A Contrastive Study of Students' Appropriation of Scientific Knowledge in Experimental Disciplines: A Case Study of a Malagasy Second-Year Class

Emmanuël Ramiandrisoa[1]; Lydia Rasoarinivo[2];
Dr. Faly Tinasoa Andrianandrasanirina[3]

[1] ED3S – PE2Di, Université d'Antananarivo, Madagascar;
[2] ENS, Université de Fianarantsoa, Madagascar;
[3] Laboratoire de recherche Interdisciplinaire en Didactique et Education (LIDIE),
Ecole Doctorale Gouvernance et Société en Mutation (GOUVSOMU),
Ecole Normale Supérieure de l'Université de Fianarantsoa – BP 1264 - 301 Fianarantsoa City, Madagascar.

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Abstract: This study stems from the observation of difficulties in teaching and learning Physical and Chemical Sciences (PCS) and Life and Earth Sciences (LES) due to the lack of laboratory equipment and infrastructure. The objective of this research is to find solutions to improve students' acquisition of knowledge. Data was collected through questionnaires (administered to students and teachers) and an analysis of textbooks. This research revealed that, due to the lack of laboratory infrastructure, teaching materials, and the inadequacy of teachers' academic and professional training, they generally resort to lecture-based teaching methods, which do not allow students to contribute their opinions. Furthermore, classroom experimentation is not incorporated into lessons, even though students believe it fosters the genuine construction of scientific knowledge.

Keywords: *Physical and Chemical Sciences; Life and Earth Sciences; Learning; Appropriation of Knowledge.*

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I. INTRODUCTION

Experimental sciences such as Physical and Chemical Sciences (PCS) and Life and Earth Sciences (LES) are omnipresent in our daily lives and play a crucial role in the transformation of our society (LEARNING, 2022). The teaching and learning of these experimental disciplines must highlight this characteristic for learners so that their learning is meaningful to young people, empowering them to take ownership of their lives and contribute to solving problems in their immediate environment. In Madagascar, science education aims to train citizens capable of understanding the realities of their environment and developing a critical approach to the problems associated with the application of science, thereby helping them to resolution (MEN, 2018). In this perspective, science education should not be limited to training future physicists, chemists, biologists and engineers; but it should (i) develop a scientific culture in the learner; (ii) train the mind in rigor, the scientific method, criticism, and intellectual honesty through the practice of the experimental approach; (iii) train the citizen-consumer in the proper use of chemical and biological products in order to preserve their health and the environment; (iv) enable the citizen to understand the phenomena of the current world, to adapt to the continuous evolution of modern technology in order to master their environment.

However, students struggle to grasp science because the concepts presented are sometimes difficult to understand, as they are disconnected from the learners' immediate environment, and also because of the teaching/learning methods used by teachers. A lack of laboratory equipment and infrastructure makes teaching abstract (Ramiandrisoa and Tsimilaza, 2025). Giordan and De Vecchi (1993) noted in their research that, due to a lack of contextualization in teaching/learning, students perceive experimental sciences as difficult and incomprehensible disciplines because of the prevalence of scientific language and formulas throughout a biology or physics lesson. A particular difficulty lies in the

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absence of hands-on experimentation during lessons in these subjects, which are considered experimental.

In Madagascar, these observations are once again a persistent reality in the educational environment for students (Ramiandrisoa and Andrianandrasanirina, 2024). Indeed, in the majority of Malagasy high schools, the teaching of so-called experimental sciences remains highly theoretical. Lessons are often limited to copying lengthy texts onto the board, followed by oral explanations and a few quick exercises; experiments are reduced to diagrams describing the various steps that should be carried out in practice. This teaching model, excessively focused on theory, does not begin with questioning that engages students in cognitive conflict and leaves little room for active participation and hands-on learning (Ramiandrisoa and Andrianandrasanirina, 2024). It certainly does not promote students' acquisition of knowledge. Such teaching practices do not allow students to develop critical and creative thinking skills (Ramiandrisoa and Razafimbelo, 2020).

