Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI:10.21474/IJAR01/4286
DOI URL: http://dx.doi.org/10.21474/IJAR01/4286

*RESEARCH ARTICLE*

# DIDACTIC CHANGE BASED ON THE HISTORICAL AND PROFESSIONAL CONTEXT FOR THE PHYSICS TEACHING.

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***Manuscript Info***

***Manuscript History***

Received: 28 March 2017
Final Accepted: 30 April 2017
Published: May 2017

***Key words:-***
Teacher's education, didactic change, historical context, professional context.

***Abstract***

A research is presented based on a case study with two university teachers of physics, in which a collaborative work that claimed the teachers education in the frame of the didactic change. A characterization of the scenarios and professional practice of the participating teachers for the identification of the personal educational epistemology. It shows some of the results obtained in the program of teachers education developed, on aspects of reflection of his educational practice, the identification of historical questions of the electromagnetism with reflections, to favor and in against, on the use of the history and philosophy of the sciences (HPS) in the education of the physics, according to the context of the students. They present offers of implementation for some experimental practices.



## Introduction:-

A developed research is presented as a product of a work of doctoral thesis (Zapata, 2017), inside which there was realized an offer based on the teachers education for the generation of the didactic change (Furió-Más, 1994; Carnicer, 1998; Mellado, 2003; Zapata and Mosquera, 2012) from the use of two differentiating elements, the use of the historical context of the physics and the implications and incident of the professional context where the physics is teached.

A study of case was realized by two university teachers of physics, who dictate class in two different faculties, engineering and education, of the Universidad Distrital Francisco Jose de Caldas, of Bogota-Colombia. This research was realized for two years, to characterize the form how these teachers teach the physics in two professional different contexts, a course of electromagnetism for students who are trained as physics teachers (teacher 1) and a course of electromagnetism for students who are trained as electrical engineers (teacher 2). For this intention the research delimited its objectives through across three fronts of work, in the first instance we sought the characterization of the scenarios and professional practice of both university teachers of physics from the personal epistemology teaching and the didactic conceptions about to the teaching of electromagnetism; The second phase seeks to recognized with the teachers participants of the research reflections on a practice from introductory elements of the didactics of the experimental sciences and the role of the professional context of performance; finally we sought to identify collaboratively with the teachers participants internal and external aspects of the historical context that have contributed to the theoretical and practical development of the electromagnetism, to

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identify elements of interest that are possible to incorporate as a strategy of didactic change in specific professional environments.

## Methodology:-

The methodological framework of this research, registers as a research of qualitative cut, from the use of the phenomenological research methods (Martínez, 1989; 2006), and action- research (Cohen and Manion, 1990; Elliott, 1994). The characteristics of the research define the work in two important moments: the first stage was carried out in the phase 1 as an approach to the work of the teachers in their natural classroom environment (Carnicer, 1998; Mosquera, 2011). A second moment was carried out in phases 2 and 3 in a collaborative work with the two participating teachers, with the purpose of reflecting on the practices of the teachers and of developing the training program for the generation of didactic change, oriented to from the two differentiating elements that support the innovation proposal of this doctoral thesis.

### Phase 1. Characterization of scenarios and professional practice of the teachers:-

For this phase the study was conducted with the teachers 1 and 2 during a semester. Interviewing them, introducing themselves to the environment of their classes, filming them and analyzing them with the help of tools of phenomenological research through non-participant observation. For the construction of the instruments of investigation there was elaborated a counterfoil of categories of analysis, composed of three categories: 1. Conceptions of the science and scientific work; 2. Conceptions on the teaching of science; 3. Modalities of teaching physics and the role of the history and professional context. With these three categories were designed 85 questions that delimited the objectives of investigation and were used for the construction of instruments.

### Survey instruments:-

Based on the defined categories of analysis, three research tools were designed to work with the two participating teachers: Instrument I, Likert type questionnaire. Instrument II, semi structured interview. Instrument III, observation grid for the analysis of the classes of electromagnetism. These classes were recorded on video for approximately two months, transcribed and analyzed with Atlas Ti qualitative analysis software. Finally, a cross testing of the triangulation of the information obtained with three instruments was performed. Analyzes of the details are published in the thesis that constitutes this research (Zapata, 2017).

