



## **Bottom-up Analysis Engineering of Investigative Practices and Innovation of Reflective Activities in Life and Earth Sciences: From Information Theory to Systems Theory**

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### **Abstract**

The heavy trends of the Information Society are knowledge that requires the spirit of innovation, creativity, flexibility and critical thinking “more than benign introspection.” In addition, information about each other’s relationships with oneself, the other and the environment is

crucial to enable individuals to understand the complex reality.

The Moroccan school is part of this societal vision, by renovating its education and training programs, which claim the development of the quality of procedural, cognitive and metacognitive strategies.

In this perspective this research work aimed at studying the engineering analysis of investigation approaches in the teaching of SVT for the implementation of a reflexive practice in lycian learners, generating the ability to process information and invest in mechanisms for understanding, conceptualizing and proceduralizing cognitive and metacognitive strategies.

Informational investigative capacity is crucial because it informs learning decisions, which can lead to innovations in the delivery of cognitive styles. To do this, we chose to conduct our study, through interview surveys and semi-structured questionnaires. The first among teachers and the second for SVT inspectors from three provincial directorates of National Education.

The results show that the majority of those involved in education are involved in the classical informational approach and the experimental approach. The use of investigative analysis approaches remains episodic in some learning units (scientific ecological output and DNA extraction).

Teachers are keen to introduce new information technologies to create favourable conditions for learning about investigative approaches, in order to improve the power of analysis, treatment and critical thinking and coping with situations of authentic and novel learning. We are concerned about the ability to understand what and how each of its actors is further shaping.

**Keywords:** Analysis engineering; information practice, information seeking, technological communication; Reflective practices, Experiential and investigative methods.

## Introduction

Approaching the understanding of the effective processes of the teaching methods of LES, can be done by different inputs and pedagogical approaches. We have chosen to analyze these processes through a strictly didactic vision, which considers the development of content, the transmission of knowledge and the conditions of acquisition as the cornerstone of teaching activity.

The teacher is then responsible for setting up the conditions for a scientific reflexive practice by and for the students, so as to bring them into a form of culture in connection with experiential methods and investigative approaches crystallized in scientific activities (Schubauer et al. 2007). In this article, we begin the impact of experiential and investigative methods on the reflective practices of LES teaching in Morocco with a case study concerning two provincial delegations of the AREF of Casablanca-Settat: Sidi Bernoussi urban delegation, and a rural delegation from

Mediouana.

For this study, we infer the intentions of those involved in LES education: teachers, inspectors, designers of LES programs and learners.

Teaching LES within the classroom is a complex process in which many factors and variables interact. The most important of these factors is the learner and how conceptual learning happens to them. So that the pupil often learns information by memorization with false representations which do not allow them to acquire advanced skills to solve complex operations. (Wibaut, 2019)

For this reason, we ask ourselves the following question:

**What is the impact of investigative methods on the development of reflective practices in qualifying secondary education: the case of life and earth sciences?**

These scientific approaches constitute the basis for the understanding and construction of intelligible cultural competences and methodologies in the teaching of LES. It is about understanding scientific principles, laws and theories and not reserve approaches, but rather cognitive strategies and mental inferences that the individual mentally organizes into an operating pattern (hypothetical mental construct), where its composition includes three processes: distinction, organization, classification and generalization, which means that the individual arrives from general rules of an inclusive nature. Also, by renovating its education and training programs, which proclaim the development of procedural, cognitive and metacognitive strategies

To help students understand scientific concepts in LES, the teacher is called upon to find the most relevant teaching methods to improve student learning.

Reflective practice proves to be an alternative solution allowing to give interest, pleasure and meaning to learning. Rather, it is the individual's mind and his thinking that gives meaning to these combined facts. During the formation of a certain perception, the learner is forced to think, interpret, reflect or infer in order to mobilize his complex thought. For this, the scripting of investigative activities is considered an effective scientific teaching process, because it provides the organizing element and the guidelines for all learning activities such as laboratory work (experiential practice: Practical dissection of a frog) or in the field (investigative method: ecological excursion) (Sibari, 2020)

Including an educational situation by investigation in nature makes it easier for the teacher and the learner to achieve the goals of reflective learning, creating a mental image of perceptual awareness, an interaction of the individual with his environment, with his knowledge and personal experiences for a new learning to occur and take hold.