Thus, in order to improve student involvement during the construction of their knowledge in experimental sciences, which is a way to facilitate student knowledge acquisition, this article seeks to identify the sources of the difficulties mentioned above and to propose related solutions.

Before going into detail about the causes that hinder the acquisition of scientific knowledge among students, the following paragraph develops a state of the art on the teaching/learning of experimental sciences and those that could be obstacles for learners when learning these disciplines.

II. THEORETICAL FRAMEWORK

For years, science has been called upon to help us understand everything that happens in our environment, from the living world to the properties and complexity of the phenomena that manifest around us. A defining characteristic of science is its use of the scientific method, which fosters the development of new knowledge, skills, and even attitudes. Through this approach, scientists' work generates new knowledge that is essential for society to address major challenges in this dynamic and ever-evolving world. Teaching and learning are thus called upon to fulfill this mission.

The teaching of any discipline, scientific or otherwise, depends to some extent on our perception of it. The image that science presents may stem from the practices of the teachers who teach it and changes from one era to another. Indeed, around the 1980s, science was taught through lectures in which the teacher, the "holder of knowledge," employed a transmissive approach. Currently, this outdated perception has been rejected and criticized by educational theorists as a classroom practice that does not promote effective science teaching and learning. Yet, some teaching practices that attempt to eliminate outdated methods seem incomprehensible to students, or even a source of difficulty for them. For example, teaching and learning based solely on observation and manipulation, aimed at explaining phenomena stemming from questions predetermined by the teacher, does not allow learners to engage in metacognition (Rittaud, 2014). This perception of science leads to the use of the scientific method, which encourages learners to question themselves about real problems whose meaning they have fully grasped.

Thus, science is currently called upon to shape learners and develop their scientific mindset—that is, a mind capable of analyzing, continually questioning, formulating hypotheses, and conducting various forms of investigation as needed. From this perspective, science education would focus on problem-solving using a learner-led approach that empowers them to be active participants in their own learning and to problematize as in genuine scientific research, even if it remains within the classroom setting. Taking into account their prior knowledge, learner-led research is crucial in this approach because it is through this process that learners progressively develop their scientific thinking and internalize the targeted scientific knowledge (Develay, 1992).

Research has suggested that teaching methods and the perceptions of both students and teachers have presented a contrasting image of science within school systems. Indeed, students often find the science taught boring, as it is perceived as abstract concepts unrelated to their daily lives. These aspects fail to meet their expectations. Furthermore, teaching practices and a lack of conviction among teachers have hindered students' acquisition of knowledge.

Several difficulties have been identified in science teaching and learning. Students have encountered challenges in learning science, particularly those related to the nature of the concepts covered and the teaching conditions. Learners experience a disconnect between the science being taught, their needs, and their daily lives. This situation complicates the understanding of science teaching and learning. Learners may thus face complex situations requiring them to move back and forth between the world of theory and models, which refers to theoretical aspects, and the world of objects and events, which constitute observable aspects. These complexities of the phenomena studied require, among other things, the ability of teachers to explicitly support student learning (Tiberghien, 2011).

A particular difficulty lies in its disconnect from the realities of science teaching and learning, which hinders students' appropriation of science. Indeed, lacking contextualization or a direct link to learners' experiences, science has become boring. Students experience a profound incomprehension of the scientific formulas and language used (Giordan and De Vecchi, 1993). This situation sometimes leads to decreased motivation, silent resignation, or even a gradual disengagement of learners. This has been exacerbated by the absence of experimental situations (Ramiandrisoa and Razafimbelo, 2020). Experimentation plays a fundamental role in understanding phenomena in experimental sciences, as it allows students to problematize, formulate hypotheses, conduct experimental investigations, manipulate materials, analyze results, and compare them with theoretical models (Fabre, 2004). Without this concrete step, students have difficulty acquiring scientific attitudes leading to the appropriation of knowledge.