### Phase 2 and 3. Collaborative work with teachers and construction of historical elements:-

Acollaborative work was carried out with the participating teachers, through the program of teacher's education, with the intention of constructing indicators that enable the identification of the necessary and significant elements involve in the educational practices, the histories of the physics and the professional environment of the students. These activities were carried out in the framework of the days of discussion and reflection that seek to delve into the important features found in the first phase and the background and studies that were found in the length of the research. The work within the training program was carried out within phases 2 and 3. In the phase 2, introductory sessions were held for the study of the basic components of the didactics of the experimental sciences, in such a way that approach of the documents some topics of interest of the didactic innovation, that allowed to reflect on this practice and the role of the professional context of performance, a light of representative elements on what the teachers of physics should know and do. In the phase 3, we sought to identify internal and external historical and philosophical issues of electromagnetism, which inventions and discoveries. At the same time, we tried to introduce teachers and reflections associated with the use of the history and philosophy of science (HPS) in teaching; To recognize the positions, both in the literature and in what they thought, for and against their inclusion, and to identify the curricular conditions that promote the improvement in the teaching and learning of physics when HFC is included (Conant, 1957; Holton, 1978; Matthews, 1991; 1994; Gil, 1993; Izquierdo, 1994; Duschl, 1997; Solbes and Traver, 1996; 2001; Hottecke, et. al., 2010). Each of these discussions was permeated by the role of the professional context of the students and the teaching of physics in such a way that the discussion constantly turns into the possible restrictions that the inclusion of HFS (Gagliardi and Giordan, 1986; Sanchez Ron, 1988; Gil, 1993; Izquierdo, 1994; García, 2011), and how it is possible, depending on the professional context of the students: future teachers of physics or electrical engineers.

## Results and Discussion:-

A synthesis of the results for three phases described above is presented below.

**Phase 1 Results:-**

We present the results obtained with the triangulation of three designed instruments, which sought to trace what they think, what they say and what teachers do intervene in this research, to characterize the teachers' initial teacher epistemology.

**Conceptions of science and scientific work:-**

Teachers manifest in general diverse positions on science and scientific work that do not allow to be pigeonholed into a single epistemological conception; Some epistemological postures are evidenced in the positivist field by positioning the experiment as the fundamental base of the sciences, in the inductivist field considering science as a systematic repetition of scientific experiments; on the other hand, they distance themselves from the unorthodox and ahistorical vision, approaching contemporary positions of science, considering that science has been marked by the economic and social, political circumstances of the history, identifying its inescapable relation with technological, a changing dynamic, in permanent construction and developed by scientific communities.

**Conceptions about teaching science:-**

In relation to teaching, spontaneous positions towards teaching and learning of science are evident, in agreement with Mosquera (2008), favoring the traditional model characterized by the verbal transmission of knowledge, where the teacher provides the bridge between science and students, by presenting knowledge developed with a high level of discipline, however, aspects of the history of physics are ignored. With respect to the role of the students, it was found that it is marked by a passive activity of reproduction and on the evaluation it was evidenced that essentially it focuses on the verification of disciplinary contents of the class from the resolution of problems, that involve handling of interpretations conceptual and mathematical procedures; to a lesser extent other activities such as practical work or group are evaluated. In relation to the laboratories these are introduced as corroboration of the theory for the verification of some traditional experiments that validate the topics developed in the theoretical contents.

**Modalities of teaching physics and the role of history and the professional context:-**

*Teacher 1:* It presents a methodology of teaching characterized by a traditional modality, where the class is taught from a rigorous disciplinary formalization, with a adequate presentation through the use of the board ordered and enriched by graphs, diagrams, drawings and colors organized enough, he worries about discussing the details for the understanding of what happens on the board, always emphasizing the associated physical concepts; constantly asks the students if they are understanding, conducts workshops in class and accompanies their development by solving students doubts. The laboratories performed are characterized by being the traditional laboratories used for corroboration of the theory. Finally, it is important to discuss that according to Millicic et al (2007), Teacher 1 characterized by being a teacher who works professionally in the same academic environment where he was trained, that is to say that this greater professional experience has been marked by their culture of origin, which is evidenced in their way of teaching spontaneous and generic, with high disciplinary and conceptual elements on physics, but distant from their applications or possible technological, social and historical implications, that is to say a teaching of physics without notable characteristics of the professional context of the students is evidenced.

