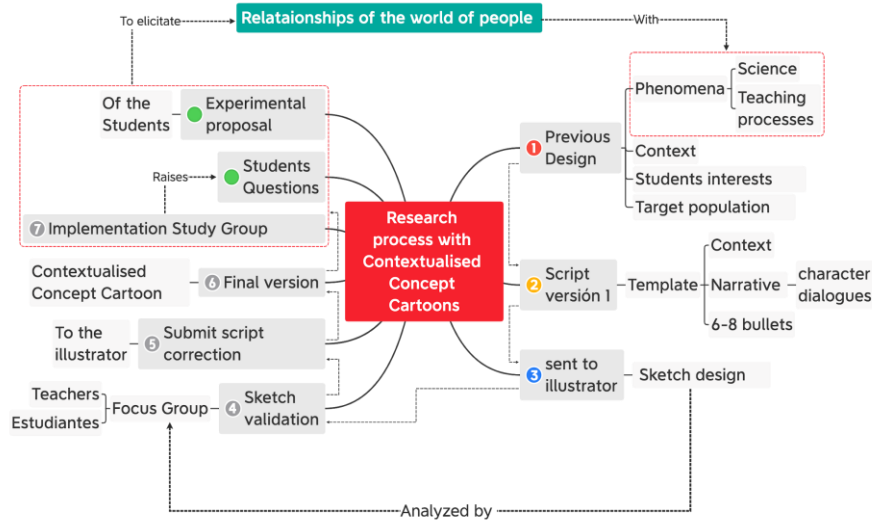
### Research Design

The research process with the CCC involved the methodological development of the production and validation of the Comics, which is synthesized in seven phases (Image. No. 1).

Phase 1 consists of the articulation of the interests of the students, their contexts and the definition of the phenomenon of study. In phase 2, a first version of the CCC script is elaborated that must contain at least the dialogues of the characters, the contexts of interaction in relation to the phenomenon, between 6 to 8 vignettes. Phase 3 consists of the interaction with the illustrator for the elaboration of the sketch. In phase 4, the sketch is analyzed for validation purposes with a focus group and the corrections made are sent to the illustrator so that in phase 5 he/she can make the final version of the CCC. Already in phase 6 the last details of the CCC are reviewed in accordance with the elements of phase 1. Finally, in phase we proceed to implement the CCC in the groups of students, this allows the formulation of questions and experimental proposals (eliciting character) that contribute to the understanding of the phenomenon.

The information was analyzed using the respective content analysis technique (Krippendorff, 1990) to organize it into interpretive categories that allowed to account for the objective of the research.

Image 1 Methodological process of the investigation



Own construction

### III. RESULTS

The research results for the case of a Contextualized Conceptual Comic called "El Trasteo" and associated with the concepts of work and energy are presented below. The development of the cartoon (Image No. 2) consists of showing the interaction experience of the characters [a group of workers from a moving company 4-person] carrying some boxes to a transport truck, in the case of one of the personage carry a box that should not and therefore must return it to the office on an upper floor, meanwhile the other characters continue to carry the other boxes to the truck. In this sense, the generic places are: office, route from the office to the truck, truck and, the objects or artifacts are: fragile boxes, other boxes, sofa, truck.

Image 2. The Contextualized Conceptual Cartoon - "El Trasteo"



Own Construction

## Questions asked and relations with the CCC

*Analysis of the laboratory proposed for the case of the CCC "El trasteo"*

In the first place, as a result of the analysis, the relationships were established between the content of the comic, the question posed by the group and the laboratory practice that they proposed and developed (Table No. 1).

Table 1. Student questions resulting from the interaction with the CCC

Question asked	Relationship between the cartoon, the question posed by the group and the laboratory practice.
Group 1. Is work done when the boxes are packed?	The group compares the moments of the cartoon to experimentally test the relationship between work and the action of transporting and packing the boxes in the truck.
Group 2 Is it correct to claim that the man in the cartoon claims that he did twice as much work?	The group experimentally replicates the action of moving a mass between two points in both directions, which reveals a close relationship with the case of the cartoon character who had to return a box to the office. Which allowed him to develop his laboratory practice to answer the question asked.
Group 3 Is the same work done from point A to point B when there are different paths?	The group designs an experiment of displacement of an object between two established points and in two different trajectories, finding that the work on the object is different, an aspect that is related to the Cartoon while the idea of Work is questioned in relation to the distance traveled. The comic led to this question, which ended up being validated for the case of greater distance traveled with a greater value of Work.