These constants lead us to ask the following question: How should science be taught or taught to increase learners'

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knowledge acquisition? For us, improving students' knowledge requires teachers' ability to contextualize their teaching, to take into account learners' initial conceptions, and to involve them in their own learning. Verifying this assertion leads us to propose the investigative methods developed in the paragraph below.

III. METHODOLOGY

A mixed-methods research approach was adopted for this study on students' appropriation of scientific knowledge in experimental subjects such as Physics and Chemistry (SPC) and Life and Earth Sciences (SVT) (Ilboudo & Kiemde, 2022). This approach combines qualitative and quantitative data to enrich the research findings. A non-probability sample was chosen for convenience, thus excluding coverage of the entire population, as our primary concern in this study is to identify the necessary information to meet the research objectives (Ilboudo & Kiemde, 2022). In other words, the objective of this survey was not to obtain a representative sample of the target population; what matters is gathering information on classroom practices (Deliou, 2014) and students' perceptions in experimental subjects within high schools in Madagascar. To gather information, surveys were conducted with students regarding their apprehensions about experimental disciplines (Physics and Chemistry, and Life and Earth Sciences) and also regarding teachers' practices. Another questionnaire was distributed to teachers so they could share their perspectives on factors hindering knowledge acquisition in these scientific disciplines. The target audience consisted of Physics and Chemistry teachers, Life and Earth Sciences teachers, and second-year students at the Manara-Penitra Idanda High School (LMI), located in the Fianarantsoa School District (CSICO), within the Haute Matsiatra Regional Directorate of National Education (DREN) (Madagascar). Data collection was carried out using various tools to perform triangulations and thus strengthen our analyses. The tools used for data collection were questionnaires administered to both students and teachers. For the collection of quantitative data, two types of questionnaires were administered to students and teachers of physical sciences and life and earth sciences from the LMI. To enrich the information, this data was supplemented by an analysis of the physics and chemistry and life and earth sciences textbooks in order to identify relationships between this information and the official instructions.

The collected data was transcribed into Excel files to facilitate analysis. This will generate graphs showing the trends for each identified item. Next, the analysis of these graphs will be compared with other data from official documents. Finally, a comparative study will be conducted in the two experimental disciplines to highlight their specific characteristics in terms of students' acquisition of knowledge.

IV. PRESENTATION OF RESULTS

This paragraph concerning the presentation of the results is divided into two parts: the first part develops the feedback from the questionnaires sent to the students (composed of in three parts) and the second part describes the responses given by Physics and Chemistry (PCS) and Life and Earth Sciences (LES) teachers regarding factors that can make teaching/ learning these subjects difficult. Seven (7) teachers and 200 students responded to our questionnaire. They all returned these 207 survey questionnaires.

A. Questionnaires Sent to Students:

Let's start directly with the first group of questionnaires. It should be noted that this one is also divided into three parts, namely i) students' apprehensions about scientific disciplines; then ii) their conceptions about teaching methods; and finally, their opinions on the elements needed to understand SPC and SVT.

Students' perceptions of the experimental science disciplines (Physics and Chemistry and Life and Earth Sciences) are shown in the graph below (see Figure 1). This figure illustrates learners' apprehensions about the two disciplines targeted in this research.

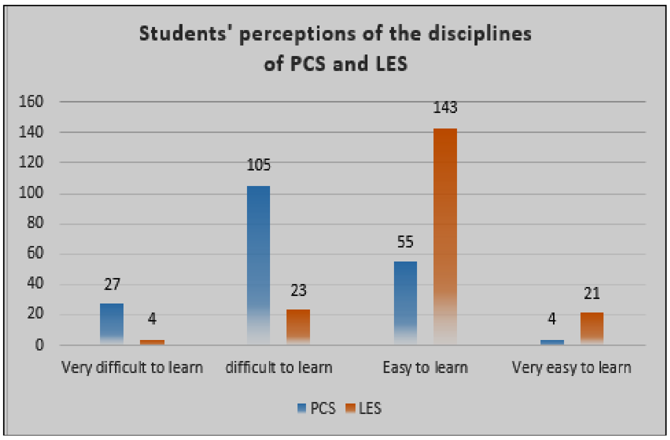

Fig 1. Students' Apprehensions About Scientific Disciplines PCS and LES.

