1

Physics Teaching in an Underdeveloped Country

SCIENCE EDUCATION IN THE CONTEMPORARY WORLD*

Professor Jayme Tiomno (Brazil)

It is nowadays generally agreed that the explosive development of science in this century is one of the major events in the history of human culture. The first half of this century stands out as a historic landmark, as notable as that of the age of great inventions which signified the transition from the Middle Ages to the Modern Age. The ease of communication and of the transmission of ideas, the actual range of scientific, technological, and industrial development, and the expansion of educational systems in the last century have, moreover, greatly augmented the impact of recent advances and their more immediate consequences. Hence, although we cannot accurately assess the far-reaching changes through which mankind will pass in the next few years, there is no doubt that these will be enormous. We even feel the need to give a new name to the present stage of history; the era of interplanetary flight, the era of atomic energy, the era of industrial automation, and many others have been given. These seek to associate our age with the most spectacular successes of modern technology, which in turn arise from scientific progress. The first of these descriptions, Interplanetary Age, emerged immediately after the launching of the Sputnik, which was an achievement that aroused widespread emotion among the masses of mankind. This was probably because outer space and the heavens have hitherto been associated with religious sentiments and have been considered inaccessible to man. This fact and others, as well as the recognition of the steady increase in the conditions of comfort created by the advance of technology in the more highly developed countries,

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contrasting with increasing difficulties in underdeveloped countries where this technology is lacking, tend to generate the conviction that scientific development is indispensable to economic development. This attitude of the man in the street toward science is new and peculiar to this century. It is contrary to the traditional tendency to regard science as an esoteric or cabalistic activity, and scientists as strangely abnormal persons engaged in mental processes that are incomprehensible to the common run of mortals and are wholly remote from everyday experience. The growing interest and curiosity of the common man in scientific subjects has increased their cultural importance, and appreciation is spreading to ever wider sections of the community. It is clear that, while the recognition of science may be penetrating increasingly into the minds of the masses, its more technical and skilled branches, which require a grasp of detail and a capacity for performance, must be restricted to those who have been specially and carefully trained for the purpose. The importance of science in general education and in shaping the mind of the ordinary citizen is being increasingly recognized, except perhaps in the most backward countries; the belief that science is opposed to the humanities has been left far behind. The progressive, rapid change from an educational system designed to produce an intellectual elite to a system of universal education, as well as the need to educate technicians and scientists on a widening scale, forces us to admit the failure of the teaching systems in use during the first half of this century. The development of educational methods more firmly grounded on a substratum of scientific knowledge, psychology, and other sciences, has made it possible to tackle more systematically the problems of scientific training for the average citizen and for the specialist, in order more efficiently to meet the requirements of the modern world. Recognition of the need for drastic revision and reform in the methods and systems of scientific education and in physics, in particular, has instigated experiments in various countries, the results of which are worthwhile comparing. It is interesting to note that most of these experiments were made with the participation of leading scientists who were the first to realize that education had to be revised. The attendance, at this and other Conferences on the teaching of physics, of outstanding researchers is a proof that the modern scientist no longer lives in his legendary ivory tower. On the contrary, he takes as active an interest as the average citizen, or an even more active one in the problems of his national community and in problems of international significance. In the present case, the responsibility of scientists and educators is particularly heavy. They are the most able persons to point to solutions and to bring home to governments and to national and international institutions the need for planning and for taking urgent steps to ward off future disasters and the hazards of irreparable damage to the development of their countries.

Of course, local conditions vary considerably from developed to underdeveloped countries, but the general approach to the problems of teaching physics is essentially the same, though the solutions may differ in accordance with the differences of local conditions. Developed countries have long gone beyond the stage of primary education for all, and are overcoming the difficulties in the way of universal secondary

education; they are now well on the way to university education for everyone. The fundamental problem there is how to teach science to a large number of students and with greater efficiency, the object being to give an adequate scientific background to nonspecialists and to train specialists in sufficient quantity and quality to meet the requirements of the nation's scientific, technological, and economic development.

It is a propitious sign for humanity as a whole that the cold war between the world's two greatest powers is being replaced by technological and educational competition. At the basis of these ventures are facts such as the effort these countries are making to turn out engineers and scientists to a total of about a hundred thousand a year. This certainly has tremendous implications for the teaching of physics at all levels and calls for a thorough overhaul of the educational process. In the underdeveloped countries, the inadequacies of the educational systems may be traced to various historical conditions, including only recent freedom from foreign rule. Often there are not enough teachers, and far fewer scientists and specialists. In countries where independence has been enjoyed for many years, although there are competent teachers, specialists, and even scientists of international standing, their numbers are insufficient to cope with the increasing needs. In such countries, generally speaking, the government is only now awakening, under the urge of public opinion, to the glaring demand for students to be admitted in larger and larger numbers to education at all levels. Often enough, the solution adopted is merely that of admitting more students to the schools without tackling the problems of increasing the number of teachers and researchers and the reorganization of teaching methods. An attack on these probelms cannot, however, be further postponed without increasing the relative degree of underdevelopment of the country. The systems mentioned cover a wide range of gradation; however, the attendance at this Conference of representatives from countries at the most widely varying stages of development points to the existence of a common field of interest and even of general principles, to form a starting point from which discussion can be engaged on specific problems and from which experiences may be compared.