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### Motivation- attitude

Addressing the CCC allowed students to establish different discussion criteria within each group. This led them to agree and create experimental strategies that enable them to address their own questions and consolidate the analysis of the data collected to solve the questions. The main reflexive aspects that students assign to the developed process have to do with a *novel and fun didactic* perspective, which involves skills to create questions autonomously about the phenomenon of study, which acquire a character of authenticity as long as are subject to experimental verification (Table No. 2).

Table 2. Motivation of students with the cartoon

Students' reflections on the experimental practice with CCC
<i>"We found it fun, educational, dynamic and enriching. Since we have the subject clearer now and we solved all the questions that arose. It generates us and forces us to create a system to verify the phenomenon. Taking the theoretical into practice thus generating a greater understanding of the subject "</i>
<i>"We carry out this practice with emotion and we think about situations related to reality"</i>
<i>"Empirical and didactic methods allow cognitive growth in people facilitating learning and a better appropriation of a topic"</i>
<i>"This exercise was too entertaining and didactic, it is too frightening to have this type of dynamic activities that promote the acquisition of a taste for learning and even more so if we talk about physics."</i>

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### Questions associated with experimentation

Now, from the analysis of the information, categories associated with the research question are organized: What ideas does the CCC allow to elicit in relation to the phenomenon illustrated in the Cartoon? As a result, ten concepts were identified which are; magnitudes, displacement, force, work and displacement, work, energy, types of energy, work and energy, situations and finally emotions. (Table No. 3).

Table 3. Concepts associated with experimentation

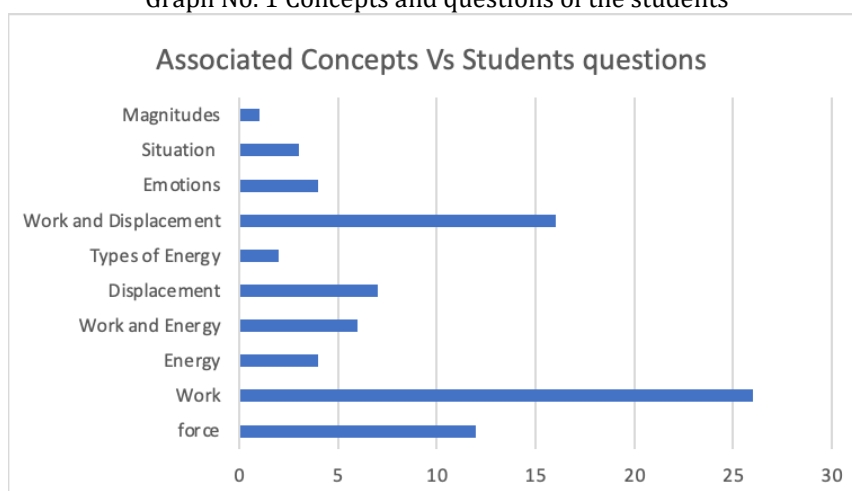
Categories:	Questions and comments
Magnitudes	What physical quantities were spent during the activity carried out
Force	"It is correct, the statement was zero since the force goes in the same direction as the displacement, the force influences the amount of work done", "it is possible that 2 types of force are handled in the movement", "the weight of the boxes influences how tired they are, if the journey had not been in the same direction, would they be even more tired or the same? ", " On average, what was the weight loaded by each one, what is the total sum of the weight loaded by everyone".
Displacement	"What was the distance traveled by each of the characters", "what is the distance that he sent was going", "why the displacement is 0 if there was movement", "because one character tells another that his displacement was 0 and the same as that of the others, if in fact he had to return? ", " why is the displacement 0 if there was movement ", " because it is determined that the displacement is 0 having a route "
Job	"In truth the work that the characters did was equal to zero", "in truth the man made the wrong boxes, I did twice the work", "why does the girl say they did not do work if they feel exhausted", "pack the boxes generated work ", " the truck did some work ", " when lifting an object in a vertical direction work is done ", " if the work was 0, the movement cannot be categorized in another physical environment ", " it is possible to do work if the boxes had been moved by other means ", " what was the weight added to the total by the person who did twice the work "
Energy	"That the force is in the same direction implies that there was no expenditure of energy", "the mass of the object makes it need more or less energy to load it", "if the boxes are carried from one place to another and then taken to the same point of origin, its work is null. This being the case, the power and/or energy would also be null ", " they will use the same amount of energy "

