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Didactic issues of teaching / learning the electric field concept in Benin republic, students' difficulties and prospect

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ABSTRACT: *There are many studies in science didactics on the learners' difficulties in teaching and learning of knowledge, but few deals with difficulties in teaching/learning about the electric field concept and associated notions. Our study aims to identify some of these difficulties and the obstacles that engender students from conceptions related to the electric field concept in various problem-solving situations by referring to the theory of conceptual fields and the theory of didactic situations. It appears that these difficulties are phenomenological and conceptual and sometimes related to the use of mathematical tools.*
KEYWORDS: *didactics, difficulty, concept, conception, learning, knowledge, electric field*

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I. INTRODUCTION AND PROBLEM

Many researchers in the didactics of the physical sciences have made interesting contributions on the subject of learners' teaching / learning and problem solving, but problems remain in the way knowledge is built and appropriated. It is therefore the teacher's task to find a good teaching-learning process to bring learners to better appropriate scientific knowledge that would facilitate the development of the ability to argue to get rid of erroneous and naive knowledgeto make progress towards scientific knowledge. The problematic of this research is based on our observations on the implementation of the new curricula and the difficulties that this creates for our Beninese learners in the appropriation of scientific concepts, particularly related to the teaching of the electric field concept. It is of paramount importance for students, because to better understand and master or construct scientific knowledge, they must ask questions about the etymology of certain knowledge and make a personal commitment to finding solutions. However, many students find it difficult to understand the course and often face difficulties in problem-solving activities, and do not know how to overcome them. Our research work is based on the observations made by the teachers of our colleges on the difficulties encountered by learners in learning about physical phenomena in general and the electric field concept in a particular way, as well as on the failure of a large number of them to properly lead the resolution of a problem especially when the situation is not usual. To this end, we project in this work to look for the causes of the difficulties in the teaching / learning of the electric field as well as the obstacles which prevent the students to accomplish the task of problem solving.

II. THEORETICAL FRAMEWORK

To achieve the objectives of this research, we use the theoretical framework of the conceptual fields of Vergnaud (1994) and the theory of didactic situations of BROUSSEAU (1986).In learning science knowledge, it is important to characterize the skills of learners or even their initial conceptions and the difficulties they encounter during this learning. This characterization needs a theoretical framework that is conceptual field theory (CBT). This theory focuses on the initial conceptions of learners, necessary for new learning and the way in which programs must be developed for the emergence of successive knowledge in accordance with the age of the learner. The learner facing problem solving is confronted with two situations. Whether:
- his prior knowledge allows him to act immediately in the face of the situation. We are talking here about usual situations.

-he does not have the necessary skills and is in this case obliged to think, to explore, to hesitate, to make efforts that may eventually lead to success or failure of problem solving. Here the learner looks for adaptation methods that he constructs and reconstructs to achieve discoveries "This theory aims to provide a coherent framework and some basic principles for the study of the development and learning of complex sciences, in particular those which are science and technology "Gerard Vergnaud, 1996. It takes into account in the didactical triangle knowledge-learner pole. This theory makes it possible, among other things, to understand how we can build concepts from the actions of the subject, the learner. It is simpler to understand that one is appropriating a concept through situations and problems to be solved. Often the risk is not being able to understand the complex and laborious process by which learners have mastery of science or not. Mastering a concept through problem-solving activities covers a long period of time with many interactions and lag. One can't understand the meaning of a learner's mistakes or procedures if one does not know the way in which one's conceptions and skills were formed and how they have evolved through a multitude of concepts encountered. It is in the light of this that in our framework of study and according to the Beninese context we mobilized this theoretical framework of the conceptual fields of Vergnaud to highlight the prerequisites of the learners on the concept electric field and its effects by organizing us from the schemes by combinations of several tasks. Cognitive processes and learner responses are functions of the situations they face. This theory is thus mobilized in the case of our research through the characteristics or parameters defining the conception of a subject in relation to an object of knowing the linguistic signifiers (concepts-in-act) to categorize the different conceptions of the learners in relation to the concept of the electric field concept in solving problems involving knowledge related to this object. The theory of didactical situations is based on a constructivist approach and does not take into account the social aspect. On the plane that the learner establishes with the object of knowledge and the educational system, this theory distinguishes three types of situations characterized by four functions. This theory makes it possible to describe and explain in a rational way the phenomena of teaching, phenomena which generally give rise to empiricism or opinion rather than reasoned discourse. We could first define the didactics of scientific disciplines, within the cognitive sciences, as the science of the specific conditions for the dissemination of scientific knowledge useful for the functioning of human institutions. This theory makes it possible to produce, improve, reproduce, describe and understand the teaching situations of the SPCTs. The theory of didactical situations (DST) is marked by the conditions in which it appeared. The theory of didactic situations proposes a modeling of the knowledge, the situations of teaching and the roles of the teacher and the pupils in class. In the case of our research, we rely on this theory through the different types of obstacles defined by G. BROUSSEAU to characterize learners' learning barriers to the concept of the electric field concept.

These two theories will allow us to analyze the conceptions, the reasonings and the errors of the learners in the resolution of the different types of problems (Dumas-carré, Goffard, 1993) starting from the operative invariants (concepts and theorems-in-act) which are the characteristic indicators of a learner's conception in relation to an object of knowledge in his reasoning. For many years, therefore, a lot of research has been done on problem solving, and proposals for strategies and global approaches have been suggested to help the student in this task, but few have dealt with the phenomenon of the electric field.Indeed, the concept of the electric field, object of our research is distinguished by its vectorial and directional character, source of specific difficulties which it is necessary to locate in order to remedy it.

There are huge difficulties for students to learn this concept. It is therefore part of a deeper approach involving multiple skills and involving the synthesis of knowledge. It is important to set up a methodology to help the student in this process.

III. METHODOLOGY

To study our problem, we realized two big activities, one directed towards the pupils and the other towards the teachers in Benin republic (Figure 1). The field of investigation of our study concerns a general secondary school. Our population here concerns high school students and as a sample student of the scientific terminal level (student who prepare baccalaureate). The way in which the learners' difficulties were identified is to submit them to two situation-problems, interviews, paper questions, organized debates on the electric field concept and related concepts and then interview-questions with some qualified teachers. and beginners to understand from their oral and written statements, how they teach the concepts related to the electric field concept into scientific terminal classes. We can't talk about the students' difficulties without being able to evaluate them and try to take into account their initial representations on certain concepts of the electric field vector. In this context we first subjected the students to a pre-test consisting of several small questions to identify the learners' conceptions about the electric field concept and then assessments on two similar and field-related problems. electric, but which differ in the formulation of instructions. We have designated one by PC and the other by PD. These exercises focus on the deviation of a particle in the electric field. We want to study whether students in solving problems have mobilized or not a given basic procedure by respecting the general resolution method according to POLYA (1957) including: the understanding of the problem, the design of a plan, execution of this plan and the verification.

