

# Innovation in the Teaching of Physical Sciences in the Context of Neuroeducation: The Case of State Secondary Schools in Madagascar

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**Abstract:** In teaching practice, the pedagogical and didactic approaches adopted have a significant influence on the level of education that students will require; conversely, the teacher's own level of education has a considerable impact on the quality of the teaching methods employed. Research carried out respectively with physics and chemistry teachers in Madagascar, on the one hand, and with the relevant secondary school pupils, on the other, has enabled us to develop a self-assessment tool for teachers. At the same time, research into how the brain works has helped us to adopt neuroeducational principles that optimise the teaching and learning of the physical sciences. This article therefore outlines how the neuroeducational dimension is incorporated into the classroom.

**Keywords:** Innovation, Learning, Teaching, Pedagogy, Neuroeducation, Neuropedagogy, Neurodidactics.

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## I. INTRODUCTION

No teacher sets out to give their work a bad name: every effort made, whether in researching subject matter or preparing lessons, is aimed at delivering and enhancing the teaching experience. It is, however, common to hear negative comments at the end of a lesson: these come from the education community itself. Firstly, the pupils, who experience certain educational difficulties without being able to change the situation; secondly, the parents, who often categorically condemn the teacher and the school in question; and finally, the teacher themselves, who generally do not understand why this dissatisfaction exists or how to remedy it. This stems from a lack of enjoyment in teaching, and a lack of desire to learn and to allow others to learn. Furthermore, a profound neurological phenomenon is sometimes misunderstood by those involved in education. According to Steve Masson, “learning takes place in the brain, but we do not know exactly what effects learning has on it, let alone the

mechanisms that govern the brain changes necessary for learning”. Speaking of the efforts made in the classroom to foster a love of learning and teaching, Jean BEAUTE said: “It all comes down to sparking a desire”: it is a question of pedagogy and didactics.

In the case of the Madagascan education system, identifying the root cause of this educational issue requires an in-depth analysis of a reality that is both multifaceted and complex. This ranges from intellectual poverty, directly linked to the daily socio-economic problems faced by those involved, through administrative shortcomings that encourage laxity and nepotism, to pedagogical failings resulting from an unbalanced professional and pedagogical training. This leads us to consider the concept of citizenship; in fact, it is a ‘crisis of citizenship’, according to recent statements by Tantely Oliva RAKOTONINDRINA and her fellow researchers.

With regard to the field of pedagogy, it might be tempting to hastily hold teacher training institutions accountable – or even blame them – when reflecting on the failure of education and/or teaching; however, adopting a systemic approach should help to address any shortcomings in what is referred to as ‘the current pedagogical situation’. To this end, any assessment of the situation and any research conducted on the subject of didactics can guide stakeholders towards holding the education administration, teacher training bodies, teachers and their respective families accountable. This is because, as the ‘science concerned with teaching methods’, didactics depends heavily on the practitioner’s intelligence, their family and professional background, and, of course, the quality of the training they have received in terms of learning and teaching techniques.

The reason for this is that teacher training, which is intended to ‘equip’ teachers with the necessary skills to begin any form of teaching, appears to be confined to the realm of psychological and organisational studies. Epistemologically speaking, this is not surprising, because pedagogy is simply defined as the ‘methods of teaching’ of which didactics is the subject, and in which it finds its *raison d’être*. In practical terms, one could argue that this teacher training ‘provides’ future teachers with guidelines and knowledge without paying sufficient attention to the importance of concepts such as understanding, emotion, will, motivation and, above all, intuition – those faculties of the learner’s mind that will either ‘receive’ or not what the trainer provides. This is where the concept of pedagogy generally comes into play: this educational tool promotes the best method for the benefit of all those involved, pedagogical flexibility to adopt different approaches with different learners, listening to others to improve one’s teaching method day by day, and above all, listening to one’s personal intuition to act with professional integrity.

