Contribution of Experience in the Acquisition of Physical Sciences Case of High School Students Qualifying

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***Abstract*—This work deals with the importance of experimental practice in the teaching of physical sciences. By practice, we rarely mean practical work carried out in the laboratory. We examined the relationship between students' knowledge of physical science and how practice may or may not help them understand chemical and/or physical concepts. What emerges from a survey distributed to our students is that they are very favorable of the use of the practice. The problem posed in this work consists in identifying the impact of experiments on the acquisition of knowledge and in responding to the problems of learning through experience in the short and medium term. The analysis of the answers allowed us to conclude that the experiment in class, by the teacher, helps to understand the physical and chemical phenomena and can be done before or after the study of the theory. The length and difficulty of practical work sometimes worry students, trying to follow the protocol step by step. This fact underscores the importance of clarity of purpose, through which students can be guided toward questioning what is expected of them, such as knowing how their knowledge has increased.**

Keywords—Experimental practice; physical sciences; students; practical Work PW

I. Introduction

A. Contexte and Problematic

Support for the conduct of experiments and the manipulation of devices by high school students qualifying during practical work has been a long-standing need for teaching the physical sciences: “Physics and chemistry are experimental sciences must be taught as such” [1], could be read in recent official instructions.

From an educational point of view, the goal of the plan is for students to question themselves, act logically and communicate, and build their learning by being representative of scientific activities [2]. Numerous dissertations highlight the advantages of experience in terms of developing transversal skills and increasing the attractiveness of students for the physical sciences, but few are interested in its role in the acquisition of short or medium scientific knowledge term in students. For this reason, it seems interesting to us to study the impact on the students of the manipulation during the experimental phases on the acquisition of scientific knowledge: the realization of experiments allows the students to acquire better knowledge in the short and medium-term?

School instructions regularly evoke the links between theory and experimental practice which plays various roles [3], for example when they recall that experimental activities "constitute the very foundation of physics and chemistry" [4].

There is a large debate around experimental practice to which several researchers have tried to answer. Should theory be taught before practice, or should theory be based on practice?

For Duhem (2016) [5], to say that the theory is built by relying directly on the facts is a mistake, since the theory is not based on experience; it is rather controlled by experience. In other words [6], the physical theory does not start from the experimental facts; it seeks what are the fundamental properties that must be attributed to things and the relations that must be established between the changes of these properties in order to be able to deduce relations from them equivalent to those given by observation.

If we say that theory precedes experience, the best example to cite is that of general relativity proposed by Einstein in 1915. A beautiful, revolutionary theory that nothing could prove at the time. The first experimental verification did not come until 1919 with the Eddington experiment. On the other hand, if we say that experience precedes theory, we have the example of King Frederick II of Denmark who had funded an astronomical research center in the 16th century, which enabled unpublished and precise observations made by Tycho Brahe.

And it is thanks to these observations that Kepler was able to propose his laws on the movement of stars [7].

Constantly concerned about "how" to improve our classroom practice, we have researched, at various levels of our professional curriculum, the difficulties experienced by students in learning physical sciences. We sought, among other things, to know the conceptions of Moroccan high school students qualifying on the role of experience in teaching/learning in physical sciences.

To answer this problem, we will first look at the place of experience in the teaching of physical sciences and then, secondly, we will discuss the methodology used. We will present and analyze the results collected, in order to answer the questions of the problem.

B. Place of Experience in Teaching Physical Sciences

Experimental activities allow the learner to practice the experimental process, criticize, formulate hypotheses, design experiments, to interpret results. We consider that the experimentation helps in a good understanding of the concepts in physical sciences or initiates the construction of knowledge and know-how among the students.

The practical experience can thus be used to consolidate the acquired knowledge and to fill the various gaps of the theoretical course, in order to avoid any type of failure.

Different approaches combine to identify the real factors of failure, by pointing out the gap between saying and doing, between concepts and their uses [8].

Other factors can thus directly influence the decision to act towards such an educational system or a style of learning, in particular in practical work: (a) self-confidence, (b) the need to refer to others, (c) the need to use one's experience, and finally, (d) instilling the training model [9].

The learner profile defined by the program requires that the learner be able to carry out simple scientific experiments capable of highlighting certain facts and detecting the causes. The learner must therefore handle, observe [10].

Experimental activities are carried out in three forms [11]: The first form called "Practical Work" (PW) is a session devoted to manipulations made by students outside the class and guided by the teacher: verification of law, determination of a physical quantity, preparation of solutions, etc.

The other two consist of integrated activities during the course:

- In "course experiments", manipulations are usually done by the teacher, but the teacher sometimes allows the students to manipulate.
- In PW - courses, the manipulations are done primarily by the students.

