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# The Pedagogical Role of Error in Life and Earth Sciences Education: Classroom Practices, and Teacher Professional Development

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*regulation*
*didactic situation*
*professional representations*

***Abstract***

In this article, we focus on exploring how upper-secondary life and earth sciences teachers perceive and interpret the concept of error within their professional practice. Particular attention is given to the strategies and attitudes they employ when addressing students' mistakes, drawing on data collected through classroom observations and structured questionnaires. The study was conducted with teachers working under the Tetouan Provincial Directorate during the 2023–2024 academic year. A total of 100 teachers participated, completing a questionnaire specifically designed to shed light on how theoretical perspectives on error are applied—or sometimes neglected—in everyday teaching situations. The analysis of the collected data highlights several important findings. First, teachers' representations of error vary significantly depending on their training background, pedagogical beliefs, and years of experience. Second, the results underscore that error is often treated not only as a natural part of the learning process, but also as a valuable resource for diagnosing students' misconceptions and guiding instructional decisions. Most importantly, the study reveals the crucial role played by continuous professional development. In-service training programs appear essential for helping teachers update their theoretical knowledge, refine their assessment practices, and adopt more constructive, student-centered approaches to managing errors in the life and earth sciences classroom.

## I. Introduction

Long devalued and regarded as a "fault", error is gaining increasing importance in modern pedagogical thinking, since the evaluation of learning has come to occupy a prominent place in teaching practices. Errors are now seen as an indicator of inaccurate results, a sign of learning difficulty and a reason for student failure [1], [2].

If error warns of difficulties encountered by students, does it not also provide information on the negative impact that teaching procedures can have on student learning? Is it not an expression of the student's loss of interest in the subject? And isn't the way in which it is treated a prerequisite for a cognitive and interactive mix that can foster a desire to learn and a dynamic for success at school?

Answers to these questions can be found in two ways: by examining the error from a didactic point of view, and by examining how it is represented by Moroccan secondary school life and earth sciences teachers.

## II. Theoretical background to this study

### a. Is error a school concept?

Although our objective does not concern the study of errors in the teaching-learning of life and earth sciences, we find ourselves obliged to study and understand this school phenomenon in order to shed more light on the teaching postures of the teachers interviewed for this study. We will therefore retrace the definition of the concept of "error" [1] before tackling its treatment within the didactic framework [3]. The role of teacher attitudes towards errors is also crucial for understanding the dynamics of learning [2], and the conceptualization of error contributes to fostering learner autonomy [4].

### b. Error: a rough definition

In his definition, Larruy borrows definitions from the Larousse dictionary, for which error is a "thing that is false, erroneous in relation to the truth, to a rule", and from the Académie française, which considers an error to be "that which does not conform to the true, to reality or to a defined norm", in which case it would be a "fault", a "misunderstanding" or a "confusion". Larruy notes that this deviation is not absolute, but depends on a precise context [5]. The error is, scientifically speaking, due to various phenomena. Firstly, it is caused by a lack of correspondence between the mental schemas adopted and the nature of the problems posed, i.e., a misapplication of difficult or poorly assimilated rules; secondly, it is caused by habitual practices deviated from by overconfidence or lack of self-confidence; thirdly, it is generated by a partial perception of the situations and problems proposed. Error is therefore not a matter of chance but a complex, structured phenomenon that detaches the student from the truth he or she must attain, and from the rules that enable him or her to do so. This is confirmed by Reason: "all cases in which a planned sequence of mental or physical activity fails to achieve its desired ends, and when these failures cannot be attributed to chance" [6].

Knowledge and error share the same thought processes, with the difference that the former succeeds in constructing itself and its rules, while the latter ends in failure.

### c. Errors in didactic literature

Whether it's a fault, according to the transmissive conception, for which the responsibility lies with the pupil who doesn't invest enough time in learning and, therefore, deserves to be punished for it, or a "bug", a malfunction in computer language, for which the teacher is responsible because he's unable to adapt his teaching to the real level of his pupils, errors are doomed to disappear, according to behaviourist approaches [7].

It wasn't until constructivist and socioconstructivist studies that errors were no longer treated as "condemnable faults or regrettable bugs: they become interesting symptoms of obstacles facing students' thinking", says Astolfi [1]. Just as it enables them to become aware of their difficulties, it becomes an integral part of the learning process, giving rise to "socio-cognitive conflict" [8] . The aim is to identify the causes of errors [9] with a view to constructing new ones.

