Research Article

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Conceptual and Methodological Issues in Error Treatment: The Case of Physics Teaching in Morocco

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Abstract

The literature on error treatment techniques in education is abundant; still, the linkage between what is theoretical and what is practical can be very contentious. For this same reason, teachers are faced with the challenge of implementing consistent approaches of error treatment. Another focal point in this study is the divide between natural sciences and social sciences. In many cases, teachers of natural sciences cannot relate to the affordances of the social sciences to reshape and foster their pedagogical practices. This paper is intended to investigate error treatment practices amongst physics teachers in Morocco beyond and above what is stated in official guidelines. In particular, the current study was carried out with a total number of 120 high school teachers in Morocco during the academic year 2021-2022. The questionnaire method was used for the collection of numeric data while the interview method was used for probing the attitudes of the respondents towards the phenomenon under investigation. The legitimacy of the data was validated by means of multiple numeric estimations. The outputs from data analysis revealed a pressing need for teacher continuing professional development, being a prerequisite for fostering physics teachers' pedagogical skills.

Keywords: *Error correction, Morocco, teaching, pedagogy, professional development*

1. Introduction

After a long spell of neglect and bias towards error analysis, today there seems to be overall consensus among practitioners of education about the legitimacy of error treatment in the educational scene. The theoretical landscape surrounding error treatment has gained a lot maturity, making of error analysis a robust discipline and an important facet of modern pedagogical thinking (Rissanen et al., 2018). Error treatment shapes and determines a whole range of teaching practices. An

error is no longer a token of inefficiency; instead, it serves as an indicator that informs on the prospects for better quality in education(Rushton, 2018). If an error can inform on learning difficulties, then how can it also inform on the negative influences that distinct teaching practices can have on the learnings of the students? How can an error be the expression of students' amotivation? Then, how can reciprocity between cognition and interaction be advantageous to the dynamics of success in a given educative context?

Any possible answers to the above questions must track two categories of content: the accuracy of the error from a purely pedagogical point of view and the representation that physics secondary teachers in Morocco have of it.

2. Literature Review

2.1 The error phenomenon in learning

An error is a false thing that is erroneous in relation to the truth, to a rule. An error, then, has the attributes of a "fault", a "misunderstanding" or a "confusion" (Novitasari et al., 2018). Marquillo-Larruy notes that the meanings associated with an error are not absolute as they depend on the context where they happen to be used. An error is eventually due to different phenomena (Marquillo-Larruy, 2005). It is first caused by a lack of correspondence between the mental patterns adopted in solving a problem and the nature of the problem itself. Poor understanding of a certain range of rules on the part of the learner would negatively affect the intended learning outputs. Errors are also caused by lack of self-confidence especially when learners' perception of their own capabilities inhibits the prospects of growth. Eventually, the error incident in a given learning context is no mere coincidence. It is the function of a whole range of factors, which are simultaneously learner-centered and context-centered. The complex nature of the error incident calls for equally complex processes of error treatment. In this vein, Reason (2013) explains that an error associates with a generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency. Knowledge construction and error treatment are equally important. However, if the building up of knowledge discards the prospects from error treatment, the outcomes from learning would cause a lot of bias to the intellectual growth of the learner.

2.2 Didactics of error treatment

There exist many epistemological traditions that offer different itineraries for error treatment. The transmissive pedagogy happens to condemn any incidence of error making, putting all the blame on learners who cannot invest enough in their learning (Lyons, 2006). Punishment is then an instrument of positive change at the hand of the teacher who can force the learner to regain interest in what is being learned. The behaviorist school aligns with the transmissive logic in that is centers all attention on the impact controlled practice has on error reduction (Nagowah & Nagowah, 2009). On the other hand, social constructivist approaches to learning offer credible alternatives to error treatment. Errors once considered as reprehensible faults and regrettable bugs become interesting symptoms of obstacles to students' academic growth (Chekour et al., 2018). Errors enable learners to become aware of their difficulties. Students learn to experiment on new learning processes to provoke original socio-cognitive conflict (Chekour, 2018). It is a question of identifying the causes of errors with a view to building new ones.