*Teacher 2*: As teacher 1, his teaching methodology is characterized by being framed in traditional teaching. In the approach of his classes is notorious his disciplinary position for the formalization of the contents in a clear and rigorous way, in the introduction of the subjects is relevant his concern for the presentation and deepening of the conceptual elements, for which he devotes considerable time of each class and presents an orderly and graphical use of the board, sometimes uses everyday analogies or classroom resources to seek exemplify something, recurrently cares about asking students one by one if you are understanding the subject, do some workshops in class and accompanies its development solving the doubts of the students. In the laboratories, a combination of traditional practices with some experimental design, proposals is evidenced, where students perform a more inclusive role in the design, assembly and solution of the practices, besides accompanying their worked process with a laboratory project that is also taken into account as an element of evaluation. As a closing discussion, it is relevant to state that according to Millicic (2004), teacher 2 is characterized for being a teacher who performs professionally in a different academic environment to where he was trained, his professional experience has been developed in his totality in a different culture, culture of destiny; however and although most of his professional experience has been given in engineering faculties, his teaching modality is not very distant from teaching for physics teachers. This is consistent with what he himself proposes, that is to say that his way of teaching, besides being spontaneous, is generic, in which the disciplinary and conceptual elements of the physics prevail, but without considering their applications or possible technological, social and historical implications; That is, evidence of a teaching of physics without notable characteristics of the professional context of students. According to the observed would not differentiate a class of electromagnetism for teachers of physics of a class for electrical engineers.

**Phase 2 Results:-**

Although the program focused on the study of the historical construction of some specific topics of electromagnetism for the identification of relevant factors, which would provide elements of deep analysis for the teaching of physics; initially, introductory sessions were held to discuss basic components of the didactics of the experimental sciences, in order to bring teachers closer to some topics of interest in didactic innovation, that would allow them to reflect on their practice and the role of the professional context of performance, in the light of representative elements on what physics teachers should know and do. Reflections and discussions were generated around aspects such as knowing the subject to teach, spontaneous teaching, the culture of destiny as a determination factor, types of teachers, lack of collective work in the teaching and recognition of the didactic change. Below is a summary of the representative elements found in each of these aspects.

**Knowing the subject to be taught:-**

Based on the work of Gil (1991), the different professional knowledge required for a teacher is discussed, from the conception of what it means to know the subject to be taught. This knowledge, according to Shulman (2001), is part of a more general knowledge developed by teachers. Thus, factors related to the knowledge of the physics were identified in terms of the importance of knowing about the internal and external aspects of the history of the sciences that allow to recognize the problems that arose around the construction of the scientific knowledge; to know the details of the scientific activity to identify the methodologies used and the moments of the same ones through the history, as well as the interactions science, technology society (CTS); Maintain an updated dynamics on recent developments and perspectives in the field, as well as relations with other subjects to identify the scenarios of interaction between different fields of knowledge, in such a way that present visions can be presented and of interest for the students on the subject

**A spontaneous teaching:-**

Physicists generally work as teachers of physics, without adequate training in teaching, in addition to environmental training (Hewson and Hewson, 1988; Gil 1991) acquired in their culture of origin (Milicic et al., 2007), resulting in an image of teaching conceived as something simple that only requires the knowledge of the subject, generating in them a spontaneous vision of the teaching, which leads them to carry out a common sense (Furió and Gil 1989). In this sense, environmental education that determines the ideas, attitudes and behaviors associated with teaching, and implicitly formed while a student (Gil, 1991), was placed within this research in two moments; It is considered, for environmental education, that the first moment occurs when it is configured while you are a student and the second is located when it is being nuanced and reorientated given the experience gained as a teacher.

**The culture of Destiny as a Determinant Factor:-**

Another important factor is found to be demarcated by the experience acquired according to the faculty where physics is taught, called the target culture (Milicic et al., 2007). This experience is marked by the dynamics associated with possible interactions with research groups, projects and curricula of the courses that allow expanding the fields of knowledge of physics given their possible scientific, technological or social implications. Finally in agreement with the denomination of the destination culture, it was found that according to the particular situation of each teacher, the classification associated with the immigrant metaphor of Milicic et al. (2008) is interpreted as the teacher 1 is located as a native teacher, considering that their destination culture coincides with their culture of origin evidenced total security and personal satisfaction to be in their natural; while teacher 2 is classified as an integrated immigrant, who perform in a culture of destination other than the training itself and is characterized by having good adaptation and relationships with this new culture, although it maintains some characteristics of its culture of origin.