At each step is associated a set of questions that must lead to the solution. Thus, to design a plan, POLYA suggests to the student to ask the following questions:

- ✓ Has he ever seen the proposed problem or a slightly different form problem?
- ✓ Does he know a neighbor problem? A useful theorem?

- ✓ In considering the unknown, does the problem evoke a familiar problem with the same unknown?
- ✓ If a nearby problem exists, has the student already resolved it, does the applied method apply? Is it able to reformulate the problem? etc.

The analysis of learners' written productions allowed us not only to make judgments but to understand the difficulties. We then had two interviews with the students, one with a student who did not have the average and the second with the one who obtained the highest mark in order to be able to characterize what is really the source of the bad grades. often observed while respecting POLYA's suggestion. Results obtained from these interviews we found statements like: " we do not handle often ", " ... explanations often do not relate to our experiences ..., " we see documents without understanding much ' ',' 'we often repeat in the exercises the methods of the teacher' ',' '.... The teacher does not often say why this is ... ", " ... we were taught like that ".

Faced with these findings, we have highlighted a practice based on scientific debate; a teaching approach based on the theory of situations (G. Brousseau 1986), essentially developed by Marc Legrand in Grenoble (M. Legrand, 1986-1993), with the aim of closely involving the learner in the construction of his know. The choice of scientific debate among learners was guided by a research conducted in France by Guy Robardet in Grenoble (G. Robardet, 1989) on assessments and surveys and showed that students experience serious difficulties when in a situation to truly practice a scientific approach.

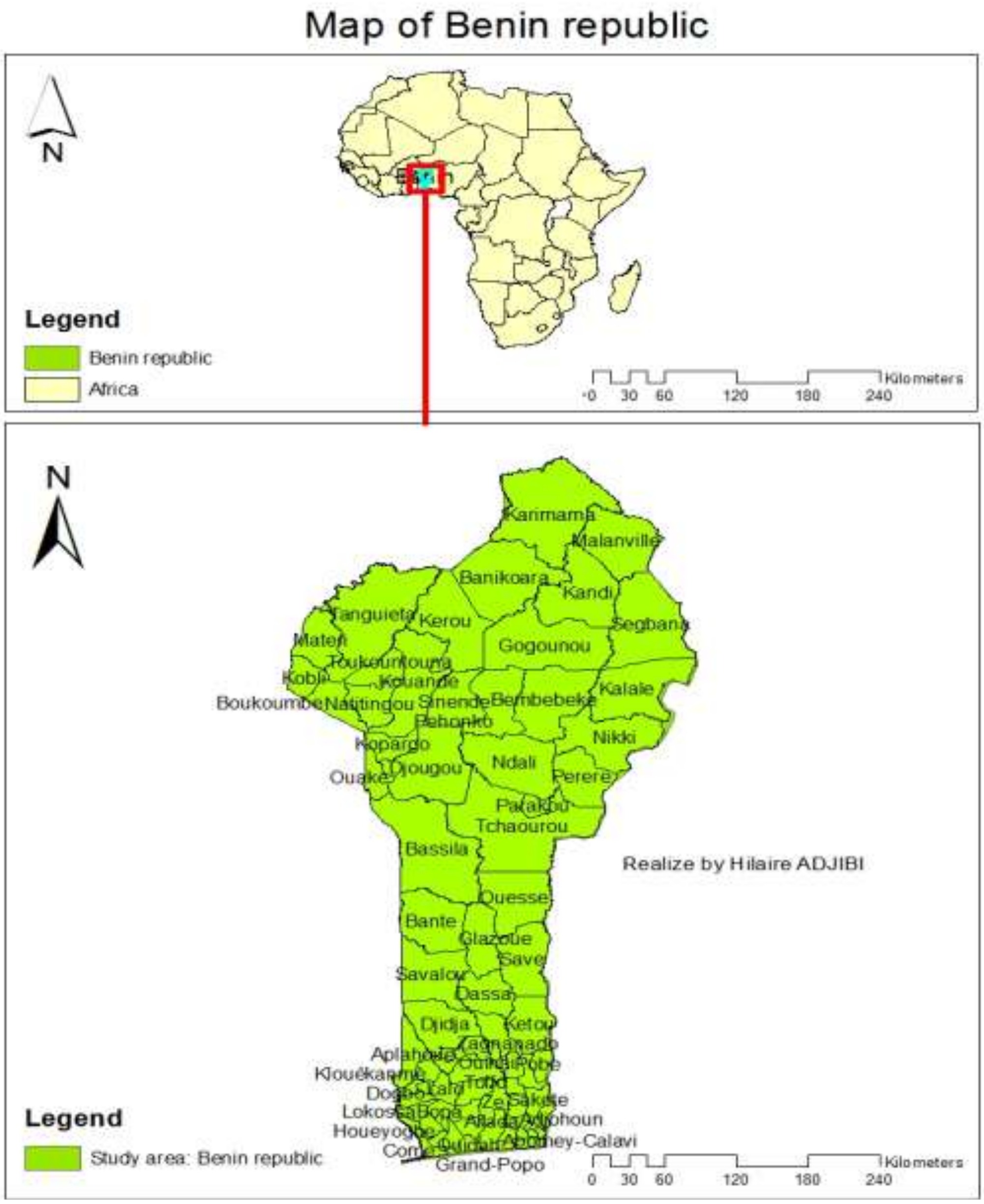


Figure 1: Map of Benin republic

IV. ANALYSIS OF RESULTS AND DISCUSSION

4-1- Analysis and interpretation of conceptions relating to the concept of the electricfield

4-1-1-Case of the effect of distance on the existence of the field $\vec{E}$ and the electric force $\vec{F}$

The following question was formulated in order to see if the learners understand the conditions of existence of the electric field and the electric force while avoiding to speak of Coulomb's law.

Question: On what condition an electric field exists at a point?

The results obtained are summarized in the following tables: responses are given by Yes or No by counting their numbers according to the possible answers suggested.

Table 9

For $\vec{E}$	Possible answers suggested	Yes	No
Condition of existence of electric field	When two charges repel each other	26	4
	When two charges attract	26	4
	When two charge arejoined	3	27
	When there is electric current	30	0
	When a charge q is fixed and only in a medium	2	28
	When a charge q is moving in the vicinity of a fixed charge q0	30	0

Table 10

For $\vec{F}$	Possible answers	Yes	No
Condition of existence of electric force	When an electric field exists	2	28
	When a charge is placed in a region	23	7
	When a chargemoves	30	0

For the majority of students, there should be repulsive forces between the loads spread along a plate of a capacitor. This distribution in principle should give field vectors in several directions.

The question they got to ask is how the vector is spread over the space between the plates and perpendicular to the plates. The electric dipole can be created diagonally and thus give field vectors in diagonal. Similarly taking into account the proximity of the loads on the plates the field vectors are more intense along the plates than between the plates as evidenced by the Coulomb force that presents the $\frac{1}{r^2}$. If r ² is small, the effect of the force is large and has therefore more influence than if large R ² existing between the plates.