2.3 Pedagogical approaches to error treatment?

Observed and used in computing and information processing, "error treatment" means a programming error that can cause a software malfunction or bug, which requires modification,

basically a new program by the programmer (Tadlaoui & Chekour, 2021). To do so, it is necessary to wait until the error occurs for the programmer to highlight it, analyze it and treat it. In an educative context, the teacher cannot afford to act as a programmer. The teacher is required to probe the causes of the error and help the learner discover alternatives towards achieving better results. This goes in parallel with what Raynal and Rieunier (2018) posit about the nature of the error phenomenon. "Error makes it possible to identify the obstacles that hinder the learning process. [...] The quality of the feedback provided to the learner is crucial for the success of the learnings" (p.35).
It is not within the scope of this study to discuss the entirety of the theoretical landscape surrounding error production but to pinpoint the practices of physics teachers in Morocco regarding error treatment.

2.4 The theory of professional representations

Since the intent of this study is to expose teachers' attitudes towards error treatment in the context of institutionalized education, the researcher in entitled to expose the theory of professional representations. Moscovici (1989) posits that a professional representation is a way of understanding, interpreting and thinking about daily reality by building knowledge that is both social and shared. Collectively generated by inter-personal exchanges, professional representations are therefore images, ideas and opinions through which a reality is set up, and by means of which the individual or the community appropriates a value system.

For individuals to endorse the professional type of representations, they must have shared patterns of behavior and interact with the same objects of interest. Then, all interactions need to be tied and confined to a social system with an established value system. In the context of this study, physics teachers are social actors with professional representations as they manage to endorse and implement the intent of the organization to which they belong. Here, it is essential to link error treatment practices to a shared value system about quality education (Hussain et al., 2020).

3. Research Methodology

This study is aimed at investigating the legitimacy of error treatment practices among secondary school teachers of physics in Morocco. Error treatment practices in an educative context stem from distinctive theories of learning that are themselves the function of well-established paradigms. The intent of the current study is not to compare or contrast theories of learning against their capacity to offer the best treatment for errors, but to check whether teachers of physics can make informed choices when it comes to the treatment of the errors made by students. The implicit background assumptions for this study stipulate that teachers cannot make the best of students' errors when the theory behind error treatment is missing, which would require not only teachers but also all educators to restore theory to classroom practices.

The theoretical scheme chosen for this study synchronizes with the precepts of applied research; it also endorses the positivist tradition that calls for quantitative methodologies of research. Knowing that the legitimacy of any given research derives from its cohesion and unity, all the methodological procedures in this research made reciprocal (Creswell et al., 2007).

3.1 Population and sampling

The abstract idea of population for this study matches the total number of secondary school teachers of physics in Morocco. Given the impossibility and impracticality of research where all cases belonging to a population are studied, the researcher is entitled to generate a representative sample with the highest possible levels of reciprocity with the population (Alavi et al., 2018). In this regard, Quota sampling was found compatible with the theoretical scheme in this study. Quota sampling may not offer the best accommodation for the logic of random sampling. Still, the context of this study does not cause

convenience sampling to generate less representative samples for the following reasons:

- The current study was conducted with 120 teachers of physics belonging to 12 academies of education and training that cover the whole territory of Morocco.
- All respondents in the current study had been practicing the teaching profession prior to the data collection process in this study.
- The logic of teacher allocation policies in Morocco is statistically considerate of the logic of random sampling as all applicants for a teaching position in Moroccan high schools have little freedom deciding where to work.
- There is uniform training for all teachers who work in the public sector as they all graduate from regional centers of training and education that endorse the same model of training.

3.2 Instrument of data collection

In the current study, the questionnaire method was used for the collection of numeric data and the interview method was used for probing the attitudes of the respondents towards the phenomenon under investigation. The questionnaire method is amongst the most frequently used instruments of data collection (Neuman, 2014). Questionnaires exist in different types and lend themselves to different traditions in research. While structured questionnaires accommodate the intent from quantitative research, unstructured questionnaires synchronize better qualitative research.

In the current study, a structured questionnaire was administered to a sample population of 120 teachers of physics in February 2022. The questionnaire was made of two sections in addition to a covering letter. The first section was aimed at collection demographic data for the researcher to expose the correlation between professional experience in teaching and error treatment practices. The second section of the questionnaire targeted the following:

- Teachers' attitudes towards error
- Approaches used by teacher for error treatment
- Didactic skills of secondary school teachers of physics

In parallel, semi-structured interviews were conducted to interrogate the respondents' attitudes towards multiple error treatment strategies. The interview method of data collection was managed to offer qualitative data with the capacity to further explain the phenomenon under study beyond the affordances of numeric data.