Recent studies have helped provide important insights for students to acquire and understand scientific concepts (Kolb, 1985), (Dewey, 2004b), (Perrenoud, 2001) in school by referring to experiential reflective theory which is based on two basic rules:

The first one : It turns out that knowledge and concepts are not rigidly received, but are effectively constructed by students.

The second :it turns out that knowledge is an adaptive process, which takes place through the individual organization of experiences and investigations with which the learner interacts, proposes hypotheses, tries to test These hypotheses to achieve the result (new knowledge) . He may revisit this result in an attempt to develop other new hypotheses, he will then be in continuous interaction with the elements of the situation, and this is confirmed by ( KOLB, 1985).

Consequently, the cognitive process does not consist in transferring representations and knowledge from the teacher to the learner, but rather in exciting the learner to a progressive construction of his own knowledge and representations (Di Scala, 2019)

The analysis and interpretation of the results of the interviews and the questionnaire allow us to link the action of teachers and inspectors with the activity of pupils.

Therefore, the results of the study of the impact of the investigative process on reflective practices in relation to the teaching and learning methods of LESs in Morocco are significant and very profitable.

### **A. Theoretical context**

**Reflective practice:** is the ability to reflect on one's actions in order to engage in a process of continuous learning, it is about "paying critical attention to practical values and theories that inform daily actions, examining practice in a way thoughtful and reflective, this leads to a vision of development ".

This first part will attempt to identify the specificity of professional teaching practice through the theory-practice link and the research-training link. We will demonstrate that these links are specific to the teaching profession and are distinct from the type of links established in other professions. In addition, information about each person's relationships with oneself, with each other and with the environment is crucial in enabling individuals to understand complex reality.

**Schön** whose work has focused on a new epistemology of practice, uses the image of the high peaks of theory as opposed to the swamps of practice to illustrate this relationship. He explains that the reflective practitioner, conversing with the problematic situations in which he intervenes, constantly asks himself the question: What would happen if...? And that he tries to answer it by

experimenting (Schön, 1994).

**Tom and Valli** recognize four main perspectives on the question of the application of theoretical models to teaching practice situations (Tom et al. 1990).

**Gage** considers theoretical models as sources of rules dictating to the teacher ways and means of effective teaching practice ( Gage, 1978).

**Clark and Fenstermacher** for them, models are a source of reading patterns for practice situations that can modify the teacher's perception and lead him to invent new means of intervention (Clark et al.1988).

**Fenstermacher and Phillips** who consider that theoretical models can provoke a questioning of the teacher's beliefs (Fenstermacher et al. 1994).

**Giroux and McLaren** the theoretical models serve as a basis for an emancipatory action by introducing a questioning of the values transmitted by the practice (Giroux et al. 1986).

It is on such a conception of experience that Dewey in (1938a)based his theory of education as the centerpiece of his pragmatist philosophy: "Learning takes place as a result of the use of information accompanied by a reflection on the effect produced by this action according to the goals sought " (Bourassa et al. 1999)

Such an approach not only respects the learning and development of students, it relies on the reflective capacity of teachers but, moreover, recognizes:

- Their role in building professional teaching skills.
- The contributions and limits of theoretical knowledge and applied knowledge in teaching-learning.
- The value of their experiential knowledge.
- The importance of maintaining continuity in their development as professionals in educational intervention.

Like (Doyle, 1986) and (Lang, 1996) underlines the importance of reflective analysis in the construction of such a professional identity (Teaching):

"The construction of professionalism must both take into account this specificity of practical training (...) and, in addition to disciplinary, didactic and pedagogical knowledge, open up to new fields of knowledge, develop a reflexive habitus, in " relying on mechanisms for analyzing practices, allowing control of one's personal involvement in a relationship, taking into account the collective dimension of professional practice, but also making room for ethical training in reflection. "

## **B. Problem**

Several scientific reasons on the didactic, pedagogical, and psycho-sociological level oblige us to apply reflective practices in the process of teaching LES in Morocco and which are likely to influence the learning and achievements of qualifying secondary students. We are concerned with the ability to understand how each of its actors further shape their experiences and their capacity for reflection in order to identify and understand the world

In this article, we are interested in the didactic methods that the teacher can actively exercise in class to develop the students' level of conceptual assimilation and subsequently to know their impact on their reflective practices.

For these reasons we will try the following questions:

- What are the different scientific methods and approaches to be used for teaching LES in Morocco by teachers of LES who are supported and supervised by inspectors?
- What are the criteria and didactic levels relating to each scientific approach that can reinforce reflective practices in LES students?