What is more, neuroscience – which ‘relates to the science of neurons and the nervous system’ – can play a significant role in the field of education. Yet most stakeholders are unaware of this. Empirical data on mental processes, brain development, how interests are formed, what differentiates individuals and, above all, how we learn have seen a tremendous surge in recent decades (Olson, 2003; Sawyer, 2006). Hence the emergence of neuroeducation. It constitutes a ‘vast field of research situated at the intersection of cognitive neuroscience and the field of education, which studies the role of knowledge about brain function in education’. It is accepted that, according to Steve MASSON, ‘understanding the brain and its learning mechanisms can provide insights to aid learning. These insights can be useful for educating children more effectively at home, and for improving learning and teaching at school’.

## II. METHODOLOGY AND STATEMENT OF THE ETUDE

### ➤ *The Interdependence Between a Teacher’s Level of Education and the Teaching Methods Adopted from a Neuroeducational Perspective:*

In order to determine the practical significance of the term ‘didactics’ in relation to pedagogy, it is necessary here to

reiterate the central role of communication in everything the teacher designs. The desire to ‘convey’ a message to the learner involves two concepts: the ‘encoding’ of information, which, from the sender’s perspective, must be interesting; its ‘decoding’, which, from the receiver’s perspective, must be appealing. In the field of education, we must therefore give meaning to the adjectives ‘interesting’ and ‘appealing’: the first refers to the effort made to ensure that those involved find their respective interests in what is being designed (engagement, personal interest); the second refers to the degree to which the message is appealing, so that a learner willingly follows what is being offered (attraction, appeal).

Thus, the aim of pedagogy is to engage every individual in the lessons designed; the goal of didactics is to attract learners to these lessons through pedagogical means. We therefore refer to ‘didactic tools’ as all materials and methods intended, directly or indirectly, to encourage this engagement of pupils (textbooks, practical work, study sheets, techniques, methods, written or oral resources, gestures, etc.). This means that being a teacher requires a sufficient level of intelligence, versatility and communication skills. This is what Jean Robert CHATILLON highlights in his article on the role of a trainer at the IUFM: ‘Teachers must not only master the subject or subjects they teach and their didactics, but also understand the processes of knowledge acquisition, group work methods, assessment methods, the education system and its environment.’ The concept of self-directed learning is therefore nothing other than a personal commitment to taking steps to learn something without the help of a teacher. In this case, interest and motivation are derived exclusively from teaching tools chosen by the learner themselves.

This explains the interdependence of education and teaching methodology in the educational setting. Without a sound education, even a teacher classified as ‘gifted’ would be unable to meet the teaching standards required by the current education system. And without effective teaching practice, education would even lose its *raison d’être*, since pupils are often not properly drawn towards the goal towards which we wish to guide them. To illustrate this reality, the teaching of civic values and moral education, for example, are intended to shape the minds of citizens for the common good; yet, drawn towards indiscipline and disobedience, pupils often view these lessons as empty rhetoric that serves no purpose in their daily lives. Didactic failure is the main cause here. Conversely, a civics teacher without an acceptable educational foundation would never be able to devise their own teaching method suited to the current learning situation. The failure of previous education is held responsible for this. And it should be noted here that when we speak of education, we are not referring solely to skills and techniques, but also to the ethics and indeed the morality required of individuals, particularly teachers. In this regard, researchers at Laval University led by Denis JEFFREY have emphasised that: ‘teachers are accountable and liable for their actions to pupils, their parents and the general public’.

With a view to optimising learning and teaching, research in neuroeducation encompasses at least three areas: ‘school neuroadaptation, which studies the brains of pupils experiencing difficulties adapting to the school system’; ‘neuropedagogy, which studies the brain mechanisms involved in learning and teaching’; ‘neurodidactics, which focuses on the brain mechanisms involved in the learning and teaching of school subjects’.

➤ *An Interdisciplinary Approach: Teaching Methodology in Secondary Schools and Neuroeducation:*

What, then, is the impact that teaching methodology can have on education? To what extent does the level of teachers’ education contribute to, or hinder, the quality of the teaching methodology employed? And what tools can be made available to the Madagascan education system to ensure effective teaching methods? These are the questions this document will attempt to answer through research in the field of Educational Sciences, particularly in the teaching of Physics and in emotional education.