4. Findings and Discussions

4.1 Sample population distribution by gender

Of the total respondents to Questionnaire, 64 (53.33%) were female and 56 (46.67%) were male.

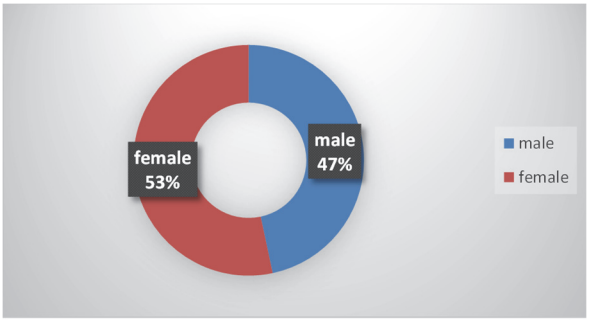

Figure 1: Distribution of population by gender

The gender aspect, noted in this study, is legitimate as it adds substance to a large body of research on gender performance in natural sciences. A substantial body of research has been concerned with the main aspects and basic choices of female teachers and male teachers when it comes to the conversion of pedagogy into quality classroom practices (Koh, 2019). The intent of this study is not to probe personality traits that cause gender differences in the educational field but to acknowledge the influence the gender construct has on teachers' attitudes and practices.

4.2 Attitudes of teachers of physics towards error treatment

The teacher-attitude dimension in this study reveals how teachers of the same discipline, who are graduates of the same training program, can have different predispositions towards divergent error treatment practices. The outputs from data analysis revealed that high school teachers of physics are not familiar with the different pedagogical perspectives that guide the process of error treatment. Most importantly, the time factor is proven a necessary condition for teachers to shape and foster their mastery of the different theories used in teaching (Chekour, 2019). While theoretical knowledge of the basics of physics is the precondition for integrating the teaching profession, this knowledge does not necessarily correlate with equally valid pedagogical practices. All the respondents in this study contended that their abilities to treat errors were constantly evolving, as the imperatives of different teaching-learning situations would require different practices in error treatment.

As surprising as it might seem, the intellectual evolution of teachers aligns with the cognitive development of learners (Barac et al., 2014). Continuous development is not an option when it comes to ensuring best quality practices in terms of error treatment as all teachers admit being required to update their management skills of errors to accompany the cognitive evolution of their students.

Of the 120 teachers surveyed, 6% had 30 years of experience or more, and 22% said they had been practicing teaching for at least 10 years. The majority of respondents, 56%, are young recruits as shown below in Figure 2:

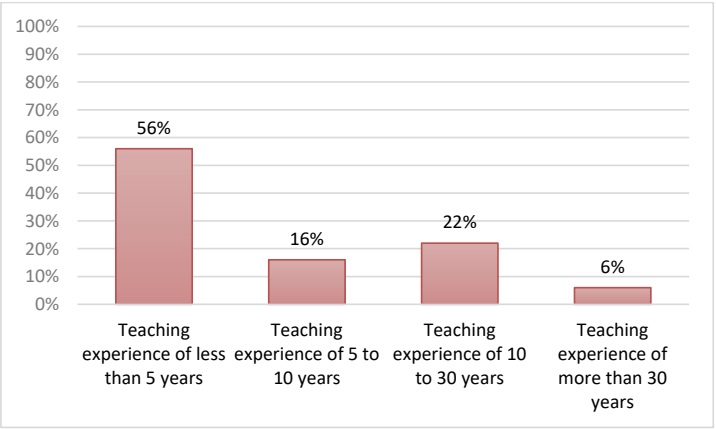

Figure 2: The gender distribution of the sample

The capacity to implement different error treatment strategies seems to correlate with the number of years teachers of physics seem to have accumulated. More than that, teacher experience affects teachers' capacity to detect students who are more deserving of attention to benefit from error treatment. With time, teachers become more alert to students with learning difficulties that require special error treatment.

4.3 Teacher conceptions of error treatment

The process of error treatment belongs dependently of an equally efficient process of error detection. For this same reason, the current study probes the capacity of secondary school teachers of physics to acknowledge different types of errors and provide pedagogical focus for learners. Interrogated bout their ability to distinguish between different categories of errors in the physics context, the majority of the respondents, 86%, contended that error treatment was crucial to students' cognitive development. While there is a widespread belief about the legitimacy of error treatment amongst teachers of physics, less teachers seem to apply error treatment approaches that would determine students' predispositions to make errors. Only 14% of the population sampled for this study happened to pay no attention to the error phenomenon in the teaching and physics.