**Some types of Teachers:-**

It was possible to make a brief description of the groups of teachers that can be identified in the programs of Bachelor in Physics and Engineering, where the teachers who participated in the research work, on the one hand is the group of *teachers of major experience*, which are characterized by being teachers of many years who even dictate the same subject always, and their way of teaching is framed in traditional teaching with very few resources of innovation; on the other hand, there is another group of *new teachers*, which show some experiences of rapprochement and innovation with students; some other teachers can register as the *research teachers*, who are essentially concerned about doing research, for them the teaching work is in the background.

**Collective work shortages in Teaching:-**
It is identified that in the academic programs of Bachelor in Physics and Engineering where they work, there is a marked deficiency of collective work for reflection on teaching and learning and even more for the generation and participation in teacher training programs, with few exceptions, such as the work developed by Mosquera (2008). It is argued that this kind of discussion among colleagues in the teaching profession to reflect on their work is not done, among others, by a factor specific to the situation of teachers in Colombia, which is related to the type of hiring in the majority of universities in the country, where it is still found that the percentage of teachers for hours is high; According to the figures from the Sistema Nacional de Información de la Educación Superior-SNIES, for main cities of Colombia, the number of teaching staff hired under the hours modality in the year 2015 corresponded to: Bogota 37 %, Medellin 64 %, Cali 62 %, Barranquilla 42 %, Manizales 33 % and Bucaramanga 52 % (MEN, 2015). This is why teachers simply do not have the time, or the labor guarantees that allow them to devote part of their time to participation in training activities (Munby and Russell, 1998). In such a way, that its priority is not the formation but the labor survival, working for hours modality in several universities at the same time.

**Recognition of didactic change:-**
It was identified the didactic change as a contribution to their teaching practices, which seeks to improve what they are doing, adding some theoretical structures along with didactic tools for the teaching task; which is not intended to change in its entirety what is done, but is to enrich and improve their knowledge and educational practices. Considering, according to Delval (2002), quoted in Mellado (2003) that it is not easy to change teachers, because they have ingrained habit of teaching based on how they were taught to them and that they are difficult to leave. This change, in addition, aspects associated with the praxis of the class, demands personal and social aspects that go beyond, among others, to the level of motivational feeling, in such a way that it becomes necessary a mobilization with availability, commitment and awareness towards the search personal satisfaction at work (Hargreaves, 1996; Day, 1999). It is also argued that changes in their conceptions and teaching practices can be carried out, as product of critical reflections (Tobin et al., 1994); Through a collaborative work where they themselves are co-producers of that knowledge (Gil, 1991), within an action research (Baird et al., 1991) that seeks to generate a continuous and gradual change (Appleton and Asoko, 1996), without pretend to imply a complete abandonment of their didactic models (Gunstone and Nothfield, 1994).

**Phase 3 Results:-**
**Approach to the historical journey of electromagnetism:-**
As a first result of this phase, an approach to the historical path of electromagnetism was developed based on an interpretation from the didactics, which was published as a book chapter in Zapata (2015). This document provides an overview of historically recognized milestones that have generated structural changes, paradigm ruptures, schools of thought, transcendental inventions, discoveries and other impacts that contributed to the development of electromagnetism (Matthews, 1991; 1994). In addition, the mentioned text identified different didactic aspects of importance that could favor the development of a course of physics and that are related to the relevance and the contributions that can be taken into account when including the HFC in the teaching of a course of electromagnetism, such as: a) scientific work seen not only from individual findings but from communities, b) scientific controversies and divergences that arise during the construction of knowledge, c) the sense of non-indispensability of a scientific method, d) the theoretical interpretations that scientists have had to make in phenomena that require theoretical explanatory models rather than observation, e) the dynamic and changing nature of the scientific knowledge, paradigm changes, f) the relations of physics with other disciplines and g) the social contexts in which the history of science and the history of the scientists staged it.

