# Problems of physics education in Brazil

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**Abstract**
This article undertakes a retrospective comparison of the evolution of physics education in Brazil from the second half of the previous century to today, with the aim of highlighting some of the problems of physics education in Brazil in the 21st century. For this purpose, in addition to the specialized literature, we considered as an indispensable reference, the first Brazilian Symposium on Physics Teaching (SNEF), which took place in 1970, and which represented the first major effort of the community of brazilian physicists to diagnose the existing situation in the teaching of physics at national level.

**Keywords:** Physics Education, SNEF, Curricular Reform.

**Resumen**
En este artículo es realizada una comparación retrospectiva de la evolución de la enseñanza de la física en el país desde mediados del siglo pasado hasta la actualidad, con el objetivo de resaltar aspectos de la didáctica de la física y algunos de los problemas de la enseñanza de la física en el siglo XXI. Para esto, además de la literatura especializada, fue considerada como referencia indispensable la realización del primer Simposio Nacional de Enseñanza de Física (SNEF), en 1970, que representó el primer gran esfuerzo de la comunidad brasileña de físicos para diagnosticar la situación existente de la enseñanza de la física a nivel nacional.

**Palabras-clave:** Enseñanza de la física, SNEF, reforma curricular.

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## I. THE DIAGNOSIS

In the first instance, it is appropriate to point out that physics education received a considerable boost in the 1960s, driven by the scientific and technological development generated by the "space race" [1, 2] which, by creating new technical careers offering professional opportunities, produced the sense of the need to study physics for a better placement in life, or to understand the new reality.

In the educational field, the body of data accumulated by educational research in sciences over the last 40 years [3] makes it possible to examine how teaching conditions and the practice of physics teaching and the needs of teaching of basic physics in Brazil have evolved.

In this respect we would highlight:

1) conceptual flaws, the absence of content and the lack of training for laboratorial teaching on the part of physics teachers are recurring observations in secondary education, which suggest limitations in the initial preparation of these teachers during their teacher training degrees;

2) the number of those trained in bachelor degrees and licentiate (teacher training) degrees in physics is fairly low due to the failure to fill places and to high dropout rates; and for the contingent of physics teachers in service, there is a lack of pedagogical support or supervision by more experienced colleagues. Furthermore, on the lack of sufficient numbers of teachers: "Verifying the data presented by the Brazilian Planning Ministry, on the number of teachers trained by philosophy faculties (the total number, assuming that all devote themselves to teaching class) we note that, from 60 [1960] to 65 [1965] (approximately), the difference between the number of teachers trained and those required remained practically constant, that is, although the number of those qualified increased year on year, our needs also increased and what we managed to achieve was to maintain the difference between one and the other constant. But, from 65 [1965], we failed to do even that, since the difference increased year on year, that it to say, our needs have increased much more than we have managed to train. This means that if we continue to prepare teachers in the same way as we have been doing up to now, we will never be able to resolve our problems" [4, p. 98];

3) in schools, the teaching of physics is poorly linked to the laboratory and to concrete situations: *Teaching is book-based and academic, and teachers rarely touch on more concrete problems* [5, p. 20]. In general, the time allocation for lessons teaching scientific disciplines is small while the number of pupils in classes is excessive, and there is a lack

of libraries with an appropriate collection[1], in addition to difficulties in the accessing and acquisition of books and experimental material;

4) many of the science books and experimental *kits* initially used in the country for scientific education which were imported, translated or adapted, as happened with the PSSC[2] and the Harvard Project[3], proved however to be impractical with teachers and schoolchildren from a different educational reality to that of the foreign students and teachers [1, 2], which stimulated the national production of more suitable "educational technology", as indicated by the results of the evaluations of the National Textbook Program (PNLD) and the National Textbook for High School Education program (PNLEM), for example;

5) the exchange of successful didactic experiences ("good practices") is compromised by the poor interaction between physics teachers –in the vast majority of cases, *each one of us is particularly unaware of what the other does in the field of teaching* [8, p. 13]. Traditionally, this interaction occurs in congresses, symposiums, teachers meetings, and others;

6) in universities, in-service training programs for High School teachers are not incremented nor are they offered outside the academic term, among other forms of the demonstration of concern with scientific and pedagogic training of teachers. Lacking in rigor, the impression one has is that *there is a complete divorce between secondary school and the University* [9, p. 41];