Teachers' lack of interest in applying rigorous approaches of error treatment is due to contextual factors that exist independently of teachers' aptitudes. Most of the teachers interviewed in this study have limited professional experience. Since the adoption of the new policy of recruiting contract teachers in Morocco, new recruits from various academic and professional backgrounds have been entrusted with teaching duties without adequate training. Recruits for secondary school positions are applicants who have left the university for a long time, and who have been trained for six months only in Morocco' s Regional Centers of training of Education. Figure 3 exposes the frequencies of occurrence for error treatment among secondary school teachers of physics.

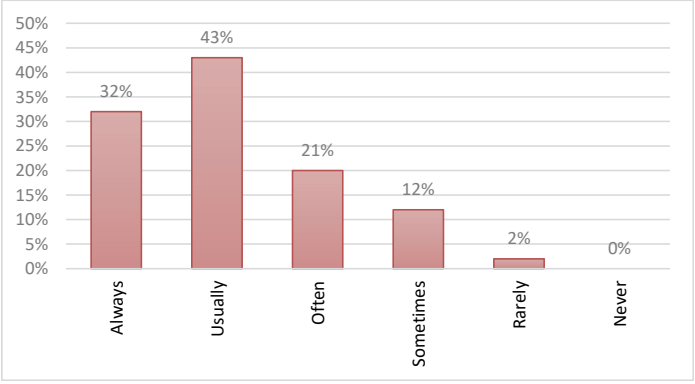

Figure 3: The frequencies of occurrence for error treatment among secondary school teachers of physics

Since the questionnaire used in the current study did not probe the origin of errors, the interview method of data collection was used as secondary means of data collection to expose the causes of error in the context of teaching physics. In this regard, most of the teachers interviewed agreed that the error phenomenon under investigation in this study is due to the following:

- The didactic transpositions adopted in the physics class are transmissive and simplistic in many cases.
- Students encounter difficulties in understanding the mathematical problems and operations that are out of context and without a direct relationship with recent pre-learnings, which widens the gap between the product proposed by the teacher and the expectations of the student.
- Students feel demotivated and disoriented because of cognitive overload, also referred to as excessive information- program overload.
- The use of the French language in the teaching of physics causes students of poor linguistic

background extra difficulties understanding teachers' explanations. Then, in many cases, the teacher is brought to oversimplify the learning products.

- Over-substantiation, or excessive explanation where the teacher explains, asks questions and answers questions, makes students passive and inactive.

As shown in Figure 4, whether random or systematic, the error problem is a polysemous construct that stems from different factors:

- Student learning difficulties
- Students lack of motivation
- Incompatibility of teaching-learning processes with students' needs
- linguistic competence

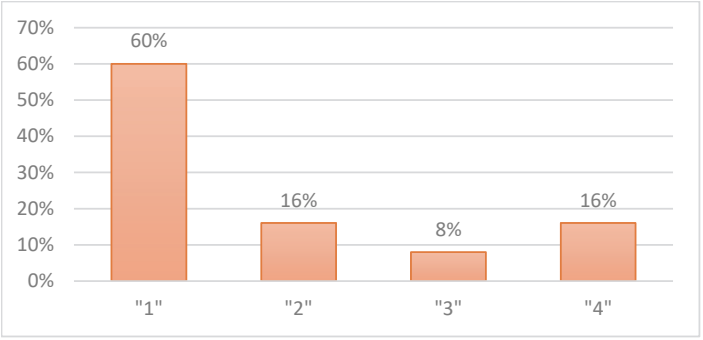

Figure 4: The determinants of errors
Notes: "1" Students' learning difficulties, "2" Students lack of motivation, "3" Incompatibility of teaching-earning processes with students' needs, "4" linguistic competence

Indeed, 60% of the teachers interviewed in the current study link the incidence of error to the learning difficulties students have accumulated throughout the years. If a student cannot learn, this is because they do not know how to learn. 16 % percent of the respondents associate errors in learning with extrinsic motivation. 8% percent of the respondents are convinced that the error problem is mainly due to the conditions of the teaching-learning operation and the methods adopted by the teacher. Then, linguistic competence is found to be another determinant of quality learning in the context of teaching physics as 16 % of the teachers interviewed in this study admit finding difficulties conveying clear messages in French to their students.