How can we involve the investigative process in the teaching of LES, to develop critical thinking and cognitive skills?

## **Methodology**

This study is carried out in of them Provincial directorates of national education within the regional academy of education and training (AREF) of the region Casablanca - Settat in Morocco " direction provincial Bernoussi and provincial leadership Mediouna " during the 2019-2020 school year, the choice of these directions is linked to reasons of facilitation of the research process.

The population targeted by our study consists of 60 qualified secondary LES teachers and 10 LES inspectors given the scarcity of the number of LES inspectors in these two provincial directorates, we had recourse to all the secondary inspectors of the AREF of Casa- Settat. The Table 1 shows us the nature of our population:

Table 1. The nature of our population

	LES teachers		LES inspectors					
Provincial leadership	Bernoussi	Mediona	Ain sbaa	Mediouana	Ain shock	Mohammedia	Jadida	Rabat Inspectors Center
Number of questioned	50	30	1	1	1	1	1	5
Kind	22 Women 28 Male	13 Women 17 Male	Women	Man	Man	Man	Women	3 Women 2 men
Age interval	[26 years old, 58 years old]		[33 years old, 60 years old]					
Administrative Grade Interval	[2nd grade, off scale]		[1st grade, off scale]					
Professional seniority interval	[5 years old, 35 years old]		[10 years old, 38 years old]					
Interval of Number of working hours per week	[4 pm, 10 pm]		Administrative schedule					
Class levels taught	High school		Supervision: high school-college					
Graduation interval	[License, Doctorate]		[License, Doctorate]					
Total number	80		10					

Inquiry ability is crucial as it informs learning decisions, which can lead to improvements in the delivery of cognitive styles.

Data collection was carried out by means of two anonymous questionnaires A and B carried out on Google forms. Closed questions are with suggested answers and the possibility of a single choice by teachers and inspectors. These formulated questions relate to each part of the study problem, they are designed around the following points:

- The approaches and methods adapted by the teachers in carrying out an LES course at the Moroccan qualifying secondary school (Perron, 2018a)
- The teaching methods / styles and activities according to the levels of cognitive processes and

the typology of knowledge taken into account by the teachers supervised and supported by the inspectors in the motivation and the interest of the pupils towards the LES in their reflective practices ( Le Dantec, 2020 )

- The tools which help us to compare and verify to what extent the experiential methods and the investigative methods used by the teachers have a direct or indirect positive impact on the quality of the teaching-learning process of the LES (Jean-Yves, 2019)

## Results and Discussion

### A. Analysis of the results of the questionnaire (A)

The collected results are processed and analyzed by Excel.

#### 1. Teachers

Table 2. approaches used by teachers

	Sidi Bernoussi	Mediouna	Total
<b>1-Explanatory-argumentative approach</b>	15	10	25
<b>2-Scientific approach</b>	10	8	18
<b>3-Hypothetico-deductive approach</b>	8	5	13
<b>4-Expositive approach by project</b>	7	3	10
<b>5-Approach by simulation</b>	5	1	6
<b>6-Experiential approach</b>	3	1	4
<b>7-Investigative approach</b>	2	1	3
<b>8-Historical approach</b>	0	1	1
<b>Total</b>	50	30	80