Putting students in different learning situations allows them to diversify their approaches to a concept. In [12], the more they are confronted with different situations, the more they can discuss this concept and the easier it will be for them to memorize a given concept.

Other experimental learning situations exist, namely the integration of virtual environments for the simulation of various practical works, such as in physics-chemistry [13, 14, 15].

The development of the scientific spirit among learners has thus become more than ever a major objective of science education [16].

The steps to carry out practical work are specified by Joris Deguet and Guillaume Piolle, research professors in their research who specified that the method for doing a practical work takes place schematically in four phases represented in Table I.

TABLE I. PHASES FOR CARRYING OUT PRACTICAL WORK

Phases for carrying out practical work			
Preparation of the experimental protocol	**Carrying out the experiment**	**Collection of results**	**Interpretation and conclusion**
It is provided in the subject of the practical work, and it can be recalled in the report to make it easier to read, or to specify the stage that the student is describing.	The actual manipulations. They follow in practical sessions in the laboratory.	Detail all the experimental results collected during the lab, as well as their precise context. The results are linked to the protocol, to the experiment, and await interpretation, and they do not in themselves constitute a concluding element in a practical report.	This is the key phase of the experimental method, the most important of the report. At this stage, conclusions are drawn, and above all variations in results when the experimental protocol is modified. It is at this stage, by the quality of the writing, that the understanding of the problem is assessed.

C. Obstacles to the Physical Science Experiment

On the practical level, obstacles sometimes stand in the way of the experience, in the case of the educational actors questioned, the lack of equipment and chemicals (silver nitrate for example), the lack of a preparer in the laboratory, and the time allotted for finding equipment and preparing (rehearsing) pose a problem for subject teachers. In [17], the creation of virtual modeling environments can be a good alternative to solve these obstacles.

II. MATERIALS AND METHODS

A. Research Approach

We opted for a quantitative study based on the exploration and description of the data collected, as well as the comparison with related studies for discussion. The objective of our chosen approach is to get a set of concrete ideas of our research problem and objective.

We chose to use a quantitative method instead of a qualitative one, because:

- it reassured the interviewee and increased the response rate;
- it clarifies ambiguous answers;
- it allows us to transmit the questionnaire to the person;
- it allows the questionnaire to be passed on to the person who is competent to answer it; and
- suitable for questionnaires with "drawers".

B. Sample

The surveys are conducted, during the 2018-2019 school year, in two provincial directorates of the Ministry of Education and National Training; Sidi Bernoussi and Moulay Rachid belonging to the Casablanca-Settat regional. The choice of these directorates is related to reasons of facilitation of the research process.

Our sample consists of n = 300 qualifying secondary school students (common core and first year of the baccalaureate), 94% of the students responded because the questionnaire was given to them in class and they had time to answer it. Indeed, simple random sampling (SRS) was used in our study.

C. Method of Data Collection

We opted for the anonymous questionnaire as our data collection instrument. The questionnaire items were divided into four parts:

- Organization of the practical sessions: determine if the organization of the practical sessions and the objectives are clear enough.
- Theory and experience: determine if one is separable from the other.
- Role of experience: determine how the student perceives learning through experience.
- Progress of the practical work sessions: determine how the pupils perceive the availability of the teacher.

And finally, a section where students could freely answer three open questions:

- In your opinion the practical sessions allow us to acquire new knowledge and skills?
- In your opinion, what are the strengths and weaknesses of TPs?
- Did the practical sessions help you understand the course in physical sciences?

III. Results and Discussion

After the collection of data by the questionnaire, we proceeded to a statistical treatment using Excel software. The results were shown in the various figures below.

A. Organization of Practical Work Sessions

Fig. 1 gives the results of the two questions relating to the teacher's explanation and the clarity of the objectives of the practical sessions as answered by the respondents:

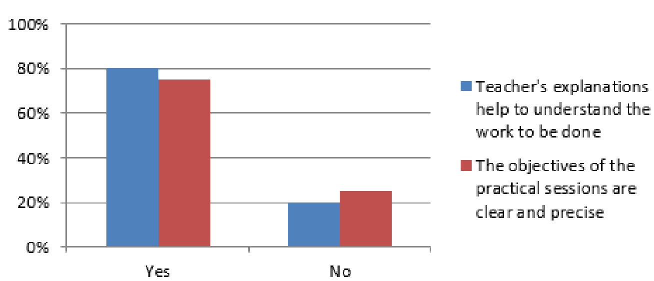

Fig. 1. Organization of Practical Work Sessions.