So, in seeking answers to these questions, we began by analysing field data on the relationship between the teaching methods used and the quality of teaching as perceived by different stakeholders. Our research into the types and levels of difficulty encountered by secondary school pupils in different regions of Madagascar enabled us to conduct an analytical study of the influence of teaching methods on the quality of teaching. This should enable us to test the initial hypothesis that all difficulties encountered by learners depend primarily on the teaching methods employed by the teacher.

The task is therefore to analyse the findings of research carried out at seven (07) secondary schools across different regions of Madagascar on the teaching of physical sciences: in Tulear, at the Lycée Laurent Botokeky; in Antananarivo, at the Lycée Jean Joseph Rabearivelo and the Lycée Jules Ferry; in Antsiranana, at Zafy Albert High School; in Tamatave, at Jacques Rabemananjara High School; in Mahajanga, at Philibert Tsiranana High School; and in Fianarantsoa, at Raharivelo Ramamonjy High School. Subsequently, the implications for the relationship between neuropedagogy and neurodidactics will be presented based on data from research conducted with trainee teachers. To this end, this article will present literature reviews and case studies in order to ultimately propose an effective educational solution that

promotes best practice in lesson preparation and classroom management.

➤ *Reasons for Difficulties in Problem-Solving: The Case of Physics Teaching in Secondary Schools:*

The study of physics in secondary schools was chosen as the focus of this research to identify the main causes of the difficulties observed: two identical questionnaire-based surveys were therefore conducted in the seven secondary schools mentioned above. This study involved gathering information from two distinct, randomly selected samples: 51 physics and chemistry teachers and a number of pupils in the first and second years.

A qualitative analysis of the results obtained has enabled us to divide the factors representing the probable causes of difficulties in teaching physics in secondary schools into three categories: issues relating to pedagogical prerequisites (PRE), which concern the intellectual resources of the teacher or the pupil; items related to neuropedagogy (NPED), which address the psycho-pedagogical and organisational realities of education; and questions related to neurodidactics (NDID), which explore the science of teaching methods and how to facilitate learning in an efficient and intellectually stimulating manner.

Thus, surveys conducted among physics and chemistry teachers and secondary school pupils show that the vast majority of the items selected to analyse the difficulties encountered in learning physical phenomena are largely related to neurodidactics. In this regard, Table 1 below presents the results of the surveys conducted among 51 secondary school teachers, showing the levels of difficulty perceived by these teachers according to the selected cause of difficulty.

### III. PRESENTATION, ANALYSES AND INTERPRETATION OF THE RESULTS

➤ *Survey Results and Discussion:*

We present the results of the surveys in the tables below, together with explanatory and interpretative notes, to make the findings easier to read and follow.

- *Teacher Surveys in the Seven Secondary Schools:*  
(N=51, 51 Teachers)

Table 1 Number of Physics Teachers in the Seven Secondary Schools.

Secondary School	Number of Teachers
Lycée Zafy Ambilobe	06
Lycée Laurent Botokeky	05
Lycée Jean Joseph Rabearivelo	10
Lycée Jules FERRY	07
Lycée RAHERIVELO RAMAMONJY	11
Lycée Philibert TIRANANA	06
Lycée Jacques RABEMANANJARA	06
<b>Total</b>	<b>51</b>

Source: Based on the Survey Results and Documentation

Table 2 Results of the Survey of 51 Teachers in the Seven Secondary Schools  
**SURVEY OF 51 SECONDARY SCHOOL PHYSICS AND CHEMISTRY TEACHERS**