From these observations of the pupils, we notice that a blur is installed in the ideas of the pupils and this blur arises from the epistemological difficulties related to this knowledge. The theory of mathematics that explains well what this notion does not fit with the imaginations of the students. Students ' reasoning contradicts established laws. The abstract presents difficulties of misunderstanding.

For learners when there is no movement of a load, there is no electric field. This reinforces the definition that an electric field is a region of space where an electric load is subjected to an electric force.

This way of understanding the existence of an electric field in a medium, contradicts the formula of Coulomb E = k x $\frac{|Q|}{r^2}$ Because the fixed Q charge is still.

So, for our learners, it is the manifestation of a force causing the displacement of a loaded body That shows the existence of an electric field. They therefore

- If there is force, there is electric field
- If there is no force, there is no electric field

  In principle, the control load which must make it possible to ensure the existence of an electric field, also creates an electric field like the source load. But this information that the witness load creates a negligible field before that created by the source load because it is weak is absent in the abstract course that most of our teachers provide.

If this is the case, in the speeches of the learners, a question that does not find an answer persists and is to know: Yes around a Source charge, there were several control loads. The latter should have influence on the source load or, there may be compensation. In this case on which side, On would observe displacement?

Learners fail to understand in the absence of control loads, the field created by the source load exists. $E = k\frac{Q}{r^2}$

At the same distance r of Q, the field $\vec{E}$ is constant but when one doubles the value of the control load, the pupils do not understand why the force $\vec{F}$ Gets bigger.

Through the exchanges we find that the pupils ' response to this question is almost unanimous. For students it is incomprehensible that force increases if the field influences the value of the electric force. That said, it is understood that for the learners the existence of the electric field is not necessary to change the value of the electric force. The "no" response of the Twenty-eight (28) students in table 10, for the existence of the electric field, determines the existence of the electric force.

This phenomenon becomes incomprehensible because the field has not changed at this distance. The mathematical relationship $\vec{F} = q\vec{E}$ And $\vec{F} = 2q\vec{E}$ Doesn't seem to be fair to learners Because it does not relate the observable reality. Two situations therefore oppose. The world of Mathematics and facts observables That do not seem to justify this abstract theory.

4-1-2-Learners ' design in relation to field-force dependence

The students found very quickly that, a serious problem arises for the representation of the vector uniform electric field $\vec{E}$. Yet usually some of them do it without actually understanding the real reasons (This confirms ourexpectation).

We therefore wanted to know later what determines the existence of the electric field at a point in a space where it already reigns, by proposing them to exploit the relationship $\vec{F_e}=q\vec{\mathbf{E}}$ (q being the charge of that point). Given the specific objective of whether the force is zero, is the field electric is zero at this point?
Some of the learners ' productions

Question: According to Coulomb's Law on a: $\vec{F}$=q$\vec{E}$ Yes $\vec{E}=\frac{\vec{F}}{q}$

What do you think of the following assertions?

- If $\vec{F}$is zero, $\vec{E}$ also is Zero?

- If$\vec{E}$is zero, $\vec{F}$also is zero?

• La force électrique $\vec{F}$ n'est ~~pas~~ nulle alors le champ électrique est nul : $\vec{F}=0 \Rightarrow q\vec{E}=0 \Rightarrow \vec{E}=0$

• $\vec{E}=0 \Rightarrow \frac{\vec{F}}{q}=0$ alors le vecteur champ $\vec{E}$ est nul alors la force électrique $\vec{F}$ est nulle donc il n'y a pas de force électrique.

9

q_1 : Disons :

- si la force électrique $\vec{F}$ est nulle, le champ électrique est nul :

On sait que $\vec{F}=q\vec{E}$ ① et $\vec{E}=\frac{\vec{F}}{q}$ ②. De ② on peut dire que q est non nulle.

$\vec{F}=q\vec{E}$. $\vec{F}=\vec{0} \Rightarrow q\vec{E}=\vec{0}$ or q est une constante alors $\vec{E}=\vec{0}$ / $\vec{E}$ est nul

- si ~~la force~~ vecteur champ $\vec{E}$ est nul, la force électrique $\vec{F}$ est nulle :

$\vec{E}=\frac{\vec{F}}{q}$ $\vec{E}=\vec{0} \Rightarrow \frac{\vec{F}}{q}=\vec{0}$ or q est une constante

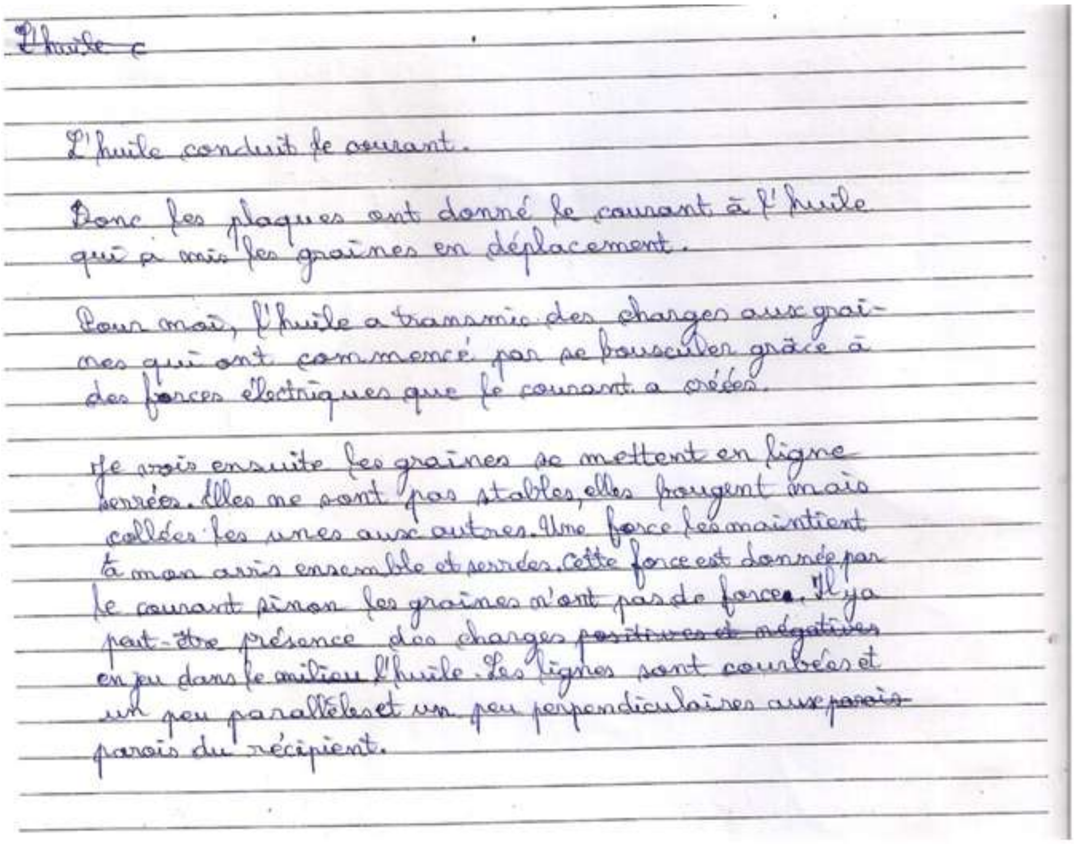
alors ~~$\vec{E}$~~ $\vec{F}=\vec{0}$ / $\vec{F}$ est nulle. C'est $\vec{F}$ qui est en fonction de $\vec{E}$.