### d. Professional representations

As the aim of this work is to define the professional representations of life and earth sciences teachers in relation to error, it is our duty to define what we mean by "representations". Following Moscovici [10], we consider them to be a way of understanding, interpreting and thinking about everyday reality, through the construction of knowledge that is both social and shared. Generated collectively by inter-individual exchanges, representations are therefore images, ideas and opinions that establish a reality that the individual or community integrates into its value systems.

To achieve professional "representations", the professional group is invited to mobilize and interact professionally in relation to the "objects" concerned by this representation, and in relational, organizational and institutional forms. These representations are "neither scientific knowledge, nor common sense knowledge, they are elaborated in professional action and interaction, which contextualize them, by actors whose professional identities they form, corresponding to groups in the professional field under consideration, in relation to objects that are salient for them in this field" [11].

## III. Methodological framework

To be able to define life and earth sciences teachers' representations of error, we have opted for a distanced approach in the sense that, as researchers, we are asked to be "capable of designing and implementing a device for elucidating reality, i.e., in its broadest sense, a working method. This will never be presented as a simple addition of techniques to be applied as they stand, but rather as a global approach of the mind that needs to be reinvented for each work" [12]. Our aim is to develop a process for understanding the phenomenon of error, by renewing approaches and guaranteeing objectivity. The

latter, based on the principles of "epistemological ruptures", "epistemological obstacles" and "recurrence" developed by Bachelard, guarantees the validity of the results of the analysis [13].

We have therefore chosen to use the questionnaire as a research model that allows for the collection of quantitative data and access to a high level of standardization.

The chosen corpus concerns 100 upper secondary school teachers, working in the provincial directorate of Tetouan (Morocco). They were surveyed during the 2023-2024 school year.

The questionnaire in question is organized around 3 areas of reflection:

1. Teaching experience in life and earth sciences.
2. Teacher training in life and earth sciences.
3. The nature and representations of error.

# IV. Results and Discussion

## a. Area 1: Teaching experience in life and earth sciences

The interest of the dimension specific to the teachers' experience lies in its impact on the modification of their representations of teaching/learning in general, and of error in particular. It seems to us that their approach to error has been accompanied by an evolution in their conception of the integration of error into the teaching-learning process in life and earth sciences. Over time, the respondent teachers have consolidated their mastery of the theories and practices used in teaching their discipline, while becoming more aware of the role of error in consolidating theoretical and practical knowledge in life and earth sciences. In fact, they recognize that they have been led to develop new teaching-learning processes, and to transpose them in new ways through the complex situations their students have to face.

The teacher's career is in itself an experience of error in teaching; it has encouraged these teachers to "cobble together" ways of solving learning difficulties, and has enabled them to situate the student in his or her intellectual progression [14].

Of the 100 teachers surveyed, 6% had 30 or more years' experience, while 20% claimed to have at least 10 years on the job. The majority of those surveyed, i.e. 50%, are young recruits, as shown in figure 1 below:

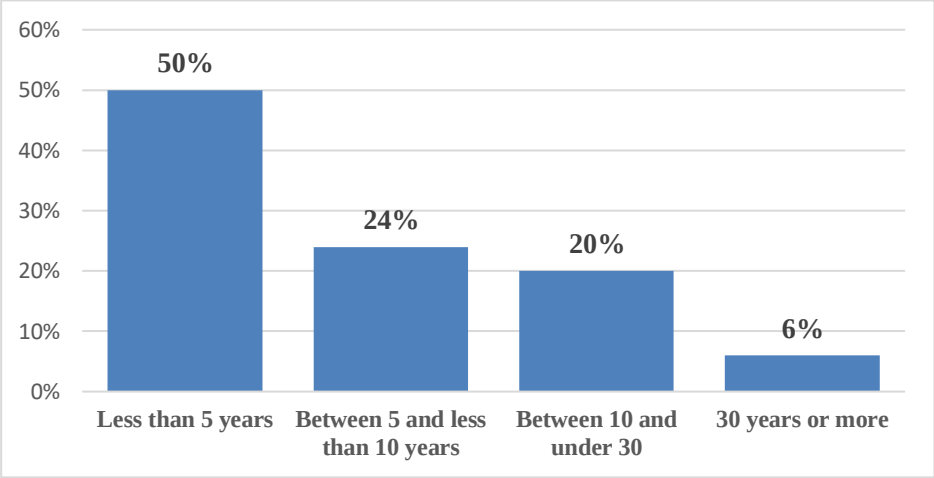


**Figure 1.** The life and earth sciences teaching experience

According to the respondents, the teaching experience with devices for integrating error into the teaching of life and earth sciences has enabled greater attention to be paid to students in difficulty on several levels, including the didactic time allocated to them, their empowerment in the face of the knowledge at stake, the differentiation of interactions around the knowledge to be institutionalized, and the revision of didactic contracts according to the pace of learning and the obstacles encountered.