7) the lack of objectivity in the definition of the guidelines/directives of the teaching of basic Physics is prejudicial to the practice of physics teaching[4]. In this particular, there appears to be a lack of clarity on the part of the teacher regarding what are the bases for the choice of teaching methodology (instruction strategies), of didactic resources, of the testing method of pupil learning/performance etc.[5];

8) despite the preparation devoted to the university entrance examination, in higher education the *human element [students] that we receive has an extremely deficient scientific training as far as [physical sciences]* [14, p. 30] are concerned. Furthermore, the complaint against the low standard, in Physics, of entrance candidates, is a constant, year after year [15, p. 38]. In addition to this, "[...] we cannot presuppose that the pupil who enters the Faculty, after taking the science option (and we are aware of what that involves), and after taking a mini-course to make up for deficiencies they have (mini-courses we know do not make up for any deficiency), knows very much; so, the Faculty is obliged (if it aims to achieve anything serious) to pick up with those pupils right from the very beginning, and provide them with what they really never received in their High School class" [16, p. 112];

9) on the teacher's work conditions [17], among existing difficulties we would highlight: the low level of remuneration offered –which deters young people from opting professionally for teaching [18]–, the excessive workload and duties, lack of suitable premises, and lack of political-institutional prestige –*does the teacher enjoy the support of the authorities within the schools where he works?* [13, p. 14].

In the final analysis, the retrospect presented here demonstrates that several problems identified in the teaching of physics in Brazil are not exclusive to a period. But that, in fact, they have become atemporal characteristics of our teaching of natural and physical sciences: the expositive method, the excessive dependence on the textbook, the absence of experimental practice, the outdated and de-contextualized curriculum, the small number of classes and the insufficient professionalism of the teacher [19, 20], in addition to encyclopedism, excessive workload and lack of social and salarial recognition of teaching.

Notwithstanding, what attempts have been made to reverse this educational picture?[6]

## II. THE CHANGES

Before we go on to suggest possible alterations, the scenario presented below well expresses the trajectory of the majority of our pupils up to higher education.

That is to say, in secondary education, physics is taught from the tenth to the twelfth grade, covering an extensive body of content from mechanics to electromagnetism and, in rare cases, even modern and contemporary physics. However, the evaluation of the results of learning achieved at the end of those 3 years of study has revealed chronic deficiencies in that pre-university preparation. For example, the students' foundation in mathematics is deficient to the point that, even when approved during the entry examination, worse than not knowing what is a derivate or integral, they enter the first year unable to handle operations with fractions.

Among the significant causes of the different lacunae in the education of the students are the problems we highlighted earlier, which translate into the compromising

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[1] According to the 2010 School Census of Basic Education [6], of the Ministry of Education (MEC), which considered both the public and private school systems, in 2010, out of a total of 38.6 million students in primary and secondary education in Brazil, 70 per cent of them (27 million students) attended schools without science laboratories and 39 per cent (15 million) studied in institutions that had no library facilities.

[2] Physical Science Study Committee: physics teaching project developed by MIT in the decade of 1960 [7], and brought to Brazil by means of the IBCC-UNESCO with support from the MEC, in 1962.

[3] Harvard Project Physics: physics teaching project developed in the decade of 1970 by the University of Harvard and translated into Portuguese in 1985 by the Calouste Gulbenkian Foundation.

[4] *Why teach Physics? Teach Physics to whom? Teach what about Physics?* [10, p. 15].

[5] Currently, are the specific National Curricular Guidelines (DCN) or the National Curricular Parameters (PCN) [11] sufficient? In as much as, it would *be necessary, for this, to establish an educational philosophy specifically for the teaching of physics* [10, p. 15]? What is the degree of social repercussion from the university entrance exams? *Are they responsible for molding teaching in the vast majority of schools* [12, p. 25]? The entrance exam *is what is truly responsible for the lack of orientation that exists* [13, p. 14]? What is the influence of the "grand projects" of the seventies [1, 2]?

[6] *What should a Brazilian high school be like: a school that has none of that* [13, p. 14]?

of the academic progress of a large number of those entering higher education, independently of the area of professionalization.