It turns out that: For 80% of the students questioned, the teacher's explanations help to better understand what is expected of them, and 75% declare the clarity of the objectives of the practical sessions.

Work on effective teaching practices [18-29], show that the teaching activities of efficient and equitable teachers are characterized by the principle of clarity, clarity in the presentation of tasks and instructions to be performed by students, clarity in the general organization of activities teaching. The explanation of concepts and concepts is done simply and logically.

What we noticed during the exercise of this profession of professor of physical sciences, is that, even if it is certain that the pupils should not be left in ignorance of the objective of practical work, they have a relative lack of autonomy. Indeed, as soon as part of the work is left to their judgment, we can say that they do not feel comfortable and ask a lot of questions.

Among the stated goals of good practical work in numerous publications are the familiarization of students with the scientific process [30]; [31], cognitive and psychomotor skills (Galloway et al., 2016) [32] and a better understanding of how science works [30, 31], without forgetting that there is a strong link between a learner's motivation and his results (Deci, Vallerand, Pelletier, Ryan, 1991) [33].

B. Theory and Experience

In Fig. 2, we have presented the results of the student survey concerning their opinion on the theory of experience.

87% of students believe that theory must precede experience, which again shows a relative fear of the student facing the unknown, a lack of self-confidence and autonomy.

In conclusion, for the pupils, it is useless to see the experiments before the theory; consequently, they prefer to already know the subject on which they must concentrate.

According to the literature many experiments were carried out without being guided by a well-established theory but were instead undertaken to explore new areas. Let's look at some illuminating examples: The development of electromagnetism is a good example: many electrical phenomena were discovered by physicists such as Charles Dufay, André-Marie Ampère, and Michael Faraday in the 18th and 19th centuries through experiments that did not have been guided by no developed theory of electricity.

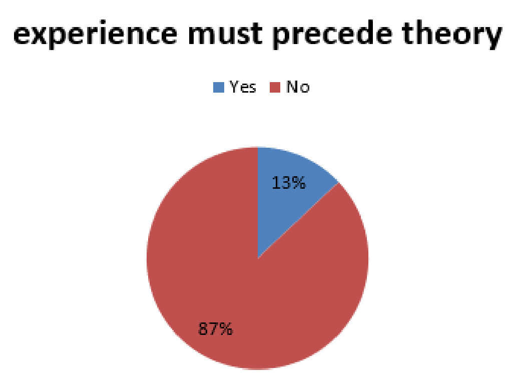

Fig. 2. Theory Vice Versa Experience.

Another example to cite: is the constant and laborious experimental effort that characterized the field of particle physics, especially the fundamental constituents of the proton and neutron, which were discovered through several exploratory experiments at the end of the 1960s to the Stanford Linear Accelerator.

For the second question of this item, we find in Fig. 3 that Almost 89% of students think that experience helps them understand the theory. When we analyzed the results, we could read that assisting or experimenting helps them build an image of the theory and keep it in mind.

The practical work during which the student is supposed to think, act and manipulate is always preceded by theory, where the knowledge at stake in these labs is already in place, which leads to reinforcing the lack of autonomy among the students of the second qualifying.

These results do not mean that experience should not have a close relationship with theory; in the end, there is only one physics, and it must ensure unity [7]. So, we can deduce that it is up to the teachers to clarify to the students the importance and the complementarity between the theory and the experiment whatever the first one.

For the last question in this section, we find in Fig. 4 that 70% of students think that the physical sciences cannot be taught without carrying out the experiments and also that the description of the experiment alone is not enough to understand the theory (76%). On the other hand, they need theory and practice to understand physical and chemical concepts.

The teachers want the PW to develop scientific attitudes as well as a creative and critical dimension in the pupils, the latter for their part, are much more reserved about the achievement of the objectives characterizing scientific attitudes.

They perceive the practical work under an aspect linked to the manipulative techniques and the illustration of the course [34]. On the other hand, we can find a part of the teachers who declare that the physical sciences can be taught without experimenting, in particular, at the forefront of national concerns and priorities in the discourse of the main political actors in Morocco [35].

C. Role of Experience

76% of the pupils think that the pupil learns more from the experience than he did than that of the teacher, 77% prefer the experiences which were made in the group. All this is linked to the previous question, which asks them if practical work helps them to better understand the physical sciences (Fig. 5).

The learning of manipulation techniques is facilitated, according to the literature and the teachers, by precise descriptive protocols, supplemented by illustrations and diagrams of the technique to be understood for the labs carried out by students in groups [36].

The teachers, for their part, emphasize their role to play in this learning as a student guide, in particular by validating or correcting the student's actions during the practical work [37].