For our learners it is obviously **yes** at first sight since the vectorial equality shows it without pushing the reflection of what would represent $\vec{E}=\frac{\vec{Fe}}{q}$ (confusion). Later, they assert that there is field when a charged particle is subjected to a force. A simple problem of notions of mathematics arises (importance of the use of the mathematical tool in the teaching of the physical sciences). There is therefore a didactic obstacle. Such a scientific debate between teachers and learners must often occur during learning. It is imperative to emphasize that science education should be based on experimentation.Finally, they were made to understand that the field vector $\vec{E}$depends on the potential difference (voltage) and not on the presence of the electric current and the electric field can exist without there being any electric force.

4-1-3-Learners conception compared to the electric field lines

Although the students said they were always told that the field lines are still perpendicular to the plates of a capacitor, we wanted to see from the observations made during the session on the movement of the grass seeds, to see if the learners understand the different interactions that occur between seeds to explain their alignment. This concern therefore requires us to submit the students to the following instructions to analyze their written production and to identify the shadow points.

Question: Explain why the lawn seeds are not strictly aligned and are side by side when moving in the video



~~L'huile c~~

L'huile conduit le courant.

Donc les plaques ont donné le courant à l'huile qui a mis les graines en déplacement.

Pour moi, l'huile a transmis des charges aux graines qui ont commencé par se bousculer grâce à des forces électriques que le courant a créées.

Je vois ensuite les graines se mettent en ligne serrées. Elles ne sont pas stables, elles bougent mais collées les unes aux autres. Une force les maintient à mon avis ensemble et serrées. Cette force est donnée par le courant sinon les graines n'ont pas de force. Il y a peut-être présence des charges ~~positives et négatives~~ en jeu dans le milieu l'huile. Les lignes sont courbées et un peu parallèles et un peu perpendiculaires aux ~~parois~~ parois du récipient.

Copies of learners on field line design

Les graines

Au départ, les graines commen-cent par bouger pour se mettre en ordre. Donc il y a une force escercée par l'huile pour les faire déplacer. Mais ce que je ne com-prends pas elles se dérangent au même niveau comme les écoliers qui font le rang. Pourtant elles étaient en ordre au début. L'huile les a rassembler comme si c'est un ordre. Ce qui est sûr, on peut dire une force vient du courant pour les rassembler. On voit des lignes droi-tes un peu courbes par endroit.

*Une charge qattire une charge q parce qu'elles se voient.

*Quand une charge se déplace le vecteur vitesse $\vec{V}$ est colinéaire à la trajectoire. C'est pourquoi la force aussi est colinéaire à $\vec{F}$. Les deux sont toujours liés.

*Les lignes de champ sont des courbes sur lesquelles se déplacent le champ $\vec{E}$.

4-1-4- Natures of learners' conceptions on the electric field concept

To categorize the nature of the learners' conceptions, we took into account the model of analysis designed. Questions related to the electric field are asked to the class as an evaluation. Written and oral productions have been recorded and the content is carefully analyzed to identify the different conceptions of the learners. From these written and oral productions of the students we make a lexical analysis of the content. For this fact, we make a summary table of the indicators of the concepts characterizing each of the conceptions of the object. This lexical study has for indicator the concepts defining each of the conceptions of the object. The following table was thus realized.

Indicators / **Question**	**Concept**	**Reasons or justifications**	**Conception**
Q1: Definition and creation	C-1-1:Zone, environment, space, locality area	A field is an empty space where there is electricity. -There is the electric word	Space (Fixed conception)
	C-1-2: Attraction, repulsion, friction, electricity	This is the field that attracts iron objects. The papers are attracted through the field	Charges (Fixed design)
	C-1-3: Empty space, load, voltage, DDP	Electricity gives the current, so there's a field.	Current (Fixed design)
Q2: Interaction, field and distance	C-2-1: distance between two charge implies the existence of field	Without distance, there is no field, you need a space.	Distance-Field (Non-scalable mixed design)
	C-2-2:Distance conditions strength	The distance must exist for it to have force taking into account the Coulomb's law	Force-Field
	C-2-3: contradiction	Two bodies charged with opposite signs are contiguous	Field without force and force without distance (non evolutionary mixed design)
Q3:Electrical field relationship, current intensity	C-3-The passage of the current creates the field	The electric cables give tingling so there is field because the current flows	Current-field (mixed design not evolutionary)
Q4: electric field vector and orientation	C-4-1- Orientation according to the plates	In the empty space between the plates	Space (Fixed concept)
	C-4-2:Decreasing potential	We've always been told that. We've never seen	Tension(Fixed design)
	C-4-3 Loading Plates	Taking into account the connection to the generator terminals	Charges (Fixed design)
	C-4-4 Following the field lines	The field moves along the line like the electric force	Field Line (Non-scalable mixed design)
Q5: collinearity vector field-vector force	C-5-1: The force is colinear to the field	The Coulomb relationship $\vec{F}=q\vec{E}$show it. But we're not convinced of that.	Collinearity$\vec{E}$ And $\vec{F}$ (Non-scalable mixed design)
	C-5-2: The force is directed according to the trajectory	It is the force that moves the particle so guides the movement and confused with the trajectory.	Non-Collinearity of $\vec{E}$ And $\vec{F}$ (Mixed and non-scalable design)
Q6: Condition of existence of field and force	C-6-1: Attraction and repulsion of charges	Loaded bodies attract or repel	Design Load (fixed)
	C-6-2: Charges in contact	Two loaded bodies in multiples	Design Load Fixed
	C-6-3:presence of the current	The current creates the loads so the field appears	Current conception(mixed non-evolutive)
	C-6-4: Moving or not of charges	A point charge creates a field	Conception charge (fixed)

The analysis of this table shows that most learners define and characterize the electric field concept by mobilizing differently two or more concepts associated with it respectively. They therefore have for the most part mixed designs having one or more characteristic parameters put into play by Thales de Milet and others to introduce the electric field as an electrical phenomenon based on the displacement of the charges. Others define and characterize the electric field concept by mobilizing the characteristic parameters obtained by William Watson (1715-1787) (force, interaction, empty space, particle transmission) to characterize the electric field as a particle transmission space. For others, without mentioning the characteristic parameters of Alexandro Volta (1745-1827) (the functioning of the pile and the characteristics of the space) uses other concepts characteristic of space to give birth the design space of the electric field concept.