## b. Area 2: Teacher training in life and earth sciences.

The question of professionalization confirms the result obtained in the previous question. Indeed, if 60% confirmed that they had been adequately prepared in initial training and in-service training in life and earth sciences teaching methods and approaches, this majority necessarily includes the 50% of young teachers. The latter therefore claim to be better prepared for the job they are about to take on. Figure 2 below shows this result:

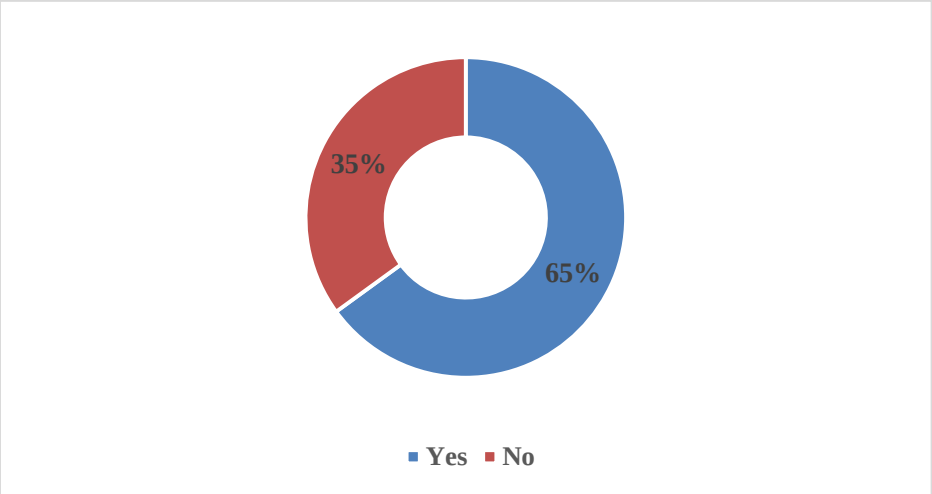


**Figure 2.** Teacher training

Analysis reveals that 65% of life and earth sciences teachers benefit from specific training - reflecting the growing importance attached to building sound disciplinary knowledge and error-centered didactic practices [7]. Indeed, updating scientific and pedagogical content knowledge is a recognized lever for improving teacher effectiveness [15].

In contrast, 35% of teachers have not received adequate training, raising the risk of over-reliance on traditional, transmission-centered methods, deemed less effective in error-based learning [16].

Research shows that continuous training contributes to the transition towards more interactive and reflective practices, such as productive error teaching and elaborate feedback [17]. These approaches foster metacognition and perseverance in students, making mistakes a vehicle for learning.

All in all, the fact that more than six out of ten teachers are trained is a positive sign. However, it would appear necessary to extend these arrangements and provide better support for the 35% who are not trained, in order to standardize didactic practices in the life and earth sciences. The aim is to promote a teaching culture in which errors are systematically exploited as a powerful didactic tool.

## c. Area 3: Around the nature and representations of error

As it is impossible to understand errors without identifying the factors that cause them, we asked teachers about the importance they attach to this issue. The responses varied in a surprising way: while the majority, 86%, claimed to take this concern to heart (with 43% thinking about it as often as possible, 32% admitting to being completely preoccupied by the issue, and 21% admitting to thinking about it often), the remaining 14% didn't seem to pay it any attention at all. This low percentage is due to the inexperience of the teachers involved. Figure 3 below summarizes these data:

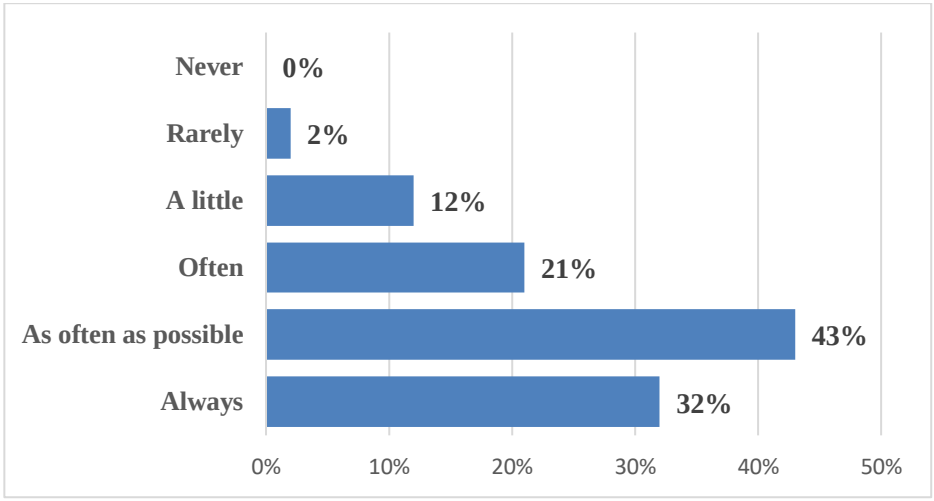


**Figure 3.** Accuracy of error origin for students

As the questionnaire did not directly address the origin of the error [18], we tried to answer this question through individual and group interviews, in parallel with the questionnaire, with the teaching staff questioned. In the light of

experience, most agreed on the sources of error. Indeed, the interviewees considered that the difficulties from which students suffer and which cause these errors are linked to:

- The ineffectiveness of the didactic transpositions adopted in the life and earth sciences classroom, which in many cases are classic and simply transmissive,
- Difficulties in understanding problems and the mathematical operations that correspond to them, when these problems are new and have no direct connection with recent pre-acquisitions, hence the mismatch between the product proposed by the teacher and the student's expectations,
- Cognitive overload (too much invalidation, program overload), which demotivates and disorients the student,
- The impact of the student's difficulties in other disciplines, such as French and mathematics, which force the teacher to oversimplify, rather than learning to problematize,
- over-support (excessive explanation), where the teacher provides answers for the students, or under-support (no explanation), which leaves the pupil thirsting for more,
- The predominance of theoretical explanations,

Whether random or systematic, we emphasize, in summary, that error is the major indicator of an essentially intrinsic problem from which the student suffers. It testifies to

- The student's learning difficulties,
- Refusal to learn,
- Incompatibility of learning processes with the teaching process, and
- The student's level of learning.

This is what emerges from the data collected from the questionnaire, as shown in figure 4 below:

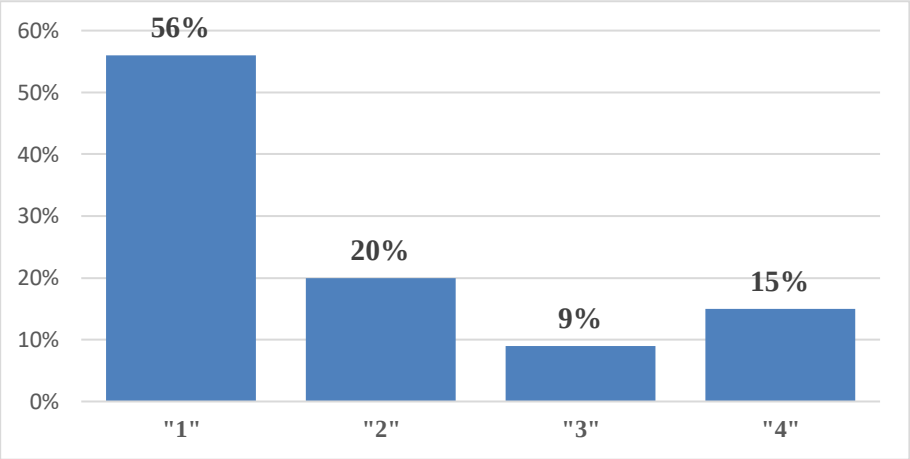


**Figure 4.** The occurrence of errors in the teaching-learning process

- "1 " Learners' learning difficulties.
- "2 " Lack of learner motivation.
- "3 " Incompatibility of teaching-learning processes with learners' needs.
- "4 " Linguistic competence.

56% of respondents put the blame for the error on the student, who, intellectually and intrinsically speaking, is unable to learn, doesn't know how to learn [19], which manifests itself in a refusal to learn, as 20% of them put it. The remainder are convinced that the problem is external, essentially due to the conditions of the teaching-learning operation and the methods adopted by the teacher and the pupil (9%), as well as to the pupil's actual level (15%). As a sign of a serious problem to be dealt with, errors are useful and important [20]. So, what representations of error do life and earth sciences teachers in upper secondary schools express?