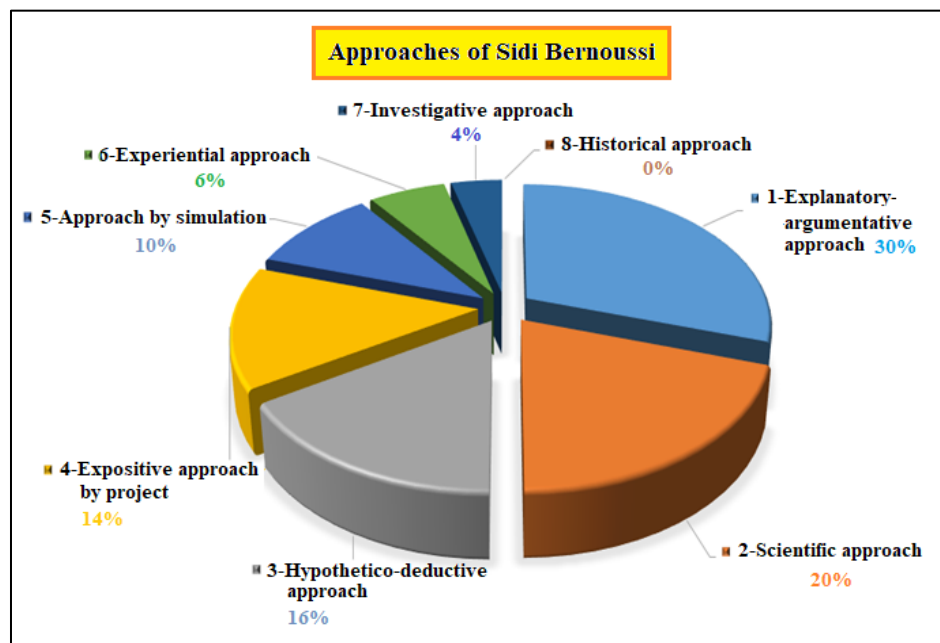


Figure. 1 Approaches of Sidi Bernoussi



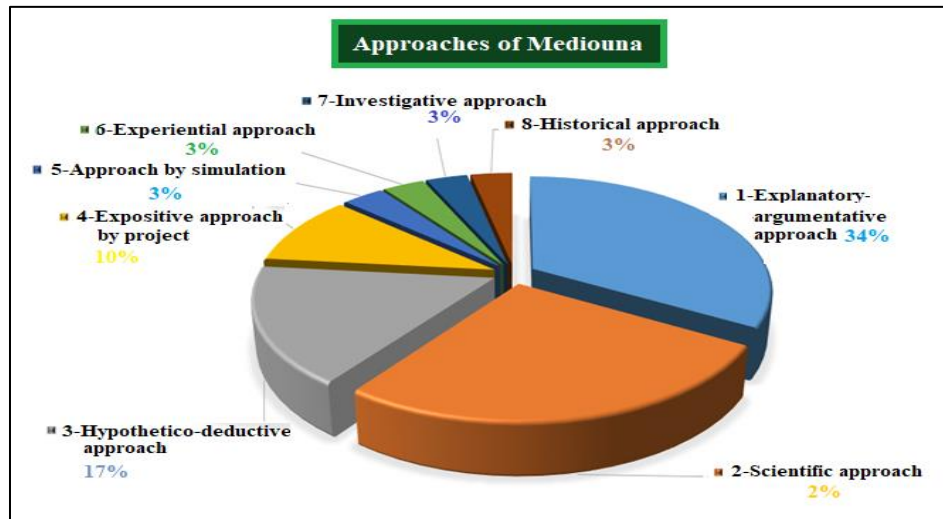


Figure. 2 Approaches of Mediouna

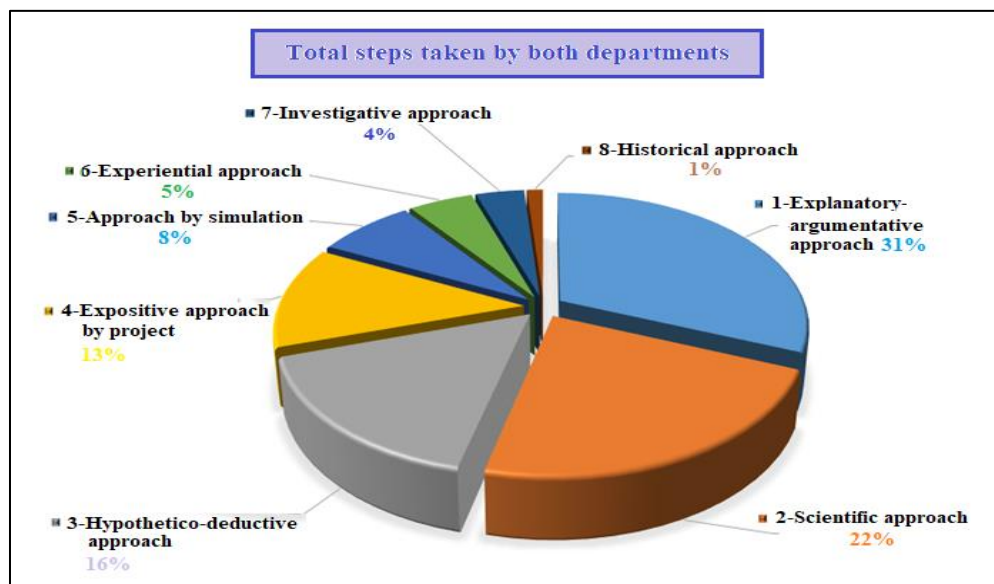


Figure. 3 Total steps taken by both departments

The results of Table 2 transformed into a percentage in Figures 1, 2, and 3 shows that:

- half (53%) of our population adapts the explanatory approach - argumentative and scientific approach;
- almost a third (37%) adapt the hypothetico-deductive approach, expositive by project and by simulation;
- The other approaches are either used by too few teachers (5% and 4%): the experiential and

investigative process or are no longer used by any teacher: the historical process.