According to Figure 1, students reported significant differences in their understanding of these two subjects. They found Life and Earth Sciences (SVT) to be relatively easy to learn compared to Physics and Chemistry (SPC). Specifically, 164 students (43%) found SVT easy to understand, while 132 (34%) found SPC difficult to grasp. Despite these findings, 19% of students stated that SVT was difficult to learn, and 7% observed that SPC seemed easy to approach.

The graph in Figure 2 below highlights the factors hindering the learning of Physics and Chemistry (PCS) and Life and Earth Sciences (LES). This generally reflects the teaching methods favored by teachers. However, it is important to remember that this information is based on students' perceptions.

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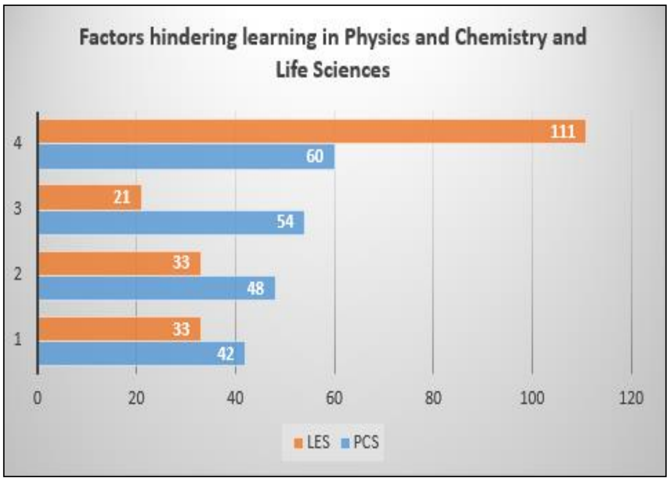

Fig 2. Teaching methods.

Thus, according to Figure 2, the teaching methods that hinder learning in the science and physics discipline revolve around the lack of experimentation and prerequisites. Students also mentioned other issues, but these were still included among the two major factors mentioned previously. Teaching methods and insufficient practical work, according to the students, were among the unfavorable factors that complicated the acquisition of knowledge in life and earth sciences.

In addition to teaching methods, the learners also offered their ideas on strategies for facilitating the acquisition of scientific knowledge. The following figure (see Figure 3) shows the students' opinions on factors that facilitate their learning in experimental sciences.

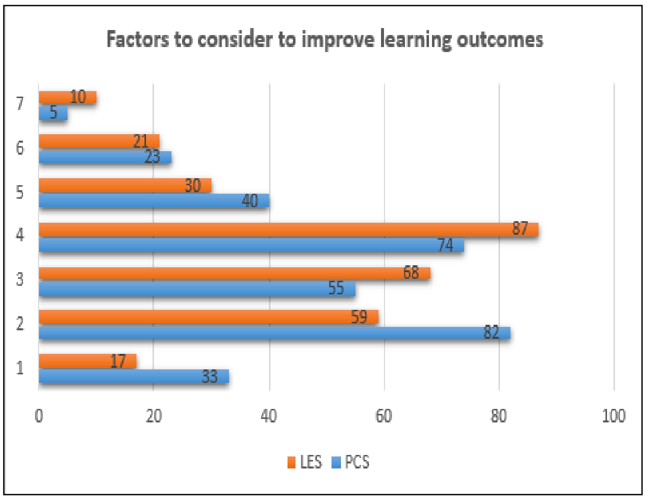

Fig 3. Students' Opinions on the Elements Needed To Understand Physics and Chemistry and Life Sciences.