In the analysis of the answers to questions Q3, Q4, Q5, and Q6, learners establish several relationships between the electric field concept and the epistemological parameters characterizing it. In the majority of cases, the relations between the concepts do not follow the order of the epistemological concepts introduced by the scientists and thus have mixed but not evolutionary conceptions. The characteristic parameters introduced by Coulomb (1736) and Faraday (1791) (electrical forces, force vectors, field lines) are mobilized separately in the resolution of questions related to the orientation of the field vector. Most learners have mixed conceptions (field-current, field-space, field-loads, field-forces) except that they do not establish a direct link with the order of the concepts introduced in the epistemological analysis of the concept electric field. The field lines introduced by Faraday do not serve in the orientation of the field vector created between two plates of the capacitor and in the representation of the force vectors and are sources of contradictions in the explanations. In explaining certain phenomena in everyday life, learners do not establish a link between epistemological concepts and empirical concepts (Moussiliou, 2017). The reasoning is based on endogenous explanations or traditional considerations.

In summary, in learning the electric field concept, most Beninese learners have mixed conceptions of the electric field taking into account very few parameters defining and characterizing it. Mixed conceptions are mobilized wrongly and not allowing us to perceive all the meanings given to it in epistemological analysis. These conceptions are not used in the explanation of certain phenomena of life. How can we perceive this limit of learning, whereas in the institutional choice made by the actors in the guide and program documents, the didactic transposition put into play takes into account certain epistemological elements? This calls for a hypothesis on the existence of learning difficulties.

4-2-Analysis and interpretation of interview results

We summarize in the following table some learners' ideas and what they look like according to our analyzes.

The student says.......	And this turns out to be............
10-not often. Everything doesn't seem real to me. 167-Hum............. I really don't know	Difficulty of representation, lack of meaning
66- You speak too much in physics ... and ... hum ... or ... hun, talk too much. It's not like mathematics teachers. The questions are often clear in maths. 68- Yes, but everything is mathematical at home. While you speak physical	-difficulties related to the statement meaning language comprehension -difficulties in the use of mathematical tools in physical sciences -difficulty of the link between mathematics and the physical sciences
48-I see that tensions are given, the masses, the charge of the electron.	Poor data processing, the student can't communicate with the figure to better sort the information
155-: Yes, and uh, so a parabolic trajectory well that's logical, it means that we need to know the time laws to know the equation of the trajectory we do not know the vector electric field$\vec{E}$. 156-: So you know the steps to succeed the exercise 157-: Say yes .... Yes …. Good 158-: Still, you did not completely succeed the exercise. 159- the teachers, hum .... Uh ..... they know what they want 160- Do you develop your own strategies for treating the exercises? 161-: I ... I use the course 162: So only what the teacher showed you in class	Lack of planning
11- How? the student does not seem to see the need	Lack of control
	Lack of adjustment
102-I have never seen an exercise of Bac passed with only one question. 145- In my opinion the questions should be detailed according to the steps to be taken	Difficulties related to text wrapping
169- often the teacher talks about it but very rarely he brings us to the laboratory 171- good at the professor complains of the time delay in the course. Hunm ...that the program is dense.	Difficulties related to the lack of practical work

From the interviews, we can remark that for most students, they do not make sense when dealing with the exercises that are submitted to them. In the majority of cases, students do not imagine that the exercises are dealing with a real meaning in life. They only treat to treat. There is a total lack of personal control in the students' statements. Self-control for the student is not necessary. This is the responsibility of the teacher. The methods of solving the exercises are fixed. This implies memorization of the methods developed by the teacher. Some students in large numbers may be supposed to be in the process of making progress in the resolution. They feel that these exercises are wrong because of the professor can't attempt to make omissions. Yet they claim that the professor is asking trick questions. They are also able to answer questions. Real facts are not lived. The information is sometimes given by schematics. The S-point is not too explicit. This should be often noticed to orient the force vector $\vec{F}$ and from the vector relationship $\vec{F} = q\vec{E}$, taking into account the Q sign to

regain the meaning of the vector field $\vec{E}$. For student, the meaning of $\vec{E}$not represented is an error in the exercise. Students have more preference for exercises where the guiding questions are given instead of the question being encompassing. We must therefore guide through the questions. Practical work is rarely done and is almost non-existent. It is more interesting to students that doing experimental activities is more appropriate than taking a course where everything is said orally without touching reality.
In the following, some debates were held with students on the effects of the electric field concept with the intention of making them aware of the deviations in their conceptions of the electric field concept.

4-3-The Debates in the characterization of learning difficulties of the concept of the electric field

The professor introduces the notion of the electric field by its effects: the attraction and the repulsion of the bodies between the charged element while proposing examples without other explanations. It provokes a debate among students by asking questions in order to guide and becomes a regulator without giving an opinion on a student's answer.

The teacher, following a problem situation presented, provokes debate while bringing each student to respect his neighbor and, to learn to think himself and to question his old thoughts to build new scientific visions. He establishes between the students a contract which consists of listening to the other without necessarily taking a position but to argue his ideas.

After a few minutes of personal reflection by the teacher, each student asks for the floor to express his point of view. The teacher sometimes accepts students' writings on the board without showing his position if the answer is true or false. This neutrality of the teacher allows the learners to progress in the discussions without losing the subject under discussion. It is not excluded that another student is of the same opinion as his comrade while validating the ideas of the other by a clear argumentation. Only the teacher at the end is held after validation by the students of the correct ideas, tries to tidy up before taking note. During the debate the teacher can reorient the learner by asking him questions based on the answers he gives but which are not clear to make him aware of his mistakes. Unlike the semi-structured interview, the debate allows the learner to be aware of his or her mistakes and to obviously question himself based on the reasoned arguments put forward by his peers about a physical phenomenon.

4-3-1-Analyzed and interpretedtion of the transcript of first debate sessionon the electrification

In this debate, rich in contradiction between students, there have been well-reasoned statements, questions to which students seek to find solutions through other questions. Releases on disagreements. The students realized that there were problems with everyday phenomena, but they were not curious enough to ask questions of lightning that are being argued by others. The fact that students do not ask questions about complicated situations is an obstacle in finding solutions to problems. The scientific debate is a bias by which students are led to ask the necessary questions, they are led to problematize to build a real knowledge that they are supposed to master themselves later because of their research. The teacher playing the role of motivator through his interventions to put order and refocus on the problem at stake. Language interactions rich in criticism and solutions provide a foundation for the construction of scientific knowledge. Certainly, epistemological obstacles appear, we confuse electrical attractions as a magnetization. It is up to the learners to look for the difference between magnetization and electrification, which is a problem that arises in front of the learners and that they must find solution while building the knowledge. For some, without the electric force, the electric field does not exist (**student E4**). So, it is when the force attracts that the field manifests itself **(student E16)** and for the latter, forces equal charge while saying that the loads are manifested by the electric forces to answer the anxiety of (**student E9).** Despite the different speeches some students are a little skeptical and remain hooked to the first ideas. This debate has shown too much controversy among students. But ideas that force students to understand arise. The course would have been done in a dictated manner with explanations from the teacher that one would not realize the difficulties of the students. By this, we understand what the new epistemology of science requires, which requires that learning be centered on the learner. From there the knowledge is built by the students themselves by counter-arguments, exchanges, arguments, consensus.