Difficulty level: TF: Very Easy, F: Easy, D: Difficult, TD: Very Difficult, SR: No Answer								
Tem type: PED: Pedagogy, PRE: Prerequisites, DID: Didactics								
#	Item	Character	TF	F	D	TD	SR	Total
1	Understanding the Course	NPED	0	29	19	1	2	51
2	Insufficient Time Allocated to Simulation Exercises in the Course	NDID	3	9	15	4	20	51
3	Gaps in Mathematical Knowledge	PRE	1	4	20	15	11	51
4	Challenges Arising from the Complexity of Physical Phenomena	PRE	4	9	27	3	8	51
5	Inadequacy of Dispute Resolution Methods	NDID	2	16	13	2	18	51
6	The Teacher's Method	NDID	11	26	5	0	9	51
7	The Formulas are Difficult	NPED	3	20	13	3	12	51
8	A Lack of Understanding of Mathematical Concepts	NPED	2	5	24	11	9	51
9	The Lack of Practical Work	NDID	2	9	10	14	16	51
10	The Lack of Exercises on the Different Types	NPED	3	23	11	5	9	51
11	Few Exercises are Covered in Class	NPED	4	17	14	5	11	51
12	Inadequate Use of Technology (Programmable Logic Controllers, Data Loggers, etc.)	NDID	3	6	17	11	14	51
13	The Use of ICT in Education and ICT	NDID	1	9	10	16	15	51
14	Use of Teaching Materials	NDID	4	23	7	9	8	51
15	Use of Teaching Resources	NPED	5	19	11	7	9	51
<b>Total</b>			<b>48</b>	<b>224</b>	<b>216</b>	<b>106</b>	<b>171</b>	<b>765</b>

Source: Surveys of Secondary School Teachers

To begin with, without analysing the levels of difficulty reported by physics and chemistry teachers and the pupils concerned, it can simply be noted that 3 of the 15 selected items relating to learning difficulties that is, 46.67% indicate that causes linked to neurodidactics predominate over those related to neuropedagogy (26.67%) or prior knowledge (also 26.67%). In fact, almost half of the probable causes of learning difficulties relate to the field of neurodidactics. As for the other

half, it is divided between the teaching skills of the teachers and the prerequisites of those involved, including the pupils. This reality on the ground is illustrated in Figure 1 below, to help understand where the focus should lie according to the comments of the teachers and secondary school pupils surveyed – in order to improve the ‘outcome’ of a particular learning process.

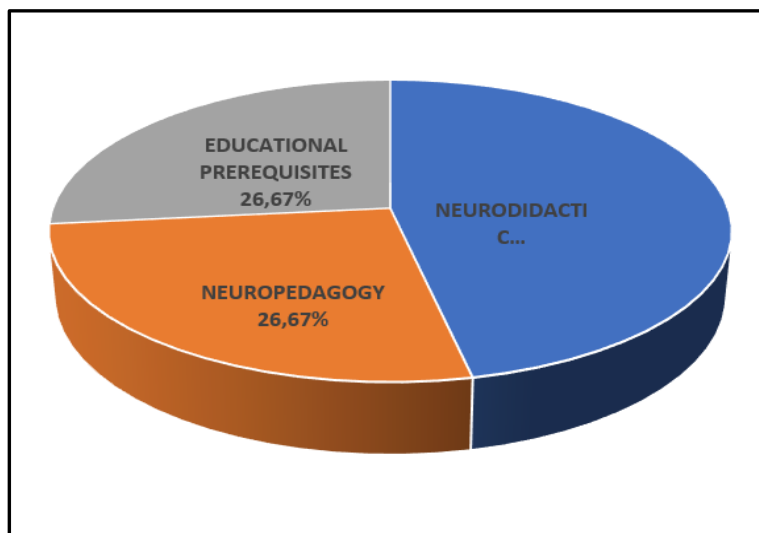


Fig 1 Breakdown of the Causes of Difficulties Recorded

The study now examines the frequency of responses, provided solely by teaching staff, corresponding to the three

categories of causes of difficulty outlined above. For each level of difficulty reported, the aim is to determine how many times

the item (or the response to the question asked) was selected by the respondent. These respective rates (percentage relative to the total number of recorded responses) therefore illustrate the

proportionality of the causes making learning easy or difficult, ranging from a very low degree to a very high degree. This is presented in Table 3.