4.4 The conceptual knowledge of error treatment among high school teachers of physics

The constructivist thinking offers viable perspectives from where to understand the error phenomenon in an educative context (Morchid, 2020). Constructivist pedagogy rebukes transmissive models of education, in which an error is a token of failure that must be penalized to prompt the growth of students. The constructivist tradition in education sees in errors meaningful and necessary constructs that inform on students' capacity to grow. The concept of error is true to the human condition and it cannot be removed from learning processes. Models of error treatment that seek to control learning environments to minimize the incidence of learning errors cause prejudice to learners who are expected to act against nature. The task of the teacher is to adapt to the singularity of every act of learning to provide students with personalized experiences targeting quality treatment. Figure 5 illustrates how practitioners of the same teaching profession would attach different meanings to errors made by students.

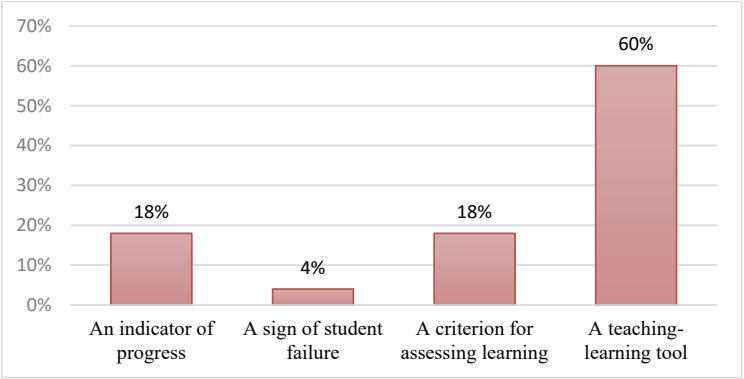

Figure 5: Teacher attitudes towards errors

An error is, then, primarily a teaching-learning tool (60%), a criterion for assessing learning (18%) or an indicator of the progress made by students (18%). Few take it for a reason of sanction; these 4% are the new recruits who lack experience. They resist change and refuse to change traditional representations of error treatment because they were themselves subjected to pedagogical practices that have long lost their legitimacy in the educational scene. The fact is that, there is urgent need to plan continuous development programs for teachers to assist them in directing their pupils towards more autonomy in learning.

4.5 The process of error treatment

In the context of secondary school teaching, the teachers are entrusted with the task of observing students and detecting the difficulties students encounter throughout distinctive learning processes (Valli & Buese, 2007). Reflective teaching guarantees teachers can regularly develop new tools to offer quality treatment to the errors made by their students. Teachers admit that students' errors are made perceptible at different stages of the lesson:

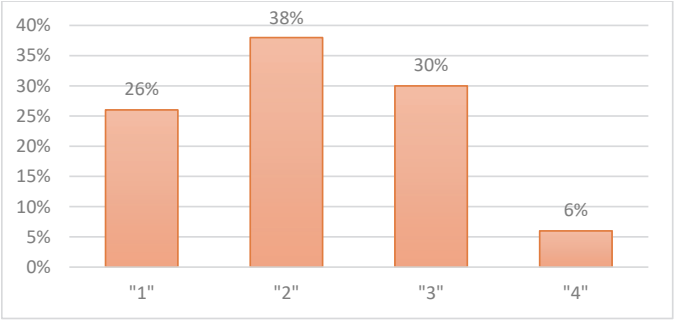

Figure 6. The occurrence of errors in the teaching learning process
Notes: "1": Errors detected in the presentation phase (26%), "2": Errors detected during guided practice (38%), "3": Errors detected during formative evaluation (30%), "4": Errors detected during summative evaluation (6%).

As shown in figure 6, teachers are more likely to spot errors when they are engaged in the teaching process, most specifically in the practice phase and the production phase. These moments of close

accompaniment are crucial for teachers to guide learners towards achieving better learning outcomes. By adopting clear-cup error treatment protocols, teachers are better positioned to foster the quality of formative feedback and summative feedback.

As for the question on how and by which mechanisms teachers should approach error treatment, secondary teachers of physics were found to favor different models of error correction: individual correction, peer-to-peer correction and group correction. For example, 84% of the respondents opted for a whole-class correction by collectively remedying for the error while only 10% would proceed with individual correction. The other forms remain restricted if not non-existent. These results show that teachers are in need of a uniform framework with the capacity to structure teaching practices targeting error treatment.