Aside from the criticisms raised by students regarding experimental sciences and the teaching methods of the Physics and Chemistry (PCS) and Life and Earth Sciences (LES) disciplines, the learners also inquired about solutions to improve learning outcomes in these scientific subjects. To this end, Figure 3 above provides information on factors that can optimize knowledge acquisition in PCS and LES. Seven items were included in this questionnaire: teaching methods; laboratory experiments; homework assignments; field trips; group work in class; increasing class time; and other 302 out of 604 student responses (50%) suggested that field trips, laboratory experiments, and homework assignments should be strengthened, particularly to facilitate learning in experimental subjects such as Physics and Chemistry (PCS) and Life and Earth Sciences (LES). Regarding the specific characteristics of each subject, students recommended that field trips be very important in Life and Earth Sciences (LES) and that laboratory experiments should be reinforced in Physics and Chemistry (PCS).

The information we have just presented concerns students' opinions on the experimental subjects studied earlier. Now, in the following paragraph (see §- 3.2), let us turn to teachers' perceptions of the factors that make teaching/learning in Physics and Chemistry and Life and Earth Sciences difficult.

B. *Teacher Questionnaire:*

This questionnaire includes the following items: very long study program / reduced teaching time; limitations of academic and professional training; lack of laboratory and teaching materials; absence of field visits; other factors which were followed by further explanations.

Seven teachers agreed to answer this questionnaire. Four (4) of them teach Life and Earth Sciences (LES) and three (3) teach Physics and Chemistry (PCS). Both groups of teachers shared the same opinions and stated that the first four factors mentioned previously hinder the effective teaching of these experimental science disciplines.

Other factors hindering their teaching were proposed by these teachers, namely: i) the need to correlate teaching hours, teaching time, and coefficients; ii) the excessive number of students; iii) the poor study conditions of students and socioeconomic problems of learners; iv) the disconnect between knowledge to be taught and its concrete applications in the immediate environment of students; v) the teachers' standard of living does not allow them to update their professional skills through continuing or initial training.

The information cited in the two paragraphs above was obtained from students and teachers through a questionnaire survey. In what follows (see §-3.3), the information is taken from the new curriculum and accompanying documents for Science and Physics (PCS) and Life and Earth Sciences (LES) in the second year of secondary school in Madagascar.

C. *Reading the curricula:*

For the Physical and Chemical Sciences discipline, teaching/learning at the high school level aims to lead learners to: a) practice a scientific approach; b) adopt a scientific attitude by developing in them the scientific spirit; c) observe and interpret in a scientific way the natural phenomena and the technical world through concepts, laws and models; d) manipulate and exploit digital technologies for the learning of physical and chemical sciences; e) develop the culture of experimentation (MEN, 2018, p.82).

In other words, the teaching/learning of SPC should enable learners to: i) pursue lifelong learning; ii) reason scientifically and solve problems; iii) analyze, interpret and solve problems using the laws of physics and chemistry; iv)

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verify the agreement between a theoretical prediction and an experimental result; v) correctly write a numerical result using a scientific presentation that takes into account significant figures; vi) mathematize the laws of physics and chemistry that lend themselves to it; vii) match phenomena or applications from everyday life or the technical world to the concepts, laws and models learned in physical and chemical sciences; viii) use digital technologies for learning (Ibid., p.82).

The preferred methods in the SPC (Science, Technology, and Culture) discipline are based on the learning paradigm of: learning to know, learning to do, learning to be, and learning to live together. The teaching/learning process in this SPC curriculum is primarily learner-centered, focusing on the construction of knowledge and skills among learners. This adopted paradigm thus fosters the acquisition of scientific attitudes in learners (Ramiandrisoa and Andrianandrasanirina, 2025).