Table 3 Frequency of Teachers' Responses (%)

<b>FREQUENCY OF RESPONSES BY TEACHERS</b>							
<b>ITEMS LIES A LA NEURODIDACTIQUE (NDID)</b>							
#	Question	TF	F	D	TD	SR	TOTAL
2	Insufficient Time Allocated to Simulation Exercises in the Course	3	9	15	4	20	51
5	Inadequacy of Resolution Methods	2	16	13	2	18	51
6	The Teacher's Method	11	26	5	0	9	51
9	The Lack of Practical Work	2	9	10	14	16	51
12	Inadequate Use of Technology (Programmable Logic Controllers, Data Loggers, etc.)	3	6	17	11	14	51
13	The Use of ICT in Education and ICT	1	9	10	16	15	51
14	Use of Teaching Materials	4	23	7	9	8	51
	<b>Total</b>	<b>26</b>	<b>98</b>	<b>77</b>	<b>56</b>	<b>100</b>	<b>357</b>
	<b>Taux (%)</b>	<b>7,28</b>	<b>27,45</b>	<b>21,57</b>	<b>15,69</b>	<b>28,01</b>	<b>100</b>
<b>ITEMS LIES A LA NEUROPEDAGOGIE (NPED)</b>							
#	Question	TF	F	D	TD	SR	TOTAL
1	Understanding the Course	0	29	19	1	2	51
10	The Lack of Exercises on the Different Types	3	23	11	5	9	51
11	Few Exercises are Covered in Class	4	17	14	5	11	51
15	Use of Teaching Resources	5	19	11	7	9	51
	<b>Total</b>	<b>12</b>	<b>88</b>	<b>55</b>	<b>18</b>	<b>31</b>	<b>204</b>
	<b>Taux (%)</b>	<b>5,88</b>	<b>43,14</b>	<b>26,96</b>	<b>8,82</b>	<b>15,20</b>	<b>100</b>
<b>ITEMS LIES AU PREREQUIS (PRE)</b>							
#	Question	TF	F	D	TD	SR	TOTAL
3	Gaps in Mathematical Knowledge	1	4	20	15	11	51
4	Challenges Arising from the Complexity of Physical Phenomena	4	9	27	3	8	51
7	The Formulas are Difficult	3	20	13	3	12	51
8	A Lack of Understanding of Mathematical Concepts	2	5	24	11	9	51
	<b>Total</b>	<b>10</b>	<b>38</b>	<b>84</b>	<b>32</b>	<b>40</b>	<b>204</b>
	<b>Taux (%)</b>	<b>4,90</b>	<b>18,62</b>	<b>41,18</b>	<b>15,68</b>	<b>19,60</b>	<b>100</b>

Source: Surveys of Secondary School Teachers

In descending order of prevalence, the data categorised into the three thematic groups outlined above can be analysed as follows: 44% of the teachers surveyed believe that pedagogical issues do not make learning difficult; 41% believe that a lack of intellectual background (prerequisites) makes it difficult, or even very difficult (16%); only 27% consider that a lack of teaching skills does not make it difficult (and therefore easy), etc. In this study, we must not overlook those who gave no response, accounting for between 15% and 28% of respondents (SR): these individuals appear to be teachers who either confused the questions asked or faced communication barriers with the interviewers or the questionnaires presented.

Despite this, the table clearly shows that, across all responses, the physics and chemistry teachers surveyed identified issues relating to pedagogical prerequisites as the main source of difficulties (Difficult: 41.18%; Very Difficult: 15.68%; totalling 56.86%). Next come those related to teaching methodology (Difficult: 21.57%; Very Difficult: 15.69%; totalling 37.25%). Problems relating to pedagogical design and organisation affect only 35.78% of responses (Difficult: 26.96%; Very Difficult: 8.82%). Figure 2 below provides a clearer picture of these views held by the teaching staff surveyed, with a view to highlighting the role of teaching methodology in classroom practice.