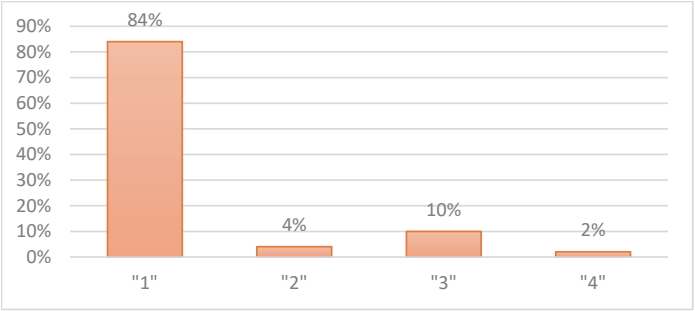

Figure 7: Modes error treatment
Notes: "1 ": Group correction, "2 ": Peer-to-peer correction, "3 ": Individual correction , "4 ": Other

From what has been noted on teachers' approaches to error treatment, there is evidence of increasing awareness on the part of teachers who acknowledge the lack of uniformity when dealing with learners' errors. Equally important and constructive is the predisposition of secondary school teachers of physics to foster their pedagogical perspectives. The line that separates natural science where physics belongs from social science where the theory and practice of teaching are shaped needs to be overtaken.

4.6 Teachers' pedagogical competence

To make sure the process of error correction does not turn into a form of stigmatization and does not cause learners to develop negative attitudes towards learning, the majority of teachers interviewed in the current study made it clear that they avoided systematic correction of errors. The adoption positive attitudes, according to the respondents, helps feed positive attitudes towards learning and helps maintain positive atmosphere for students' oral productions. Eventually, error treatment can attract new meanings other than those observed in transmissive pedagogy. Error treatment convert into problem-solving strategies, supported by the teacher's internal and external regulations.

The outputs from the interview revealed that the correction of errors combines two dimensions; one is constructivist while the other is cognitive. The constructivist perspective causes the teacher to intervene in the error correction process to assist students in the construction of specific concentrations of knowledge. The cognitive dimension, on the other hand, is purely learner-centered as it highlights learners' abilities to cause their own growth by means of appropriation. As far as the teaching of physics is concerned, teachers agreed that mechanical treatment of errors is not rewarding for students in the long term. Understanding the cause of the errors and probing all the meanings in relation with the tasks being performed increase students' productivity because they can relate what is learned in class to a more diverse knowledge base.

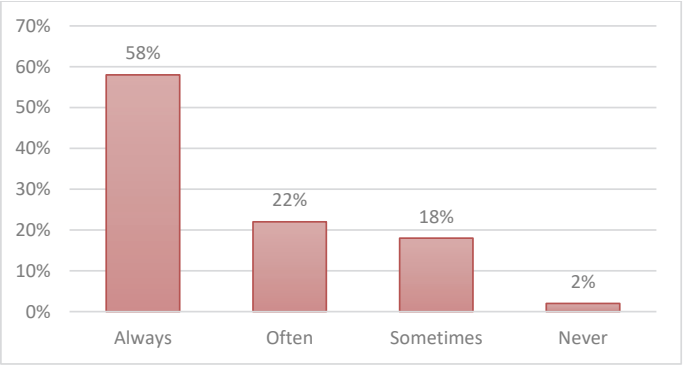

Figure 8. The frequencies of error treatment

As for the frequency of error treatment, 58% of teachers say that correcting errors is a highly frequent phenomenon in the classroom. Others do not seem to give error treatment the same attention. This raises questions about the pre-service training of teachers and the need for setting up continuous training.

Indeed, the presence of errors in the teaching-learning process is not without influence on teachers' conception of their profession as well as on the degree of motivation they may feel. The fact is that the large majority of teachers believe that they have to update their teaching approaches and pedagogical options for treating learners' errors. Teachers who are indifferent to the error phenomenon in the classroom context often have less professional experience and are also graduates of the same pre-service program.

5. Conclusion

The current study is an endeavor to highlight the reciprocity between theory and practice in the context error treatment. After exposing the theoretical landscape surrounding error treatment, we managed to highlight the error treatment practices implemented by high school teachers of physics. We also managed to probe teachers' readiness to update their knowledge base on error treatment. The outputs from this study revealed that error treatment pedagogy is polysemous and in constant evolution. Another significant finding from this study is that the divide between natural sciences and social sciences causes prejudice to the teaching of physics in secondary schools because teachers cannot relate to the affordances of the social sciences to reshape and foster their pedagogical practices.

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