As for the discipline of Life and Earth Sciences, it is a science which should enable learners to improve the living conditions of man and his well-being and to implement various skills essential to the success of a solid education through pedagogical and didactic approaches such as: i) observations at different time and space scales, ii) experimentation, iii) simulation, iv) modeling, v) conceptualization, vi) investigative approaches, vii) use of digital technology, etc… (Ibid., p.93).

Thus, Life and Earth Sciences (LES) should provide learners with a broad scientific culture and develop various cognitive, social, sensorimotor, and behavioral skills (Ibid., p. 93). LES teaching and learning should enable learners to develop types of learning such as learning to know, to do, to be, and to transform themselves and society.

The results presented above illustrate the diverse perspectives of the various stakeholders (students, teachers, and curriculum designers) involved in science learning at the secondary level in Madagascar. The paragraph above provides further discussion of these different elements raised in the results.

V. DISCUSSION

For ease of analysis, our study is divided into three parts as follows: one part focuses on the apprehensions of students and teachers regarding the experimental disciplines (i.e., Physics and Chemistry and Life and Earth Sciences) targeted in this research, particularly those that hinder the teaching and learning of these disciplines; the second part examines the teaching methods used by teachers of these disciplines; and finally, the proposed solutions suggested by students and teachers. These three points were discussed in the order they appeared.

A. Apprehensions of Students and Teachers:

Apprehensions appear as a set of information and opinions, forming a personal, structured, and organized explanatory system whose main function is to justify impasses in teaching/learning (Astolfi and Peterfalvi, 1993). They stem from students' or teachers' conceptions of the disciplines involved. These conceptions could be a springboard for learning (Giordan, 1996). But at certain times, the characteristics of these apprehensions can hinder students' acquisition of knowledge (Joshua, 1989).

The ideas put forward by the students reveal that the acquisition of knowledge in experimental disciplines depends on the teaching methods, the reinforcement of prerequisites, and the experimentation carried out during instruction. Teachers also confirmed that the lack of experimental laboratories makes learning science difficult. Research has corroborated these findings (Ramiandrisoa and Tsimilaza, 2025; Ramiandrisoa, Andrianandrasanirina, and Andriamanalinarivo, 2025). These authors demonstrated in their research that contextualizing teaching and learning is a reliable springboard for optimizing science learning. Furthermore, according to the teachers surveyed, teaching and learning these disciplines requires significantly more time than is currently allocated.

The field visits included students in these proposals to facilitate understanding of these experimental disciplines. In other words, these teaching/learning practices are embedded in another form of contextualizing teaching/learning. But this time, the objective is to demonstrate the relationship between academic knowledge and relevant social practices (Martinand, 1989).

B. Teaching methods

Teaching methods encompass the activities that teachers organize and carry out using their knowledge and skills within the learning environment (Legendre, 2005). They include the teacher's actions aimed at eliciting a well-defined form of learning in students during the classroom setting (Giordan & Girault, 1994). These methods are therefore simple actions that vary according to the activities and objectives of the lesson. During a lesson, the teacher can choose the method they will use based on the goals they want to achieve, the students to be taught, the subjects to be covered, and the context.

The teaching methods used by the seven teachers surveyed are based on theoretical lessons. These methods do not take into account either the learners' initial conceptions or the need to review prerequisites. Such practices diminish students' motivation to learn these subjects and do not promote knowledge acquisition, because the process of knowledge acquisition involves learners actively shaping their understanding by comparing new information with their prior knowledge. Students' actions should be influenced by a conceptual shift that overcomes pre-existing conceptual frameworks at the time of knowledge construction (Giordan & Girault, 1994). This conceptual shift is a learning process involving the transition from initial conceptions to more scientific ones (Bêty, 2010).