Finally, I want to emphasize that the challenge that the world of today, with its content transformation, is presenting to all nations is terrible. Each must either keep up with its rate of development or perish. And it is by investing on an increasing scale in scientific development, in the training of competent specialists and teachers, and in expanding the educational system and bringing it up to date that the nations can fit themselves to stay abreast of the tide of progress in the modern world, and so survive.

The problems and difficulties of physics education in Latin America had been extensively discussed in the First Inter-American Conference on Physics Education (Rio de Janeiro, June 24-29, 1963). The recommendations of that Conference are helpful in showing the shortcomings and difficulties in that area. Some of these are clearly presented by the following summarized resolutions:

SUMMARY OF RESOLUTIONS ADOPTED BY THE FIRST INTER-AMERICAN CONFERENCE ON PHYSICS EDUCATION

- The teaching of physics at all levels should be based primarily on experimental work instead of on the mere accumulation of information.
- The teaching of physics in high schools should be adapted to the intellectual level of the children at this stage.
- Strong support is needed from national governments and international organizations to develop programs for the production of auxiliary teaching tools, particularly inexpensive equipment, and of films in the national language of the country.
- The training of physics teachers should be carried out at universities or at special institutions of university level (and not at institutions that are at the secondary-school level, except for the practical teaching of pedagogic subjects).
- In training physics teachers, emphasis should be given to scientific education in physics and an adequate knowledge of chemistry and mathematics.
- National agencies that grant scholarships should have advisory bodies which include scientists and university professors.
- Efforts should be made to introduce generally the system of full-time appointments for university staff, as well as the benefits of the sabbatical year of leave.
- University teaching of physics, even for technical careers, should be the responsibility of physicists.
- Existing plural physics departments at the same university (often up to six) should be amalgamated.

Many of the Latin American participants emphasized the unsatisfactory state of the teaching of physics in underdeveloped countries. Typical of their point of view are the comments from a paper submitted by Professor P. G. de Paula Leite.

OBSERVATIONS ON THE TEACHING OF PHYSICS IN DEVELOPING COUNTRIES*

Professor P. G. de Paula Leite (Brazil)

I am aware of the dangers of generalization. My experience being mainly restricted to Brazil may lead to conclusions that are not applicable to all other developing countries.

Let me stress some points that are very unsatisfactory in the teaching of physics in underdeveloped countries, both at secondary-school and at university level.

As a general picture, teachers are almost only concerned with their task of instructing rather with problems of education. They pay much more attention to the description of facts and apparatus and to the formal handling of equations than to developing in students the ability to use physics and to understand physical phenomena and concepts.

The most common failures of students who finish secondary schools in underdeveloped countries are the following:

1. Lack of ability to do experimental work even of a very simple nature, and a distaste for doing any manual work.
2. Difficulty in reporting on the results of their observations.
3. Difficulty in working by themselves on situations that were not discussed in detail during the lectures.
4. Lack of interest in any subject that was not worked out in the classroom, and even a marked difficulty of studying alone with textbooks that do not follow the same approach as that of their lectures.
5. Lack of adaptation to teamwork.

These shortcomings are the consequences of the teaching methods adopted in the high schools and of the fact that the children do not have much direct contact with technical developments and gadgets in their daily experience.

As far as the actual teaching is concerned, there is a lack of training in educational psychology in the presentation of the subject according to the intellectual development of the children.

Another point which is worth mentioning is that the teaching of physics in secondary school is mainly directed toward preparation for entrance examinations at the university, mainly for technical careers. The

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shortage of places at the university and the inappropriate type of examination have terrible consequences. Physics teachers in high school ignore the need for children to understand fundamental concepts and be familiar with experiments. They concentrate their attention on the solution of problems of the kind that are set in the examinations. Thus the students do not really learn any physics but concentrate on cramming for the strenuous competition of the entrance examinations. No improvement can be achieved until these examinations have been drastically changed. Then a completely different approach to the teaching of physics, somewhat on the lines of the PSSC program, might be attained.

Physics teaching at the university level presents no brighter picture. Having to supplement the wholly inadequate foundation given in the secondary school and having even to eliminate erroneous concepts from the students' minds, the teachers fail again by insisting on any encyclopaedic coverage. The lack of experimental equipment, the excess of students, and the shortage of instructors make the situation worse. The pressure to restrict the teaching of basic sciences to the first year so that immediate professional training can be started also has its ill effects. As the students have no time to think or to understand, they cannot enjoy the benefit of a solid foundation of basic science.

I should like to propose that, in order to improve the teaching of physics in developing countries, we should act as follows:

1. Modify completely the entrance examinations at the universities, so that they find out how much physics the student really understands.
2. Adapt the PSSC program to local conditions and train high-school teachers in these methods.
3. Set up national committees for the teaching of physics and require university professors and high-school teachers jointly to study ways of rapidly improving the present situation.