4-3-2-Analysis and interpretation of the transcript of the second debate sessionon the electrification

Through the answers of both, one notices scientifically true answers and answers that present doubts. So, the students in this discussion realized that there is a problem. A solution of this problem would allow them to better understand the phenomenon. They would have read the answers in the documents and would not be aware of such a situation to be solved. Faced with this situation, it is up to the teacher to propose explanatory models that do not doubtless succeed at the level of the learners. Explanatory models that truly reflect the scientificity of knowledge. There have been several interventions by the professor in the form of questions that are leading to further debate despite the traditional ideas some learners have of the lightning phenomenon (thunder). The students distinguished the phenomenon of electrificationfrom the phenomenon of magnetization.

They retained that the electrification takes into account the friction and the discharges. Discharges for learners come from the fact that loads are being transported through the air. Discussions on the phenomenon of lightning allowed learners to better understand the phenomena of attraction and electrification by contact and friction. Between the ground and the clouds there can be shifts of charges, so it is normal that between neighboring bodies the same phenomenon can occur.

4-3-3-Analysis and Interpretation of the transcript of the third debate session on grass Seed movement

Sometimes the teacher avoids answering some questions from the students due to lack of explanations or his knowledge is limited in relation to certain facts. He skillfully rejects some of the students' questions as if he is going back to the explanations. Arguments are advanced by the students for certain physical facts but often mixed with doubts. Truths spring up without scientific reasoning. Contradictions of ideas. Challenges already built ideas. There is a need to problematize.

According to (ORANGE, 2002) following Bachelard (1938, 1949), he specifies that scientific knowledge is reasoned knowledge that results from the construction of explanatory problems. It is therefore important to point out that during scientific debates, the naive initial conceptions without questioning the learners change and evolve towards scientific knowledge, that is to say knowledge to build. In this debate, we look for the reasons at play during interactions. The notion of electric field is the explanatory problem at play. From these exchanges, there is a lot of reasoning in the empirical register. Students only reason with what they knew and do not in most cases try to realize whether it is necessary to pass absolute empirical ideas to build knowledge. But some interventions and rare such as the interventions of the learner E3 for example show progress. But the environment makes that some students do not perceive that their absolute ideas without questions, can progress because of the explanatory models of the teacher.

In our research work, we found in our interviews and evaluations that learners in solving school problems have difficulty with non-goal determination, lack of planning, self-control, and are often confronted with problems. cognitive overloads.And also, how to pass for most of a schema register of a situation to an algebraic register for the resolution.As for learning the concept of electric field, how to understand that inside two plates of a capacitor connected to the terminals of a generator, the field vector is perpendicular to the plates. What also happens between the charges of the same sign distributed along the plates? Is there no field between the charges on the plate?

For learners each charge on the surface of the plates creates its field taking into account the formula of Coulomb $E = K\ \frac{q}{r^2}$ Following various directions, how can we understand that the field of the shot is uniform and perpendicular to the plates?

Given the Coulomb formula $E = k \times \frac{q}{r^2}$ One wonders how has such a formula established by Coulomb? His teaching is practically nonexistent. The didactic choice made by the teacher is it not the basis of the learning difficulties of the learners relative to the electric field concept? These are all questions and remarks to which we are led to find solutions.

4-4-Analysis and interpretation of the results of the interview-semi-directive with some qualified teachers and beginners

A recording of an explanatory interview that will complete and justify the views of teachers and may be confronted to better appreciate. It will only be here after Vermersch (1994) to discover to the other teachers, the story of a teacher on his didactic practice on the teaching of the electric field concept.In order to find the sources of the difficulties encountered by learners in the learning of the electric field concept, we held with a few teachers of CAPES or CAPET intervening in scientific terminal classes a questionnaire interview whose questions are presented as follows.

Questionnaire-Interviews with Teachers
Q1: Did you once teach the course on the electric field?
Q2: If yes, how do you proceed to its visualization?
Q3: Do you make history of the electric field in your classes? What do you think about the importance of this story in class?
Q4: In your class how did you manage to teach learners that the electric field is uniform inside a capacitor subjected to a constant electrical voltage?
Q5: What is the role of electric field lines? Do you speak of it as in the case of the magnetic field?

The following table summarizes the answers given by teachers to our questions during this interview followed by a short analysis.

4-4-1-Characteristic parameters of the learning difficulties of the electric field concept

Questions / **Teachers**	E_E	E_D
Q1	All teachers once taught the electric field	All teachers once taught the electric field
Q2	No teacher has ever performed the visualization of the electric field. Some say that they have never been trained in this direction and do not have any notions that can allow them to exploit existing salvage materials around them to carry out such experience	No teacher has ever performed the visualization of the electric field.
Q3	No teacher has ever made the history of the electric field in its course. Some claim that they do not have time to go and see what is happening in the history of a science even seeing the density of the program to be executed. But aware of its existence.	The E_D Say they have no idea of any story about a course.
Q4	For the 2 groups of teachers This is done by affirmation. And this without any other explanation	For the 2 groups of teachers This is done by affirmation
Q5	Nothing is known about the role of field lines except that they indicate the direction of the electric field vector. Electric field lines are not taught. But the notion related to field lines is taught in the case of the magnetic field	We don't understand anything. We work without thinking about the field lines.

4-5- The Difficulties of Teaching / Learning the Electric Field

Through the students' responses, it appears that the notion of the electric field from the point of view of vector character is poorly understood by the pupils. First, its definition as a " physical quantity " and its effects " changes the physical properties of a medium " is almost unknown by students because no document as activity books used by teachers, field is not so defined. Certainly, the orientation of the vector towards the decreasing potential is known but impossible to bring the arguments that explain this orientation. Students lack the necessary arguments. It should be noted that the concept itself is difficult to understand. It should also be noted how the teacher also poses the problem, sometimes blocking learners in finding solutions to the problem. It should be noted that the difficulties involved in learning this concept are enormous. Given the results of the students in the evaluations of this notion. Among these difficulties, it should be noted that many learners do not understand the real notion of the electric field, and from the point of view of vector character, this notion is poorly understood. First, its definition as "a physical quantity" and by its effects "changes the physical properties of a medium" is almost unknown by the learners because no activity book used by the teachers, this field is not so defined. Admittedly, the direction towards a negatively charged level is known but impossible to explain the reasons which support this orientation. It should be noted here that the concept in itself from the vector point of view is difficult to understand, if the notion of vector already seen in mathematics is not so well mastered. Misunderstanding that a field that has been created can still produce a force. Misunderstanding in the orientation of this vector electric field. The uniformity of the field between the plates of a capacitor brought to different potentials. The notion of two colinear vectors. Students do not understand why the electric field vector is collinear with the electric force vector.

4-6- Different conceptions of the concept of the electric field: a springboard for its learning

For most learners, the electric field is known as a space where electricity exists without any other precision. So, an area where there are electric charges. Wherever the electric current exists. Even the places where electric cables carrying electrical power pass for the transport of electrical energy serving places of use such as houses, utilities, factories. It can be obtained for them between the plates of a capacitor because there is also the electric current, the plates being connected to the terminals of a voltage generator. Some learners suggest that the electric field is a place where electric charges exist. The electric field can exist in the wire where the current flows.