In Brazilian higher education establishments, the ways of dealing with problems such as those mentioned are different. Nevertheless, in the majority of them, actions have been undertaken to compensate for the deficits of basic education evidenced by the university entrance examination.

Both the teaching of general physics ministered in the courses of technical careers as well as the undergraduate course in physics are equally affected by the situation. A fact to which university physics departments should pay more attention. And, specifically in relation to undergraduate physics, the perspective is of curricular reform.

The National Curricular Directives for the Bachelor and Licentiate (teacher training) degrees in Physics [21], published in 2002, already indicated the urgency of changes to the curriculum of physics education of national courses, in terms of dealing with dropout rates, of the broadening of opportunities for those graduating, and of improvement to the teaching of introductory physics disciplines, among others.

Similarly, also made available in 2002, the National Curricular Parameters [22] indicated changes in secondary education based on the contextualization of knowledge, the updating of content with emphasis on contemporary science, interdisciplinarity, and others. What remains, indisputably, still is a challenge with enormous repercussions on initial and continued training of physics teachers.

Below we will present other aspects pertinent to this current discussion.

## III. FINAL CONSIDERATIONS

Perhaps by way of illustration of the dimension of the existing challenge in the training of teachers in the field of science education[7], it may not be inappropriate to make explicit two questions, the solution to which remains open. The first of these, as has been demonstrated, is recurring: the offer of an education compatible with the modern and contemporary world. The other, incipient: the inclusion of individuals with special needs in normal schooling.

[7] We understand by: a) *Education in Sciences*: "Education in sciences [...] has the objective of enabling the pupil to share meanings in science texts, or rather, to interpret the world from the scientific point of view, to handle some concepts, laws and scientific theories, to tackle problems thinking scientifically, to identify historical, social and cultural aspects of sciences" [23, p. 71]; b) *Science Education Research*: "This is the production of knowledge about education in sciences; search for responses to questions on teaching, learning, curriculum and educational context in sciences and on the science teaching body and its continuous training, within a consistent and coherent epistemological, theoretical and methodological framework [...] all these aspects [instructional and curricular development in sciences, professional development of the teaching body, organizational development and of school management] have an influence on education in sciences and may be focused upon as a research activity. That is to say, science education research is the production of knowledge in that field [...]" [23, p. 71-72].

Another debate which it seems to us is worthy of deeper exploration has to do with postgraduate education, given that the expectation is notorious that the results should acquire a broader character than the exclusively academic.

It should be pointed out that postgraduate education holds the principal responsibility for the training of personnel both for research and for higher education, meeting the needs of postgraduate courses themselves as well as those generated by the economic growth of the country and the expansion of the national university system.

For this reason the precariousness of our basic education, attested by evaluations such as Enem, Saeb, Prova Brasil or Pisa, becomes a significant obstacle to the improvement of the human capital in the universities, because this low quality tends to depress the quality of higher education.

Now in relation to the filling of teaching places in physics departments: whether we are satisfactorily evaluating candidates for teaching physics in higher education, is a question to which an editorial was dedicated in the Revista Brasileira de Ensino de Física [24, p. i], in 2004, but the same question remains relevant today.

Concerning the shortage of physics teachers, there is a lack of 23.5 thousand physics teachers in secondary education. According to some studies [25, 26], to meet this demand 55 thousand physics teachers should have been trained in the decade of 1990, whereas only 7.2 thousand qualified.

Regarding the application of the research results into physics teaching in the classroom [25], we recently began to accompany progress of this nature originating in professional masters degrees in physics teaching.

In addition, complementarily to these observations, it is worth referencing the results of the "Physics Teaching: Reflections" colloquium, promoted by the Brazilian Physics Society in conjunction with the Ministry of Education, in 2005, in which recommendations were presented to support public policies with the aim of modifying this educational scenario [26].

Finally, beyond the situations presented, our attention is caught by the facts of the lack of enthusiasm on the part of teachers, of their exposure to risk of physical injury, of the scant assistance with specific content for professional practice, of the demotivation of young people for studies, of the non-viability of mass awards of diplomas, among others, not merely because they point to the need for a radical revision of strategies employed so far in the treatment of these problems, but also because they suggest that the challenge we face is not exclusively technical.

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