## 2. Inspectors

Table 3. Approaches that inspectors advise teachers to use.

Procedures	Number of inspectors
1-Explanatory-argumentative approach	3
2-Scientific approach	2
3-Hypothetico-deductive approach	2
4-Expositive approach by project	0
5-Approach by simulation	1
6-Experiential approach	1
7-Investigative approach	1
8-Historical approach	0
Total	10

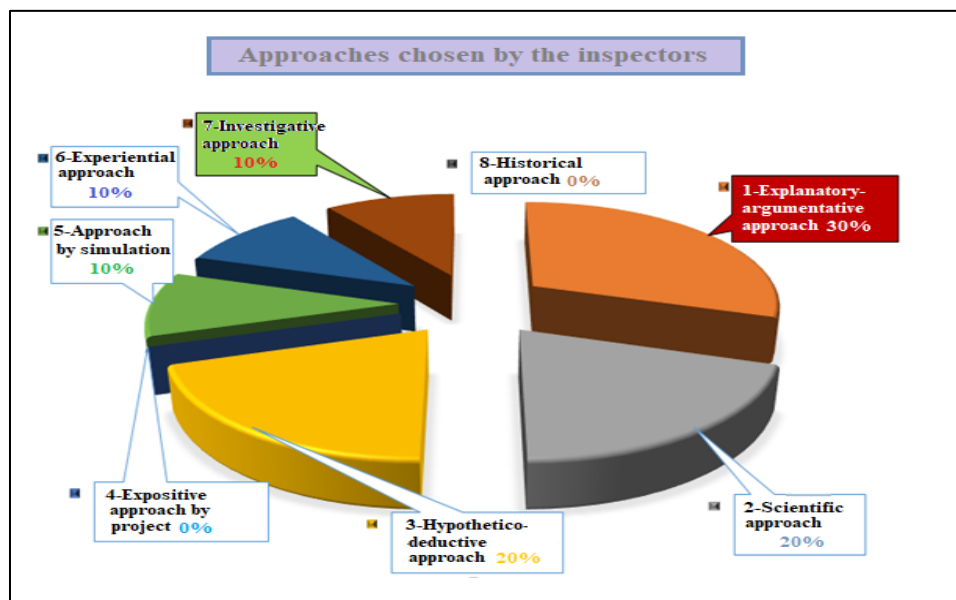


Figure. 4 Approaches chosen by the inspectors

Analysis of the results in Table 3 and Figure 4 shows that almost three quarters of inspectors 70% advise teachers to use the procedures respectively: 30% explanatory argumentative approach, 20% scientific approach, 20% hypothetico-deductive approach . While one-third 30% advise respectively: 10% the experiential approach, 10% the investigative approach and 10% the simulation approach. The other steps are not insignificant for them.

### B. Analysis of the results of the questionnaire (B)

For the following results, concerns questions on the levels of cognitive processes and the typologies of knowledge of two different approaches:

- One the most representative: the explanatory-argumentative approach and the other the least

chosen: the investigative approach, for teachers and inspectors.

### 1. the explanatory-argumentative approach

- Cognitive processes

Table 4. levels of the cognitive processes of the explanatory-argumentative approach

	Cognitive processes (pc)					
	PC Lower			Superior PC		
	To memorize	Understand	apply	analyze	assess	create
Explanatory-argumentative approach	80			10		

Analysis of the results of Table 4 transformed into a percentage in Figure 5 shows that:

- The majority (89%) of our population answered that the explanatory-argumentative process has an inferior cognitive process (memorization, comprehension, application).
- The minority (11%) answered that the explanatory-argumentative process has a superior cognitive process (analysis, evaluation, creation...).
- Type of knowledge:

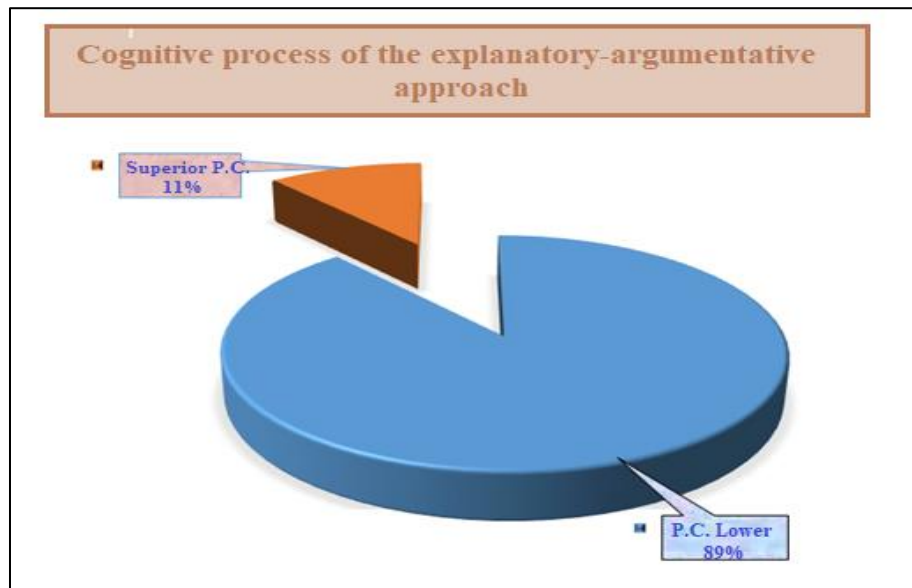


Figure. 5 Cognitive process of the explanatory-argumentative approach

Table 5. levels of the knowledge typology of the explanatory-argumentative approach.

		Knowledge typology (TC)			
		TC Lower		TC Superior	
		Factual	Conceptual	procedural	metacognitive
Investigative approach	75	15			

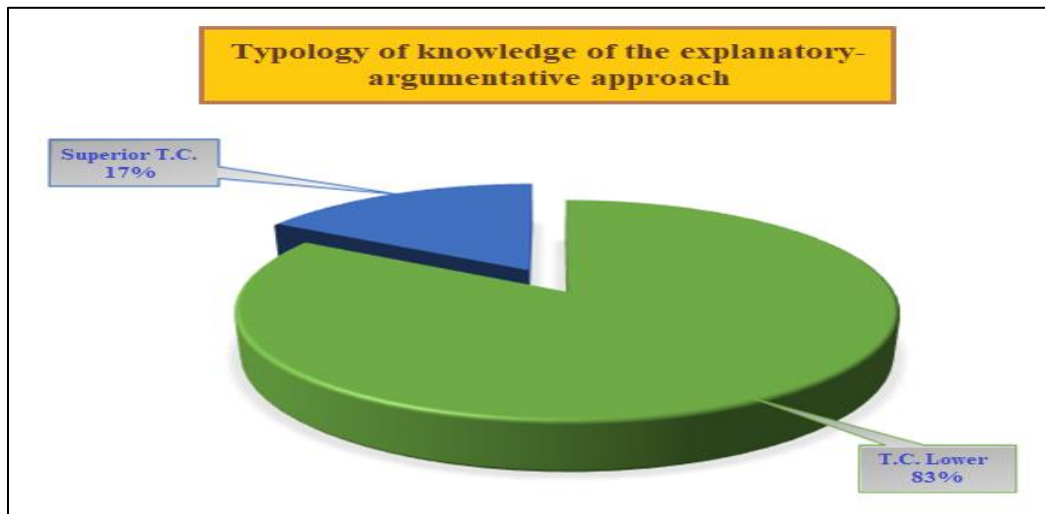


Figure. 6 Typologu of knowledge of the explanatory-argumentative approach

Analysis of the results of Table 5 transformed into a percentage in Figure 6 shows that:

- The majority (83%) of our population answered that the explanatory-argumentative approach has an inferior knowledge typology (factual, conceptual).
- The minority (17%) replied that the explanatory-argumentative approach has a superior knowledge typology (procedural and metacognitive, etc.).

**2. The investigative process**

- Cognitive process

Table 6 . levels of cognitive process of the investigative process

	Cognitive process					
	PC Lower			Superior PC		
	To memorize	Understand	apply	analyze	assess	create
Investigative approach	5			85		



Figure. 7 Cognitive process of the investigative process

Analysis of the results of Table 6 transformed into a percentage in Figure 7 shows that:

- The majority (94%) of our population answered that the investigative process has a superior cognitive process (analysis, evaluation, creation...).
- The minority (6%) replied that the investigative process has an inferior cognitive process (memorization, comprehension, application).
- Type of knowledge:

Table 7 . levels of the knowledge typology of the investigative process.