4-7-Errors as learning difficulties of the concept of the electric field

Definition given wrong. Confusion between electric field and a domain considered space. Confusion between negative charge and lower potential. Confusion between electric field and current concept. Learners believe that it is the conduction of the current that gives rise to the electric field. Students believe that the field lines are the trajectories of the field vector and those of the mobiles. Confusion between the presence of a force conditioning the presence of the field. Students are unaware that the parabola described by the electrons is due to the direction and value of the particle entry velocity between the capacitors. Everything at the entrance of the domain the direction of the speed imposes a direction of evolution to the particle and progressively is modified by the electric force. Discussions between students do not go to this level of reflection.

4-8- Didactic obstacles in learning the concept of the electric field

Difficulties are didactic or epistemological. The choice of teaching tools made by the teacher can be a barrier to learners learning electric fields. The device put into play by the teacher to teach the course on the electric field may reveal no situation giving meaning to the understanding of the electric field. The course done by this teacher becomes a narrative of the original facts without the learner finding any sense because it is devoid of any problem situation. The learner behaves like an observer receiver before a speaker filled with scientific knowledge but communicated in an abstract way. If the method used by the teacher does not actively involve learners in the construction of knowledge to realize the problem that generates this knowledge. The search for solutions to this problem to solve allows learners to better master the notion taught. So the learner must be stuck to a problem (a difficulty) which he does not automatically have the answer and invest himself with his pairs with oral exchanges thus emerging from other difficulties related to the epistemology of this knowledge to build.
After analyzing students' productions and their oral responses, we identified several obstacles. The first is that of the first observation. Bachelard defines it as "a first obstacle for scientific culture. Indeed, this first observation presents itself with a luxury of images; it is picturesque, concrete, natural, easy. There is only to describe and marvel. It is believed then to understand it. "[Bachelard, 1972].

Indeed, we have noticed that the majority of students say that electric field lines are always curved lines that look like circular lines on which the field moves. For them this is what they observe in the documents. Observation can therefore be an obstacle. In addition, some are able to represent the field vector well perpendicular to the plates. They had to observe it on several documents thinking then that their design is good in all cases. They can’t understand why we are talking about the uniformity of the electric field in some cases. Here again, observation is an obstacle.

Then, we identified an obstacle that Bachelard describes as "tautological": "The child explains that things are so because they are so. [Bachelard, 1938]. So, for some learners there is no explanation for some phenomena, they say "it's like that".

We have also identified another obstacle: the artificialist obstacle that Piaget defines as "the product of human fabrication" [Piaget, 1926]. Indeed, a student explained that for the displacement of the particles it is surely an imagination of the teacher if it is only lines of light that we are represented. All these phenomena that are described are purely created by man. When we talk about particle deflection by the field, it is rather the man who would have made it like that. This is an obstacle since the students can’t observe it directly, which can hinder the understanding of the phenomenon. These are just videos as in the action movies "affirm some". They are then forced to believe it by reading documents. Some students will not be convinced of the result and will refuse to believe it.

Another obstacle defined by Bachelard is that of general knowledge: "This science of the general is always a judgment of the experiment, a failure of the inventive empiricism" [Bachelard, 1972].In productions, we noticed that some students wrote that the field vector is perpendicular to the plates of a capacitor was due to general knowledge. They had to hear this phrase «all done» during their schooling without understanding its effects. They explain the phenomenon by general knowledge since everyone knows without looking for another explanation.
Students who have identified a tautological obstacle believe that the concepts are so in the documents. We believe that if it is found in official teaching documents, it is a barrier to learning that blocks the student. So, teaching experimental science and technology is not easy. Indeed, students already have representations about what the teacher will teach. It is important for the teacher to be interested in these representations in order to identify possible obstacles to learning. The teacher will then be able to set up varied and varied learning situations that will enable students to overcome these obstacles. Being unable to observe favors obstacles. Student representations are the means they use to bring out their ideas. Some students will present the obstacle

in all their representations, others not. Identifying students' representations allows them to be placed at the center of the education system so that they are "actors" in their learning. It is therefore necessary, in order to facilitate the teaching/learning of the physical sciences, to bring students to experiment.

Types of obstacles	Characteristics	Example in the teaching of the concept of field
Teaching	Teacher's choice of didactics promotes errors in the student	A learning activity on the concept of the field in the Terminal class promotes an absolute conception of this concept (example: load)
Epistemological	The knowledge mobilized by the teacher in the construction of this notion is a source of errors in the pupil	If the knowledge to be built vehicle the absolute conception of the term, the reasoning based on the design changes
Psychological	The lack of prerequisites or some essential notions is a source of difficulty in building knowledge	If the pupil does not control the concept of attraction and repulsion, the concept of load, it is easier for him to construct a knowledge involving his designs.

V. LEARNING PERSPECTIVES OF THE CONCEPT OF THE ELECTRIC FIELD CONCEPT

Practical work is a great way to acquire knowledge and methods. This is well reflected in the answers provided by the students about the practical work. One could even say that this is their main objective, hence the very important role played by the "exploitation of experimental results" activity. It should also be noted that theoretical know-how and experimental know-how are, in a way, prerequisites for the practice of a scientific approach: what fundamentally distinguishes the scientific approach from the basic know-how is the degree autonomy in the process and the decision. But the scientific process goes well beyond the simple way of acquiring knowledge limited only to the field of Physics and Chemistry. As "to know, one must imagine in freedom and refute with rigor, not to admit anything by argument of authority but by reason and observation, experimentation and verification", the scientific approach is thus, in addition, an excellent formation of the spirit . And practical work participates in this educational act. The scientific process contributes to education in general. As recalled by the idea: "By learning Science we learn to reason" (Georges CHARPAK) (contemporary French physicist, Nobel Prize).

A poor representation in the mind of the learner is a factor of non-success in solving a problem. A practical session is one of the richest and most fruitful educational activities. Practical work is a great way to acquire knowledge and methods. The experimental approach occupies an important part of the course. During each science lesson we are obliged to cover up the experimentation to facilitate our students' understanding of abstract notions. Whenever he has to organize the steps of a resolution, the student practices a scientific step Some learners' difficulties sometimes come from the limits of their intellectual level and are manifested by obstacles which in reality should not be blockages in learning for the construction of knowledge.

Exchanges about a problem allow students to build knowledge. Students before class have naive knowledge of the scientific world, without any clear direction. According to Goffard, the teacher needs to review how to formulate activities. It is therefore necessary (Goffard, 1992) to design activities where from the knowledge possessed by the student, to make him aware of the area of validity of these and to acquire new ones.