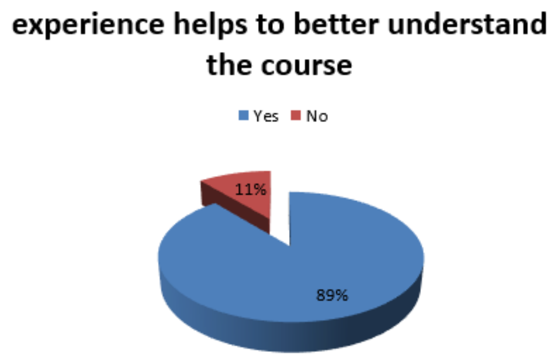

Fig. 3. Theory and Experience.

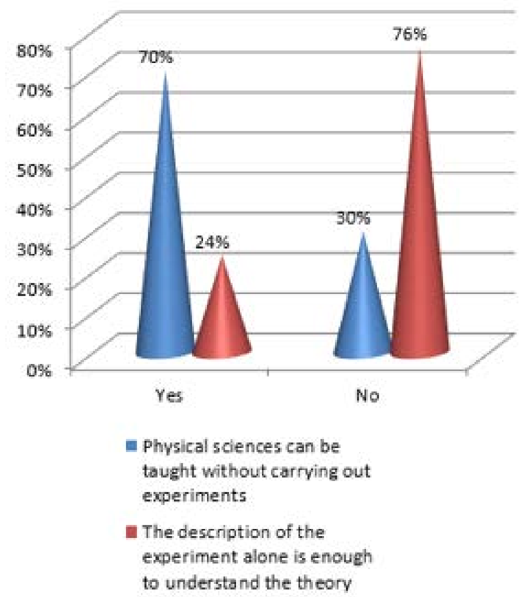

Fig. 4. Physical Sciences can be Taught without Experience.

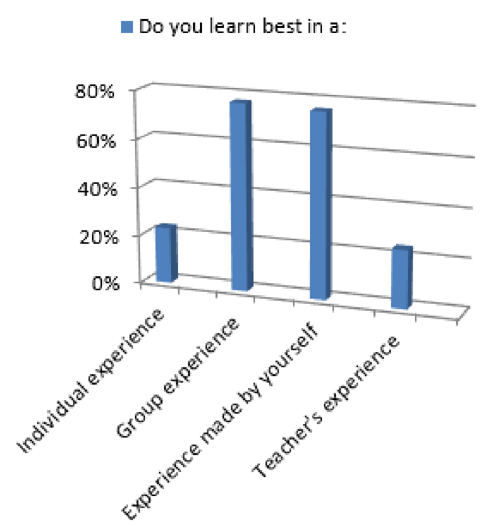

Fig. 5. Types of Experience that Students Learn Best.

D. Progress of the Practical Work Sessions

For students, the lesson must be flexible enough to integrate the discussion on a topical subject if the opportunity arises; for this, we asked the student's opinions on the course of the practical sessions (Fig. 6).

It appears that:

- The majority of the students questioned affirm that the teacher helps to build knowledge and overcome the difficulties encountered in understanding physical and chemical concepts.
- Most students are very interested in experimental activities; with the majority finding that the teacher helps them better understand the course.
- The results of this document have shown that the use of experience (under the guidance of the teacher), as an educational means in the teaching of the physical sciences and plays an important role among learners in the plan of acquisition of correct knowledge and concepts related to the program.

The teachers, for their part, emphasize their role to play in this learning as a student guide, in particular by validating or correcting the student's actions during the session.

For the last part concerning the three open questions, is not discussed in this report. The reason is that the majority of students surveyed did not answer these questions.

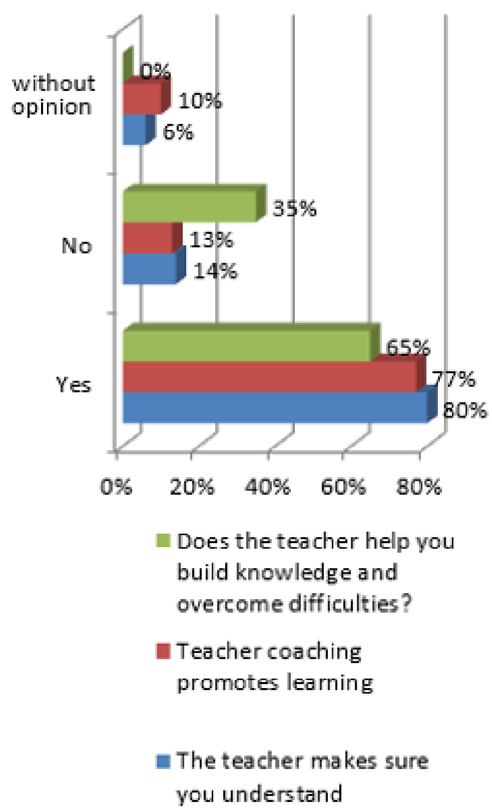

Fig. 6. Role of the Teacher in the Practical Work Sessions.