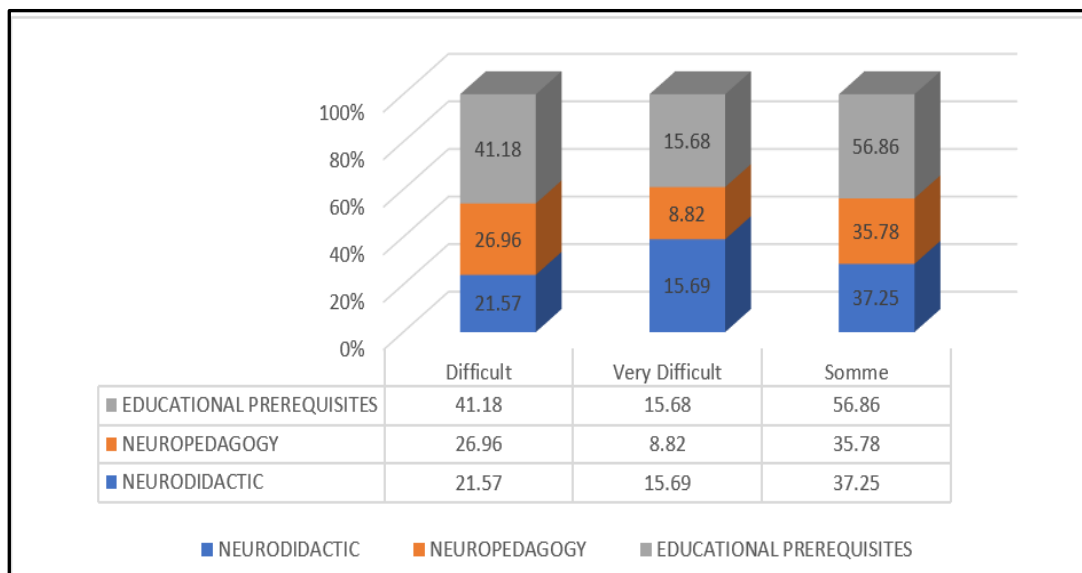


Fig 2 Frequency of Teachers' Responses (%)

➤ *A Teaching Approach Based on Self-Assessment:*

At every level of education in Madagascar, educational leaders have long since developed an assessment system and are constantly seeking to improve it. For learners, marking schemes, assessment activities, grading, marking, periodic or end-of-cycle reviews, and various regulations are put into practice. As for the teaching staff, the system assesses them according to a wide variety of criteria, which are often confused with interpersonal relationships and the existing professional hierarchy. What appears to be the condition for job retention is 'good conduct', a vague concept linking personality and behavior, ways of thinking and working, teaching skills and social etiquette. To assess staff more effectively, few managers like to focus on pedagogical, didactic or professional abilities. And despite the assessment grids designed for this purpose, decisions are often made solely on the basis of data relating to day-to-day behavior and relationships with school staff. In such cases, the assessment of teaching ability is carried out simply by analysing the success rate achieved and/or exceptional cases relating to classroom management. This is why Philippe MEIRIEU has proposed, in terms of the general organisation of teacher training, that it should 'focus on learning and place the teacher in a situation of action research': this proposal will steer assessment towards pedagogical, or even didactic, competence.

The situation described above raises the question of the role self-assessment can play in the art of teaching. It involves a systematic process of self-awareness and taking personal responsibility for one's own teaching practices. Any school or university administration can thus establish its own self-assessment system, have self-assessment forms completed, examine the self-assessment data collected, design a verification assessment, and make tactical decisions based on these tasks (praise, encouragement, correction, reprimand, sanction). Such logical reflection should enable educators to progress through a methodologically designed process aimed at imparting knowledge to pupils and students.

**IV. CONCLUSION AND RECOMMENDATION**

➤ *Discussions on Teacher Evaluation and Self-Evaluation:*

The current situation in the Madagascar education system does not lend itself to teacher evaluation, due to the socio-economic and health problems plaguing the country. A certain level of general demotivation amongst teaching staff, ranging from primary and secondary schools to universities, hinders the organisation of a professional evaluation worthy of the name. It is likely that those responsible for evaluation lack the necessary knowledge, competence and professional ethics, and do not have the courage to take action. In the case of state education, for example, the real administrative tasks have for several years centred on issues of recruitment and the reform of the civil service. Nevertheless, the continuous and thorough evaluation of teachers must raise the standard of educational provision; failing that, self-evaluation must at least be implemented at all levels.