**Review of historical experiments:-**
In the second part of this phase a discussion was made around a selection of experiments, which were considered historically important for the development of the electromagnetism, described in table 1. The purpose was to advance an analysis of the way in which they developed to identify representative characteristics about the experimental details, the problems that generated them and the scientific mobilizations that allowed them; all this with the intention of highlighting or not in a class of electromagnetism. After the analysis, we identified a series of aspects that emerged from the discussion and which guided the dynamics of the reflection towards: a) The implications of scientific work, b) difficulty of the experiments recreating historical experiments, c) modification to

experiments to lead to the classroom, some proposed experiments and d) the importance of the experiments for the class closure reflections. A synthesis of the results found for each of these aspects is described below in the sessions directed towards the study of experiments on electromagnetism.

**The implications of scientific work:-**

We found representativeness in the recognition of the interrelation and transversality that has existed between the experimental developments of physics with other areas of the knowledge such as biology, chemistry, technology, etc. For example, the case of Galvani and Volta with the development of the electric pile and the scientific events that was necessary around the biological speculations from which this invention emerged (Galloni, 1965). Similarly, elements related to the other experimental historical moments analyzed were identified, identify, among others, the uses that Leyden's bottle implied in the works of Franklin (Holton, 1978); The complementary work that Faraday carried out in the field of chemistry by raising the laws of the electrolysis, and on the other hand the revolution caused by his discoveries of induction and the invention of devices like the electromagnetic rotor and other devices for induction that gave rise to the motors, generators and transformers; the construction of the Van de Graaff generator as a solution for the generation of high voltages, which allowed accelerating particles in collision experiments in nuclear physics and the transcendental importance of the Hertz experiment on the generation of electromagnetic waves as the first experimental test that verified the electromagnetic theory of Maxwell. In relation to the course of this historical contextualization, it was found that the recognition of some elements of history allows showing an image of the most accurate science and close to the reality of the work of scientists and the context in which it has developed to throughout history (Solbes and Traver, 2001).

**Difficulty of experiments, recreating historical experiments:-**

Within this historical route it was also found that it is not easy to reproduce some experiments, taking into account that the precision requirements, the materials used or the calibration and measurement times require an unfolding experimental conditions that are not possible to obtain in a class practice with students. It is considered that to look for to reproduce these experiments in similar conditions is a complex task by the exigencies of fine mechanics that require mounts, times, etc. However, we discuss the importance and ease of other assemblies that can be constructed as part of practical lab work for the class, which we believe can be recreated in accordance with how they were designed historically. In this particular the conditions, requirements and possible variations that could be taken into account for the implementation of the experiments of Leyden Bottle, Volta Stack, currents and fields of Oersted and electromagnetic waves of Hertz were discussed. Table 1 describes the technical characteristics and classroom intentions that emerged from the reflections and analyzes on each of these experiments, for which a historical value was identified that briefly describes the historical implications that can be taken into account to motivate students to perform historical tracking in each practice. Likewise, for each experiment the characterization of the experimental variables that are proposed to intention the design of the experiments and analyzes of the same ones is identified.

**Table 1:-** Proposal recreates historical experiments.

| Experiment | Historical Value |
|---|---|
| **Leyden Bottle** | Use made of the instrument to accumulate large amounts of electricity, the variations in its construction with the use of water or without, with metal inside, with silver coatings, etc. Besides its usefulness to extract sparks of different sizes connecting the inside and the outside of the bottle, that were used in the experiments of Franklin, devices for therapeutic treatments or circus demonstrations in show and fairs of the time.<br>**Experimental variables:** Bottle size, bottle material, bottle thickness, metal content type inside the bottle, types of metal coating of the bottle, sizes of metallic coating of the bottle, ways of loading the bottle, types of connections between bottles. |
| **Volta Stack** | Recognition of relations between physics and biology with the contributions of Galvani, realization of diverse experiments that involved knowledge of chemistry for the decomposition of salts and the electrolytic reactions, works developed about the animal electricity (Chau, 1984). Volta contributions to the process to reach the invention of the electric battery. Developments in electricity and the magnetism with the appearance of a source of direct current that allowed the invention of electromagnet and other technological applications such as telegraph, electroplating, water decomposition, electrochemical relations, etc.<br>**Experimental variables:** Shape of pile metals, metal material, number of metal disks, type of salt solutions, forms of accumulation between disks and saline solutions, use of |