According to Giordan and Girault (1994), learners' acquisition of knowledge depends on several important factors, such as: material problems (laboratories and experimental equipment); class size and group dynamics; limited teacher training; textbooks; and assessment establishing a link between the targeted scientific practices and

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the assessments used to verify the acquisition of knowledge and skills. Ignorance of these points undoubtedly hinders the teaching and learning of these disciplines. Indeed, most of the reasons for the decline in students' interest in scientific subjects are primarily their lack of participation in the knowledge construction process and the problem of contextualizing teaching. Therefore, taking into account the elements proposed by Giordan and Girault (1994) largely resolves the obstacles to students' knowledge acquisition.

What do students and teachers say about improving student learning in Physics and Chemistry and Life and Earth Sciences? The answers to this question are the purpose of the following paragraph.

C. Possible Solutions Proposed by Students and Teachers:

The solutions proposed by students to improve their learning are generally centered on experimentation and field visits to contextualize teaching and avoid overly theoretical, boring lessons that can lead to disengagement, as these practices allow them to argue, manipulate, and discuss. Some authors have echoed these ideas, stating that to learn, students need to encounter situations involving communication, exchange, and the confrontation of arguments and experiences (Giordan, 2006; De Vecchi, 2007). To this end, the teacher's role is to place students in situations where they can become aware of their needs and limitations and construct their own knowledge. Therefore, it is essential to ensure that learners construct their own knowledge (De Vecchi, 2007).

As for the teachers' comments, they felt that, aside from the lack of hands-on experimentation in science teaching due to equipment and laboratory infrastructure issues, the insufficient training received by teachers needed to be addressed to improve student learning outcomes. The issue of student class sizes is also a significant factor. According to Giordan (2006), in what he calls "allosteric learning," all successful learning is a change in understanding. For this author, all knowledge acquisition stems from complex activities that require well-structured strategies from the teacher. The effectiveness of a teacher's actions is always manifested within a context of interaction with the student's learning strategies. New skills are required for teachers to effectively address this. Indeed, it is essential in teacher training to reform skills to provide reference points for the needs and limits of learners, to contextualize teaching, to frame exchanges and activities, to share aids to conceptualization, or to give meaning to knowledge.

VI. CONCLUSION ET PERSPECTIVES

This research aimed specifically to contrast students' acquisition of knowledge in the two experimental science disciplines. The teaching/learning of the disciplines of Physics and Chemistry (PCS) and Life and Earth Sciences (LES) in the second year of secondary school (Second degree) at the LMI, a Malagasy public high school implementing the new teaching methods introduced in Madagascar in 2018, was chosen for this study.

To conduct this research, we opted for a mixed-methods approach based on a questionnaire survey and an analysis of textbooks. This approach allowed us to determine that students consider Life and Earth Sciences (LES) easier to learn than Physics and Chemistry (PCS). One of the difficulties in learning SPC is the lack of experimentation and review of prerequisites during lessons. Students also suggested that field trips and laboratory experiments should be significantly strengthened to improve learning in experimental disciplines. For teachers, infrastructure and laboratory equipment problems hindered the teaching and learning of these experimental sciences. Furthermore, insufficient teacher training, the disconnect between knowledge to be acquired and its visible applications in daily life, and the poor socioeconomic conditions of students made learning science difficult.

Several solutions were proposed in this research, including taking into account students' initial conceptions and contextualizing teaching through field visits or experimentation during teaching/learning sessions. Involving learners in the process of constructing their own knowledge is a key objective. Teacher training is also crucial to equip them with the skills to design and plan learning activities that foster self-construction of knowledge and skills. Furthermore, the acquisition of a scientific mindset and students' appropriation of knowledge largely depend on teachers' ability to present problem-solving situations that are accessible to learners but allow them to problematize, argue, and exchange ideas among themselves or with their teacher (Ramiandrisoa and Razafimbelo, 2020).

This study focuses on a comparative analysis of learning in Physics and Chemistry (PCS) and Life and Earth Sciences (LES). Beyond the specific challenges students face in acquiring knowledge within each discipline, it is important to understand whether these situations vary from one classroom to another or from one teaching practice to another, as the results presented do not differentiate between these characteristics specific to each class or teacher.

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