Thus the construction of problems in physics is a job that students could make a real learning situation if the teacher makes a good pedagogical choice where the didactic contract is well defined and we clearly know the role of the student and that of the teacher. To learn well, it is necessary to be fully involved in the content of learning. This will effectively get rid of the false absolute conceptions that one had of this content to build scientific knowledge that is to say to get rid of the knowledge considered as inappropriate to evolve towards strong knowledge adapted to the problem situations. In the appropriation of knowledge or the construction of knowledge, the teacher must effectively integrate the learner into the core of learning and not consider learners as empty or misguided. This way of looking at learners is an obstacle to learning or even solving problems. Solving physics problems is not just about calculating, but also explaining physical phenomena.

The retrospection of the learning situation defined by the noosphere in the main orientations for the teaching of scientific knowledge through the implementation and acquisition of the different types of skills reveals the existence of several didactic parameters that influence the preparation and the conduct of class sequences on the teaching / learning of physical science chemistry and technology and which generate learning difficulties. In the management of these learning difficulties, the different didactic choices made by the teachers are real sources of cognitive obstacles that influence the learning of the learners. Several didactic parameters such as:

the organization chart and the functions of the tool, the differentiation of the foundations according to the different levels of education, the harmonization of the frameworks defining the different types of skills, the serious consideration of learning obstacles remain to be envisaged in the design of a more effective tool for the implementation and development of skills for the acquisition of knowledge in physical sciences chemistry in Benin.

Learning barriers and conceptual difficulties to manage

According to Cornu and Vergnaud (1992), for teaching practice and the management of difficulties in conducting a class sequence on the teaching of a concept, didactic thinking is organized around two levels; that of student representations and conceptions and that of the conceptual organization of learning difficulty management corresponds to each level of learning(Fabre, 1999).

At the first level of learning, the management of pedagogical difficulties is essentially concerned with the learner's reflection and takes into account his psychological aspect. At the second level of learning, the management of didactic difficulties requires an epistemology of knowledge to teach to secure their learning. Several authors have already studied the reactions that exist between the two axes (psychological and epistemological) of the didactic reflection on the learning of a knowledge. In most cases, this relationship that can link the knowledge concerned to the initial representations of the learner appears as a design opposition that can be interpreted as obstacles to learning. It is better to pay more attention to the choice of theoretical references to prevent conceptual difficulties than to try to manage later cognitive obstacles in learning (Fabre, 1999).

Thus, the construction of problems in physics is a job that students could make a real learning situation if the teacher makes a good pedagogical choice where the didactic contract is well defined and we clearly know the role of the student and that of the teacher.

To learn well, it is necessary to be fully involved in the content of learning. This will effectively get rid of the false absolute conceptions that one had of this content to build scientific knowledge that is to say to get rid of the knowledge considered as inappropriate to evolve towards strong knowledge adapted to the problem situations.

In the appropriation of knowledge and the construction of knowledge, the teacher must effectively integrate the learner at the heart of learning and not consider learners as empty or filled misconceptions heads. This way of looking at learners is an obstacle to learning or even solving problems.

So, for the success of problem solving, we have found that it is not enough to develop at the learner level better self-regulation problem-solving strategies such as goal-setting, planning, control It is important to find other, more effective ways to deliver classroom-based courses by exposing learners to the problems of ownership of the concept and to problem solving them. This will allow them to build their own knowledge from controversies during a scientific debate.

VI. CONCLUSION

The results obtained in this work, taking into account the opinions of the two samples, show that the difficulties encountered by many Beninese students in the learning of the uniform electric field are at several levels:

Difficulties at the phenomenological level: the students find it difficult to understand the physical phenomenon itself, in particular the phenomenon of electric field lines, to a lesser degree the phenomenon of uniformity of the electric field. Everything seems like a myth. According to the arguments given by the learners, the lack of practical work, the complexity of the phenomenon itself, and the excessive use of the mathematical tool make these phenomena difficult to understand. Also, the explanation of electric field should not be limited to the use of only the mathematical model but must be supported by other forms of presentation (physical, verbal, visual, graphic, gestural, digital) which makes it possible to facilitate and deepen understanding.

Difficulties related to the use of mathematical tools and schemas: pupils have difficulties in the use of vectorial relations as well as to explain the notion of the vector. This mathematical tool is not mastered by the learners, who do not manage to apply it correctly in the problem-solving activities. The justifications given by the students point to their weakness in mathematics, moreover they corroborate with those mentioned by the teachers. This difficulty is also raised by Dean (1980). Also, the use of the schematic representations is another major source of confusion for students. They can't decode the language of the schemas. Learners attribute this difficulty to the lack of exercises for this type of activity and their weakness in mathematics.

Conceptual difficulties: Learners fail to understand how a charge q_1 recognizes in its neighborhood that there is presence of another charge q_2 to exercise on the latter a force and reciprocally (these difficulties are related to the epistemology of knowledge).

Difficulties related to the concept of force and speed: the learners think that the electric force that makes the particle move must be collinear in all cases to the velocity vector so always tangent to the trajectory described by the moving particle.This leads them to doubt the perpendicularity between the electric field lines and the plates of a capacitor subjected to a DC voltage.

Difficulty understanding that the electric discharge is a manifestation of the electric field. The connection between the electric field taught in class and the phenomenon of lightning seems strange and requires a deep learning to move away from their belief in the word lightning.

Some didactic difficulties are also noted as:

- ✓ Each area of knowledge develops a relationship specific to the experiences.
- ✓ Several important experiences in the construction of problems and knowledge in physical sciences are not feasible in the classroom.
- ✓ The experimentalallows for the acquisition of practicalknowledge during schooling.

We conducted this study through questionnaires to some teachers, an evaluation, interviews, and scientific debates with the learners. The aim of this work is to make a first identification of the difficulties that students encounter in understanding the phenomenon of uniform electric field, the use of the mathematical tool including the notion of the vector and the exploitation of the graphical representation. In the Beninese context, this work made it possible to highlight the points on which the students encounter the most difficulties in the learning of the uniform electric field phenomenon and in problem solving, which can be summarized as follows:
• difficulties in understanding the electric field phenomenon, and to a lesser degree its directionality;
• difficulty in applying previously acquired notions in mathematics, especially vector collinearity andnotorious confusion in representations

The arguments raised by learners about these difficulties are:
•The lack of mastery of mathematics, especially the notion of vector and its collinearity;
•Difficulties related to the complexity of the electric field phenomenon;
•The lack of practical work to recognize that the vector uniform electric field is always perpendicular to the frames of a capacitor.This is due to the fact that the teachers do not put the learners in a real situation to understand what really a line of electric field is.

We see that students have spontaneous ideas about the notion of field, which also does not allow them to organize well for the success of a problem solvingrelated for example to theconcept of electric field. Learning problems about the field are worth highlighting. A confusion is created between the lines of field to see the lines of force and the trajectory of a particle in movement. The learner does not manage to make a detailed analysis of the starting situation and the precise moments of application of the theoretical tools available, meaning the moment when they haveto choose what law to apply or relation as the consequence of Newton's second law.

This work helped us to find in the reasoning of the students some essential elements to develop in course which could favor the appropriation of this notion of electric field.

These results can serve as tracks to deepen surveys and extend them to other contexts and points of support for the development of certain proposals for remediation.

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