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| | commercial animal tissues as saline solutions. |
| **Oersted's experiment** | Importance of the first experimental test that will link the electrical phenomena with magnetism. Oersted study on the independence of the phenomenon of possible effects of the surrounding environment on the cable through which the current flows, related to thermal or ionizing effects of air. Experiment generated by the use of continuous currents produced by the Volta battery, of recent invention for the time. Theoretical relationship with the contributions of Ampere and the actions between currents. **Experimental variables:** Current currents, wire size, distance from the compass to the cable, effects produced by materials between the cable and the compass (wood, water, etc.), position of the compass with respect to the cable, change in cable position (horizontal, vertical) to identify the direction of the generated magnetic field. Applications Ampere law and effects of a current of a cable on another cable with current, distance between cables. |
| **Hertz electromagnetic waves** | Importance of this phenomenon as the first experimental validation of Maxwell's electromagnetic theory. Details of the construction and design of the original Hertz experiment. Implications of this development for the transmission of information without cables (waves of radio, television, etc.) **Experimental variables:** Modifications to the original design, alternate ways of replacing the original design and the construction from materials of low cost, transmission distance generated electromagnetic wave. |

***Modification to experiments to bring to the classroom and contextualize their applications:*** Due to the difficulty of some experiments, as described above, it is proposed the design of five experimental practices; making some modifications in the original conception of the experiment but maintaining the intention to be sought shows the phenomenon. For this purpose a description for each proposed experiment is proposed, in table 2, the objective of each one is described and a characterization of the suggested variables could be taken into account in the design of the assembly, development of the practice and contextualization in different application topics.

**Table 2:-** Alternate experiments proposal.

| Experiment | Description |
|---|---|
| **Coulomb's Law** | Two polypropylene spheres are hung from the same point in the manner of two simple pendulums. A Wimshurst machine is used an electricity generator to charge the polypropylene beads. The effect of electrically charging the spheres with charges of the same sign is manifested by a repulsive force separating the spheres. It addresses the solution of the problem by balance of forces in the spheres; the angle of the spheres is measured. The electric force ratio is established as a function of the inverse of the square of the separation distance between the spheres. **Experimental variables:** The load supplied to the spheres is controlled as a function of the number of turn given to the Wimshurst machine, spacing of the spheres, size of the polypropylene spheres. Contextualize the meaning of practice towards other phenomena that has a behavior associated with the inverse square of the distance in phenomena that propagate with spherical symmetry as sound waves, seismic, etc. |
| **Flat plate capacitor** | This practice is proposed as a complement to the Leyden bottle. It is sought to construct flat plate capacitors using low density metal paper and varying the dielectric between the plates, in terms of material and its composition of dry solid, semi-dry solid, liquid, etc., to establish different capacitance values. **Experimental variables:** Paper area of flat metal plates, types of dielectric (paper, paper impregnated with different fluids such as oils, fluid dielectric, etc), dielectric thickness to vary the separation distance between metal plates. Contextualize the experiment towards the construction of capacitors, use of dielectrics, uses of variable capacitors, etc. |
| | A neodymium magnet is hung from a spring that hangs vertically (forming a spring mass system). At the point of equilibrium of the spring mass system mass, a coil of wire is placed around the magnet, constructed according to the size of the assembly and connected to an oscilloscope. The magnet is oscillated generating a simple harmonic motion (MAS) of the spring mass system, the movement of the magnet inside the coil induces an electric current |