Work and energy	“Does work consume energy?”, “Why did the energy decrease if there was no work?”, “What happens with the energy when carrying out a force and a journey from one place to another?”, “Because there is energy expenditure if work is not done ”, “ why if there is physical exhaustion, Twhich means energy expenditure, the people who lifted the box did not do any work ”, “ why energy was used even though the work was zero ”
Types of energy	mechanical work is independent of biological energy
Work and travel	“Because the curly girl says that they did the same work if the displacement was 0”, “why is the work related only to the horizontal displacement and not the vertical displacement to the weight or height”, “since the force is in the same direction of displacement, there is no work ”, “ if the force is in the same direction of displacement, the work is really zero ”, “ it is possible to do work if the boxes had been moved by other means ”, “ the same work of a point A to a point B, when there are different trajectories? ”, “if it is not considered work for returning to the same position, how is it defined that they did? ”, “if the same work is done in less time, will end up just as tired?”, “why is it not considered work when the force goes in the same direction”, “if the force goes in the same direction as the displacement is zero, the work is true?”, “ What relationship between force and displacement in subject to direction so that the work is equal to 0?”.
Situations	"Because they are so tired", "why do their arms hurt", "why did people end up so tired", "did their activity end in the truck or at the point of origin?"
Emotions	“Why did they load the boxes lying down if they have arrows that indicate their position?”, “Horizontal with respect to what”, “why not bring the truck closer”,

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Likewise, as can be seen in Table 3, the students established their questions and explanations around eight (8) physical concepts, within which they are most frequently found: work, force, and work-displacement. Here in second order the concepts of energy, work and energy, types of energy and magnitudes are grouped. Now, it is also observed that the Cartoon prompted the study of the phenomenon by finding two other contextual concepts such as emotions and situations.

Graph No. 1 Concepts and questions of the students



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#### IV. DISCUSSION

As evidenced in the results, the students' questions and their reflections on the phenomenon reveal a process of questioning their own scientific knowledge when interacting with the comics (Naylor & Keogh, 2000, 2013). This means that the cartoon is a pedagogical tool that facilitates the generation of ideas and attitudes regarding the phenomenon, in this case the transport of cargo, explained physically from the concepts of work, energy and displacement.

Now, the work with comics in this research also finds as a notable aspect that the students have their own conceptions about the concepts involved (Say and Ösmen, 2018), which was combined with their attitudes and motivations to ask the questions and be able to construct their experimental proposals. This process confirms the power did to tactical of the cartoon as an alternative narrative in physics class that contributes to question the ways in which a phenomenon is understood (Reyes, Romero & Bustos, 2018, 2019, understood Samková, 2020).

#### V. CONCLUSION

Addressing the CCC as a didactic strategy leads to the recognition of the situation of research in Science Teaching, where the experiences of students connected with social and cultural aspects are recognized. In this sense, the teaching strategy developed allowed the students connect their experiences with those of the characters from the cartoon. This evidenced the contextual nature of their actions and attitudes in the work sessions, since concrete experimental plans were raised that used material available in their own training contexts, in this case the mechanical physics laboratory of the engineering course.

When interacting with the contextualized conceptual cartoon, students question both their own knowledge related to the displacement of charges, as well as the knowledge of physics that is associated with it. This was reflected in the questions asked and in the concepts referenced in the results.

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