In this context, early work by A. MORRISON and D. McINTYRE helps us to understand the psychosocial aspects of the two assessment systems, given that, amongst other reasons, the assessment carried out by education inspectors (observation, surveys, interviews) does not foster interpersonal relationships or a positive working atmosphere. These researchers even argue that, in order to assess the effectiveness of teaching, 'it is difficult to design a survey in which the pupils and teachers concerned are comparable'. For the same reasons, these researchers emphasise that: 'comparisons between teachers, based on pupils' success, become very complicated and of rather dubious validity'. However, many school leaders still use this method based on a rating scale: a linear scale of three, five or seven points which the evaluator, or 'judge', ticks to express their assessment of the person being assessed.

When it comes to self-assessment, the same techniques and tools can be used, except that the assessor is, first and foremost, the teacher themselves. A. MORRISON and D. McINTYRE developed this method using paper-and-pencil self-assessment tests. Practitioners therefore often use the

'Minnesota Teacher Attitude Inventory' (a comprehensive measure of teaching attitude), which has enabled them to gather more accurate and realistic information. This model actually presents five sub-categories of attitudes that enable a better analysis of the examinee's level in terms of teaching quality: towards assessment, 'modern' versus 'traditional'; towards pupils, 'favourable/unfavourable'; towards specific pupil behaviors, 'permissive/repressive', 'rejection and desire to control/tendency to give pupils freedom'. Some researchers have devised other models with three scales of opinion, and depending on the criteria to be observed, OLIVIER and BUTCHER, for example, have used sub-categories such as: 'naturalism/idealism' to describe attitudes towards pupils (a question of child-centredness or teacher-centredness); 'radicalism/conservatism' to assess educational orientations; 'theoretical/practical' to judge the ways of achieving a given pedagogical objective. However, all this makes the evaluation process longer, more cumbersome and more difficult to carry out in an honest and professional manner.

With regard to teaching practice, Philippe MEIRIEU has proposed what he calls 'the didactic pathway', comprising five stages, some of which may be optional: defining and classifying objectives; formulating a hypothesis regarding a mental operation to be performed; a simple typology of the mental operations required; reflection on a key learning principle; and proposing a general framework for instructional design. Philippe MEIRIEU's theory can thus greatly enhance general didactics, and self-assessment guided by this didactic path should improve teaching practices overall. The question to ask is: Have I gone through this stage? Am I capable of designing and implementing this or that stage? However, we must not overlook the specific nature of each subject, where the relevant pedagogical approach requires additional effort. This could also slow down and complicate both the teaching and the assessment process itself.

#### ➤ Conclusion:

Through this study, we were able to confirm two hypotheses: the neuropedagogy and neurodidactics adopted by the teacher have a significant influence on the standard of education that will form the basis of the pupils' learning; and conversely, the teacher's own level of education has a considerable impact on the quality of the teaching methods employed in their work. Research carried out respectively with physics and chemistry teachers, on the one hand, and the relevant sixth-form students, on the other, has enabled us to develop a self-assessment tool based on the primacy of didactics over pedagogy and prior knowledge.

The aim is to allow a passion for teaching to drive the search for educational ideas: half of a teacher's working hours should be devoted to this aspect. The other half will be divided between teaching and cognitive activities: focusing on the joy of teaching and learning, as well as fostering mutual trust among those involved in education, will make day-to-day life easier for motivated teachers.

Before concluding, it should be noted that this article is not intended to serve as a comprehensive textbook on general pedagogy, nor to provide sufficient knowledge regarding the pedagogy of any particular subject. However, it sets out factual

information regarding the teaching of Physics and Chemistry in secondary schools; and, above all, the findings of the resulting research could prove useful in any other field of education. In particular, researchers interested in Educational Sciences, pedagogy and didactics are therefore invited to draw upon certain useful insights from this work, according to their individual needs.

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