It wasn't until the constructivists came along that the representations of the transmissive model, where the imperfection that is error is seen as a fault to be blamed on the student, and the behaviorist model, where it is blamed on the designer and his inability to adapt to the level of the students, were forgotten. In this case, errors are viewed positively. The progressive construction of knowledge is made visible thanks to this indicator of the student's didactic process, the activities carried out and the obstacles encountered. It's the expression of the intellectual work they put in to adapt their representations to the new situations they encounter.

The cumulative experience of the teachers interviewed reveals a high degree of awareness of their representation of error, as can be seen in the following figure 5:

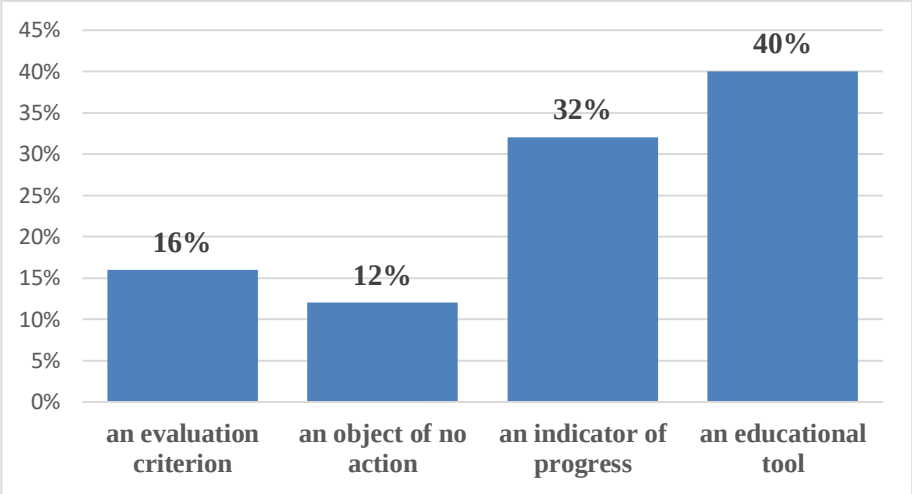


**Figure 5**. Representations of error by life and earth sciences teachers

For them, error is first and foremost a teaching-learning tool (40%) or a criterion for assessing learning (16%), and an indicator of the progress made by their pupils (32%). Few take it as a reason for punishment; these 12% are among the new recruits who lack experience, or those who resist change and refuse to modify their professional representations and practices. In both cases, the need for regular in-service training and the rejuvenation of the teaching corps is becoming increasingly urgent, so that teachers are able to guide their pupils towards awareness of their difficulties and avoid their recurrence [21].

## V. Conclusion

This paper has examined the relationship between teachers' handling of student mistakes and their educational beliefs, demonstrating that mistakes, in fact, are not impediments, but rather, integral components of the knowledge construction process in life and earth sciences. Just as Soncini, Matteucci, and Butera [22] suggest, mistakes are not failures, and teachers who care can elevate mistakes to meaningful conversations that promote the construction of knowledge. Given theory regarding the function of the error in learning, the study aimed to explore how teachers (or the educational practitioners) enact theory in practice (or realize theory) in the classroom [23] as the theory consisted of mostly suggestions. Classroom observations and interviews conducted with life and earth sciences teachers in the Tetouan Provincial Directorate demonstrated that the professional beliefs of teachers are the primary influencers of how they deal with errors in students' work. Rather than viewing errors as issues to be fixed, several teachers recognize mistakes as opportunities that allow students to explore, think, and revise. This, in turn, facilitates active engagement and the application of higher-order skills [24],[25]. Our results also show that reflecting on and using errors can change teachers' own professional stance. Handling mistakes constructively pushes teachers to reconsider their teaching methods and beliefs, fostering a more student-centered and inquiry-driven classroom [26]. Moreover, because scientific knowledge is constantly evolving, ongoing professional development is essential. Training helps teachers integrate error as a deliberate learning tool and supports the creation of a classroom culture where mistakes are valued, not feared [23], [25].

Ultimately, promoting the educational value of errors benefits both teachers and students. When teachers see mistakes as opportunities rather than failures, they create a more adaptive, resilient, and reflective learning environment. By embracing errors as a natural part of learning, they help students engage more deeply with scientific concepts and develop the critical skills necessary for lifelong learning [22], [24]. In this way, errors become a powerful pedagogical tool, capable of transforming teaching and learning for the better.

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