| | |
|---|---|
| **Faraday Induction** | that flows through the coil. The purpose of the experiment is to analyze the relationship between the induced current, the variation of the flow of the magnetic field flux through the coil and the MAS of the magnet.<br>**Experimental variables:** Frequency of oscillation of the spring (varying the mass or the spring), frequency of the current generated in the coil determined with the oscilloscope, to determine the relation between the oscillation frequency of the magnet and the frequency of the induced current, can be construct the MAS graphics of the magnet through video analysis or motion sensor and compare them with the graphs generated on the oscilloscope. Contextualize the applications of the phenomenon in the electric generators, alternators, etc. |
| **Salt oscillator** | The purpose is to show an effect similar to that obtained with Volta Stack to generate a potential difference. This experiment generates a potential difference due to the difference of electron affinities between two liquids. A glass syringe containing salt water closet is placed vertically and partially submerged within a vessel with water, the difference in densities between the water flow, salt that moves from the syringe to the container and the flow of the water entering the syringe. Electrodes are placed inside the syringe and in the water of the vessel that is connected to a voltmeter to measure the voltage variations associated with changes in fluxes.<br>**Experimental variables:** Syringe size, salt saturation levels within syringe water, electrode generated current, frequency of oscillations and relation to current, relationship of oscillation with respect to the variation of water in the vessel and the speed of variation. Contextualize the behavior of this physical phenomenon with biological phenomena such as neurons and cardiac cells, which behave similar. (Gonzalez, Arce and Guevara, 2008). |
| **Electrostatic Shielding** | The purpose is to generate a demonstration within the class about the applications of Gauss's law by Faraday's cage, for electrostatic shielding. It consists of placing a cell phone inside metalized bags (you can use food packaging or commercial package mouths), to show that inside a closed metal surface the electric field is zero. Transfer the phenomenon to the electromagnetic in electrostatic shielding.<br>**Experimental variables**: To vary types of bags and conditions of closed surface necessary to generate the armor, tests with other metal surfaces closed like cages. Contextualize industrial shielding applications in specialized or telecommunications laboratories. |

**The importance of experiments for class closure reflections:-**

After the analysis of the different experiments discussed in this section, which sought to rescue and to discuss their historical value on how they were developed, and identify the internalist and externalist context in which took place. Consistent with what Izquierdo et al. (2016, 79), who propose that in order to overcome the limitations of superficial analyzes of scientific theories, based on whether they were true or false in a given epoch, it is necessary, when trying to repeat historical experiments, *"were the scientific ideas in the time that were postulated, the strategies of disclosure that were used, the possible interpretations that were had with the instruments available and the usefulness of the same ones for the theoretical advance"*. Consequently, with this intention of historical route that was carried out, and in addition to the analysis of each experiment, several representative factors were consolidated through four points, which were revealed as differentiating elements and that decanted the background of reflection. These elements focused on the following considerations: not all historical experiments are viable for the class; historical experiments can be recreated with the current conditions; for the teachers training the recreation of some historical experiments may be important and finally it was considered that for the training of engineers it may make more sense the applications of experiments than the recreation of historical experiments. The proposals in relation to each of these items are described below.

**Not all historical experiments are feasible for the class:-**

It was found that the historical reconstruction of a good amount of experiments in physics is not easy to construct, considering the technical requirements, the complexity of the assemblies or the precision of them. For example, the Coluomb force experiment if you do not have the high level laboratory equipment, which usually has a definite assembly with Coulomb scales (according to the usual laboratory equipment in Colombia of brands Phywe, Pasco, Leybold), is not easy to mount under conditions similar to those posed by Coulomb. The same happens with the original experiments of Faraday by its high requirements of fine mechanics for the construction. It is then considered that experiments such as the construction of a Coulomb scale are not simple and the intention to show the behavior of the force as a function of the inverse of the square of the distance can be shown with other modified assemblies, which are more feasible to build or assemble in the environment of a physics class. However, it is considered that the knowledge of these difficulties can be used to construct critical thinking in students, consequently Freundlich(1980), who argues that the development of critical thinking can be generated from the recognition of controversies of science and in this case promoting skills to compare the original experimental designs with which students can assemble.

**Historical experiments can be recreated with current conditions:-**

It is possible to recreate historical experiments by adjusting the restructuring of experimental conditions that may have certain variations according to the existing resources. In this sense, it is concretely posited that some practices can be proposed to the students through a historical problematization of the phenomenon, in which one must resort to history to know the details of its development and original operation. From this historical knowledge of the phenomenon and inspired by historical documents (Anderson, 1992), to propose the experimental conditions necessary to carry it out, with alternative materials or simple instruments. Providing a value in learning not only from physical foundations but from the development of student thinking to address the problems of experimentation, which is in accordance with the approach of Teichman (1999), considering that this type of work could foster the speculative rationing that is necessary to infer the processes of scientific discovery provided by the experiment.