	Knowledge typology			
	TC Lower		TC Superior	
	factual	Conceptual	procedural	metacognitive
Investigative approach	7		83	



Figure. 8 Typology of knowledge of the investigative process

Analysis of the results of Table 7 transformed into a percentage in Figure 7 shows that:

- The majority (92%) of our population answered that the investigative process has a superior knowledge typology (procedural, metacognitive).
- the minority (8%) answered that the investigative process has an inferior knowledge typology (factual, conceptual).

In this exploratory study, we sought to better understand impact steps investigation on the development of reflective practicesqualifying secondary education compared to other teaching methods; case of life and earth sciences, and to question the possible impact of teachers and inspectors in this dynamic.

The analysis of the first results (Fig.1, Fig.2, Fig.3, Fig.4) of this study shows that the majority of teachers and inspectors chose the explanatory-argumentative approach by a significant percentage compared to the other approaches.

In high school, it is desirable that the concepts of the programs be constructed and not imposed (the importance of argument and explanation, on the one hand, and the proportion of that provided by the teacher and that sought by the student , on the other hand, falling within the teacher's pedagogical freedom). It is a question of seeking explanations relating to the real world and, in (almost) all cases, of implementing an explanatory-argumentative approach.

The choice of this approach by educational actors is due to several rational reasons, among which we can cite:

- The little time available for teaching the subject in class.
- The overload of the program presses the teacher to complete the program especially for the final years.
- The little exchange and debate on the new aspects of recent teaching approaches due to the absence of continuing training.
- Fragmentation and discontinuity in daily teaching activities.
- ...

But the analysis of the second results of this study (Fig.5, Fig.6, Fig.7, Fig.8) of this study shows that the majority of teachers and inspectors declared that the explanatory-argumentative approach most chosen by the latter, develops in learners of inferior cognitive processes: memorizing, understanding and an equally inferior knowledge typology: factual and conceptual.

While one approach among the least chosen: the investigative approach has a high cognitive process: analysis, evaluation, creation and such a high typology of knowledge: procedural, metacognitive ...

So we can say that the importance of the choice of an approach for the teaching of LES is not proportional to its effect and its action on the development of reflective practices in learners, from which we will seek a logical interpretation has this contradiction.

For the objectives that we want to achieve by reflective practices in LES, we cite three main ones:

- The learner's understanding of reflective practice in the classroom during the teaching-learning process of LESs: become cognitively aware of the intentions pursued, the rectified choices, the methods, the means and even the actions in class (Gagnon, 2016)
- The change of / in practice: it is a lasting modification, conscious of these teaching practices in different aspects of the learning situations of the LES (Miguel, 2019)
- Skills development: in the learners, that is to say a better mastery of the subject of LES (knowledge, skills) which give self-confidence for the pupil by the ability to evaluate his work himself (Rousseau, 2020)

To achieve these objectives, the investigative process is legitimate in the sense of teaching students to do science and to learn the nature of science proper in its real context, with regard to reflexive science practices.

The investigation approach gives fairly precise indications on the methods of problem solving, on the investigation itself within the framework of a proof logic (Coquidé, 2009) it remains very elliptical. on the time of research.

Even if the conceptions of the reflective practices chosen by the teachers of LES for the construction of scientific knowledge in the classroom have implemented scientific teaching approaches including the cognitive processes and the lower knowledge typology that do not agree with the investigative approach. We seek to show how the articulation with styles and pedagogical activities, intellectual and epistemological processes justified, allows the students to build the meaning of the investigations through the deployment of a learning logic, and the side of the teacher to break with a practice of illustration, demonstration, centered on the teacher (expository approach, explanatory-argumentative approach).

We are therefore going to analyze the way in which LES teachers implement the investigation process and, through learning activities, the reflective practices involved in the methods proposed by the teacher.

What information does this give us, in return, on the implementation of an investigative process by two actors: teachers (teaching) and inspectors (supervision)?