IV. CONCLUSION

Our work aimed to explore the role played by experience from the students' point of view. The results obtained according to the statistics were favorable and benevolent and go to achieve the objective of the research and respond to the problem raised. The results that we can draw from our brief experience allowed us to raise many points of interest in our opinion:

- The importance of the physical sciences comes through experimentation, whether it is a demonstration in the classroom or the form of practical work, carried out in groups by the students themselves.
- The classroom teacher's experiment helps to understand physical and chemical phenomena and can be done before or after studying the theory.
- Try to vary as much as possible in the practical work sessions, showing the theory before the experiment or letting them discover the theory. We could see that they preferred to know the theory before applying it to the labs.
- Practical work PW helps students to visualize the concepts taught, explore and develop their critical thinking skills.

We can recommend to information and communication technologies, in particular carrying out practical experiments using digital tools in environments which depend on certain factors which seem to influence these practices.

Indeed, the reflection on the modalities of digital use by students gives rise to several debates [38].

In addition, and a context of virtual experiential learning, several pedagogical approaches can reinforce the playful learning approach, particularly at a distance, which thus represents a powerful vector for promoting socio-professional skills [39].

To this is added the importance of the educational act and the effective role played by the school in the construction of society based on solidarity and equal opportunities in different social and environmental environments [40].

V. RECOMMENDATIONS

For research in didactics, this study can serve as a support for various didactic reflections on experimental practice and in particular, the development of practical work in physical sciences taking into account the opinions of learners. It can allow a reflection on an interaction between pupil and teacher and, between groups of pupils to promote their autonomy and participation in the construction of their knowledge.

An interesting avenue for future research would be to seek to confirm these results by using a larger sample by conducting more similar experiments in other scientific disciplines to be able to draw a more general conclusion.

In addition, we can identify in future research the constraints and obstacles hindering the integration of information and communication technologies for practical laboratory work (lack of training, software, appropriate materials, assistance administrative, etc.).

We can thus take advantage of the learning difficulties often detected when learners do not reach the level required for their age groups. They can take the form of poor motivation, limited memorization or concentration, inability to solve problems, maladaptive social behaviors, etc. [41].

The concepts of evaluation and oral communication are also important, making it possible to gradually improve learners' communication techniques and skills, while maintaining minimum stress and keeping the oral communication project in its persuasive dimension [42].

We can refer to the various works of educational researchers, such as those of Fallon in 2019 who explained that the first research focused on understanding scientific concepts using physical equipment, but technological advances mean now that there are new options for introducing this learning, through the use of technology and simulation.

Indeed, the results indicate that the students developed a solid foundation of procedural knowledge about building different circuits and functional knowledge about circuit components which they applied to different circuit designs.

Adding that teachers need to be very vigilant and work closely with learners, to ensure that accurate understanding is developed [43].

We can thus appeal to the research of Yardley's 2012 [44], research aim to introduce readers to the theories underlying experiential learning, which considers the theoretical basis of experiential learning from a learning perspective social and constructionist and applies it to three stages of medical education: the first experience in the workplace, internships, and residency.

Another study investigated the level of usefulness of e-module based on experiential learning in the physical sciences. The authors worked on Research and Development (R&D). The method used is a descriptive method with data collection instruments, namely the usefulness questionnaire of the electronic module evaluated by the teacher.

The results showed that e-modules based on experiential learning were very useful in learning physics [45].

The results obtained can be exploited in future attempts to ensure better integration of the experience in the Moroccan education system, the main actors must collaborate to overcome the obstacles that prevent this integration, namely: the Ministry of Education and of training, and the teacher.

VI. Limitations

Although this study yielded important results in the quantitative database dealing with the importance of experimental practice in the teaching of the physical sciences, it has certain limitations.

Indeed, the research is limited to a small sample belonging to two provincial directorates of the Ministry of Education and National Training; Sidi Bernoussi and My Rchid belonging to the Casablanca-Settat regional academy in Morocco.

We did not consider the rural environment. This was due to the lack of equipment and resources available to the research team, which forced us to work only in the Casablanca-Settat region.

Another limitation is that we have relied solely on the physical sciences, rather than other important scientific disciplines that are meant to be incorporated and generalized in this study.

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