**For the training of teachers the recreation of historical experiments may be important:-**

Although research has shown that for the training of physics teachers the meticulous reproduction of the instruments and conditions of historical experiments can contribute to the formation as described by Heering (1999); According to what we analyze, we do not necessarily have to carry out the experiments with the reproduction of the original instrumentation, to achieve a successful exercise in the classroom. I argue that this would be in agreement with Kragh (1989) approach, which discusses that the realization of the experiments is an integral whole in which the theoretical expectations and the interpretation of the data are involved, which would require too many abstractions and thus ahistorical glances to isolate the sense and the experimental conditions of the phenomenon, in this sense one can think that the historical experiments are unique and unrepeatable. According to this, we consider that the historical recreation of certain experimental conditions can contribute to the formation of students, but from the problematizing sense of the experiment and the requirements that it entails (Kpinis, 1995). That is, what is sought is to start from the original experiment when students try to recreate the conditions, not necessarily with the same materials or with the same type of instruments, to face the problematic implications that these experimental conditions require, knowing the historical details and the original conditions under which the experiment was carried out, can with the equipment available in the laboratories or with low cost materials perform the recreation of the experiments, with the necessary adjustments or adjustments so that they can obtain satisfactory results and in accordance with the phenomenological typology of the experiment and the fundamental physical principles. Finally, it is discussed that this type of exercises contributes to the formation of physics teachers under the idea of Matthews (1994), in which a good science teacher must have a reasonably developed knowledge not only of his discipline but of the cultural dimension And historical of the same, that later will project in its students.

**For the training of engineers the applications of experiments may be more meaningful than the recreation of historical experiments:-**

After several discussions, a consensus not easy to achieve, it was suggested that for the teaching of physics in the context of engineering might make more sense to the applications approach that the experiment may have, compared to the strictly historical approach of the same. It was suggested that the historical knowledge of some experiment can be involved as theoretical reference information for the introductory sustenance of the laboratory guide; while the problematizing aspect of the practice should be more focused on the experiment as a condition of application in an engineering context. This would make sense in relation to Sánchez Ron (1988), who argues that the inclusion of history in the teaching of physics for engineering is not considered as necessary. In our case, for training engineers, the contextualization of the experimental practice on the historical approach of the experiments would be privileged, in order to generate an environment of greater motivation for the students, in agreement with Redish and Smith (2008); Trumper (2003); Glynn and Koballa (2005) argue that the classroom involvement of contextualized processes in the real world, in this case experiments, will promote meaningful learning with a more solid conceptual construction.

## Conclusions:-

The program of training of university physics teachers based on the historical context of physics and teaching professional contributed to the characterization of the epistemology of the teaching staff of the participating teachers, the joint elaboration of some concepts on the didactics of the sciences, the epistemology of science, the history of science and the knowledge of the subject to be taught. Evident reflective transformations that manifest conceptual, attitudinal and procedural changes towards the teaching of physics, in which teachers make explicit their recognition of the importance of knowledge of the historical elements of physics for their training and as a complement to teaching. In addition, the implemented program model has revealed changes in the ways of thinking and acting on the part of the two university teachers, seen in changes in the epistemology of the teacher and in their classroom practice, the teachers recognize the need to identify contexts professionals for teaching.

The use of the historical context of the physical and professional students, as a proposal of innovation within the training program deployed, was considered a differentiating tool that motivated the interest of the two participating teachers. On the one hand, the historical context generated a special interest for the deep study of the subject, allowing to deepen the knowledge of physics, the recognition of the tensions that revolved around the internalist construction of the concepts, the identification of different epistemological currents and the valuation of the history of the sciences as an inherent element of the knowledge of the teacher. On the other hand, taking into account the professional context of the students where the physics is taught, allowed to raise reflections around relevant themes, student interests, possible successes or failures of a class, the impact of physics in each context, the teachers habits, the orientation of the experimental work, which part of the HFC may or may not be representative, how to involve STS relationships in the classroom, among others. All with the purpose of estimating the need to consider this context as a didactic tool to favor students motivation and learning.

When it comes to the need for teacher training for the generation of didactic change, having as one of its referents configuration historical contextualization, it is sought that teachers in addition to expanding their knowledge on the subject to teach, can reflect and argue with the students critical discussions about science, from showing the construction of sciences in terms of internalist and externalist controversies, the construction of scientific collectives, the dynamics of constant change, and so on. It should also contribute to science education from a more enriching CTS perspective, with an image of university science with the highest content of scientific pragmatism, as well as the historical, social, philosophical and political aspects that were necessary for that its construction could be given; In addition it helps to better base science and technology as spaces of knowledge that increasingly penetrate into social every day and future professionals of students, is a possible teaching of science conceptually transparent.

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