These results are perfectly in line with the findings produced by the work carried out by MEN on LES teaching in Morocco, which specifies that: "In secondary education, experiences and

investigations are used in an illustrative vision of concepts, of verification of a law / principle, or in an investigative process (Kouchou et al. 2017)

During this study, we noted the persistence of scientific approaches (explanatory-argumentative D. 30 ° / °; scientific D. 20 ° / °; D. hypotico-deductive 20 ° / °), in the teaching of LES at Morocco even when teachers think of implementing an investigative process, this is explained by the presence of a "classic model" in the thinking of teachers: a empirical-empiricist conception (Cariou, 2011)

From the point of view of knowledge, the teachers of LES are very limited by the official instructions, the concepts in play are not researched and the problems to which these concepts come to answer are not identified.

This unproblematic conception of the knowledge to be taught leads to a difficulty in considering and designing sequences that could allow students to pose and construct problems, which is reflected in the students' cognitive processes (memorize, understand, apply).

It is believed that the cause of the adaptation of the problem by the pupils as defined by the investigative process is a step which is difficult to initiate by the teachers of LES in the classroom, because a teaching activity of LES driven by an expected school form, takes place under a framework that is characterized by strong interventionism, the fear of not completing the session in the allotted time and the imperative to complete the experiments on time.

Considering the manipulations planned by the teachers are manipulations which constitute compulsory passages (week of practical work) for certain classes in high school where all the classes will do this practical work the week scheduled (Alonso, 2019)

These activities have moreover a function which goes beyond their sole role within the framework of the investigative process, since they also participate in the evaluation of the targeted skills, or in the preparation for the evaluation of the experimental capacities of the learner.

The preparations for the sessions are therefore not organized according to the investigative process, but according to the essential activities to be carried out which are planned for themselves.

In general, our results confirm certain studies which show that the majority of teachers and inspectors explain their difficulty in implementing an investigative process.(Razouki, 2017)

Due to the fact that the "autonomy" left to the pupils during the moments of formulation, explanatory hypotheses, presentation of the arguments and possible experimental protocols, implies taking into account all the proposals in the rest of their sequence and "part of the teachers



seems to prefer more guided sequences to that, where the hypotheses and / or protocols are strongly suggested by the starting situation ” (Mathé, 2010).

Thus the teachers give, through the reflective practices that we have observed, a teaching which is based on an approach by competences and of problem solving of learning, where the teachers are organized by the implementation of the scenario of a decision. account of the learning processes of students.

This explains why, even if the inspectors who made the visits to the classes were able to identify the beginnings of problematization. (Essaoudi, 2012)

Even if the analyzes and discussions carried out are rigorous, the fact remains that this research has certain shortcomings that must be taken into consideration, since the measurements used are reported during the covid19 (UNESCO, 2020) containment. The field constraints did not allow us to collect a representative sample of teachers and inspectors. Indeed, repeated measurements over time will allow us to collect fine and valid information.

We would also like to go far in the analysis by comparing our results with observations in the classroom

## Conclusion

These results, which are only very partial since they are based on two didactic parameters: the approaches and the cognitive processes, tend to show that the teachers of LES and the inspectors all agree on the investigative approach that is developing in the learner reflective practice and higher cognitive learning processes. (Perron, 2019b)

In this sense, despite the changes in ministerial institutional orders in Morocco (such as the introduction of the investigative approach, skills-based approach and problem-solving pedagogy, in the programs), we can see a certain stability in the effective reflexive practices teaching even if the contestation of explanatory-argumentative, scientific, and hypotico-deductive approaches has "become a classic of science didactics" (Clément, 1998).

This is why the appropriation by teachers of the investigation process is conditioned by the construction of a didactic model and a theory of learning.

Finally, we can propose that the theoretical framework of learning by problematization (Farges, 2020) as a possible framework for thinking about the investigative approach in science. It can indeed help teachers to move from a strong dirigisme piloted by predetermined questions to a dirigisme controlled by the points which must necessarily be reflected (reflective practices...) by the pupils.

So, within an investigative process, if it can be about allowing students to:

"Participate in the search for the validity of the productions of other students, in other words by participating in the reasoned choice between several methods, several hypotheses, several experimental protocols, several explanations, several models" (Boilevin et al. 2007).

For pedagogy by problematization overlaps with the investigative approach which reinforces reflective practices provide the means to think about the anchoring of this search for validity in that of the constraints and needs on the models of learning and teaching of LES in Morocco (Bekhat, 2020)

These intersections not only allow students to give meaning to the investigations chosen and discussed collectively, with regard to the problem that is being constructed, but also informs a reflective practice of learning in both directions (feedback) the teacher / l 'pupil, through the analysis of pupils' activity in terms of problematization, if they are really engaged in an investigative process.(Clemenceau et al. 2007)

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