

PHYSICS EDUCATION IN ASIA

Edited By

SHARIFAH BARLIAN AIDID
M. ZAWAWI ISMAIL
AIK KHOON KOH
M. MOHINDER SINGH

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A Survey of School and Pre-University Physics Education in Pakistan

KHURSHEED A. SIDDIQUE and SYED A. KAMAL

*Department of Physics
University of Karachi
Pakistan*

ABSTRACT

Hundreds of students take physics in schools and at intermediate (pre-university) levels and they perform well, but they do not perform well in universities. It suggests a gap of knowledge among the university requirements and the school training of physics in Pakistan. The absence of modern physics in our introductory courses and the non availability of well trained teachers are the measures of failure to train good students. This paper reviews the existing curriculum, teaching methods and facilities, teachers training programmes and suggests methods to improve upon them. The recommendations of the two workshops on physics teaching held in Karachi (December 6-7, 1985 and December 27-28, 1986) have also been incorporated.

INTRODUCTION

Pakistan is not a small nation with nearly 100 million people, but our science is extremely small in terms of absolute size. Speaking of physics, the total number of Ph.D. teachers in 20 different universities of the country is less than 75 and this number is steadily decreasing.

Acquiring knowledge and establishing technology have been the shared urges of mankind and the basic knowledge of physics lies at the heart of all modern technologies. Pakistan needs to expand its number of scientists, especially the physicists because the physics of today is the technology of tomorrow. In order to benefit from the modern technology, Pakistan needs to develop an infrastructure for physics education.

The available system of education in Pakistan is essentially a continuation of the colonial system of the pre-independence era. A student majoring in physics for a master's degree spends ten years at a school for Secondary School Certificate (S.S.C.), two years at an intermediate college for Higher Secondary Certificate (H.S.C.) and then finally attends the university for four years. It can be done at three different institutions at Karachi. The Department of Physics, University of Karachi enrolls students in B.Sc. (Honours) and M.Sc. and offers a traditional physics course. The Department of Applied Physics registers students for M.Sc. and its course has a wider orientation towards electronics and solid state physics. The Department of Physics, Federal Government Urdu Science College enrolls some students for their programme in General Physics.

The process of selecting a career actually starts at secondary school level and at higher secondary level in Pakistan. Only a minority of students ever take physics and only a small num-

ber of these intend to make it a career. Competition among disciplines for the bright young students is very intense. The number of physics students is continuously decreasing in Pakistani universities as evident from the following table.

TABLE 1. NUMBER OF STUDENTS PASSING PHYSICS EXAMINATION

Sessions	S.S.C.	H.S.C.	M.Sc.	Enrolment in M.Sc.
1983-84	20667	9454	60	260
1984-85	21270	11126	61	250
1985-86	22348	10034	55	235

The above table describes the situation of physics education in Karachi. Karachi is the largest and the most populated city of Pakistan. Nearly 9% of the total Pakistanis live in Karachi and provide more than 50% of the tax revenue to the government. Approximately 14% of the total university students (57,000 in 1984)¹ attend Karachi University. Karachi is a good representative of Pakistan and the data present the situation of physics education in Karachi.

TABLE 1 and TABLE 2 show that a large number of students pass physics at S.S.C. and H.S.C. level (the pre-university levels) but very few proceed to earn a M.Sc. degree in physics (TABLE 3 and TABLE 4). Only 0.27% of the students who pass physics courses at S.S.C. level earn a Master's degree. Not only the number of M.Sc.'s are low, but the quality of students is also decreasing, as can be checked from the figures which show that the number of first divisions is also on decline. This is a very poor situation indeed. It seems we stand today in danger of losing several of our younger generations unless we face up to the real issues with rare courage.

High school and college students who have taken physics as a group are intellectually exceptional. They perform well on standardised tests and rank high in scientific ability. However, not all bright and capable students take physics at the university level. In fact, academic and economic factors affect a student's decision to take physics at the university level. Whether the quality of students taking physics at the university level has changed is a frequently asked question and it is a consequence of poor results we are getting in our universities. It is difficult to support it through data. Although the physics students of today are perceived to be of higher quality than the students of other basic sciences, they are however, not quite as capable as physics students of a decade earlier. It is a fact that the present students are not performing well. Somehow, there is a gap in performance at the university and pre-university levels. Our major focus in this article is not only to find the reasons for this gap, but to suggest measures to bridge it.

POLICY MATTERS

There can be many reasons for our students not performing well at the university level. The simplest of them is that we are not getting better students. There is no policy to attract brighter students to physics.

In spite of the claim that there is a shortage of physicists in Pakistan, we observe that more than 50% of degree recipients in physics leave the field. Most of the students prefer engineering and education as their profession and a very small number join research organisations. It is sad to notice that there is practically no place for physicists in industry because our industry is not research oriented.

Students have become increasingly concerned with their economic well being. This is reflected not only in the huge growth in medical and engineering students, but also in the shift towards business and computer science. The choice may be affected by openings in advanced technical programmes, perceived employment opportunities and potential for higher education. Most of the students have as their goal immediate employment and medicine and engineering offer better chances. Most of our good students join engineering and medical education leaving the average students to continue their involvement with physics. An average student finds the university curriculum too difficult to cope with, so in turn, we get lesser number of good physicists and this number is continuously decreasing. Recently Government has started a School Health Scheme to absorb the unemployed doctors in the country and more than 5,000 doctors got jobs throughout Pakistan. A similar scheme is under consideration for engineers. Although most of the school health clinics do not have any facility to offer and the doctors sitting in these clinics will not be performing their duties properly, but they are lucky to get an unemployment benefit. Engineers are expected to get the benefit soon. As there is no such scheme for scientists, it will not only affect the quality but the enrollment of the physics students in universities.

Everyone in the Government claims that they are encouraging the transfer of technology. All this means the transportation of machines, designs and processed raw materials to run our industry. No one bothers to think that technology without science is useless. In fact, no one appears to stress that for long term effectiveness, technology transfer must always be accompanied by science transfer. It is essential to train better physicists to support the technology transfer. It is necessary to strengthen the incentives for physics and technology, but it cannot be achieved with an annual spending of 0.1% of our GNP on science and technology. It is sad that there is no national commitment to acquiring of and enhancing scientific knowledge. It seems that we do not have any declared policy for science and technology in our country.

Economic issues such as salaries and job opportunities are valid professional concerns. The continuing vitality of physics as a profession depends on our ability to attract the brightest and highly motivated students to physics. To attract better students in physics we have to create better job opportunities with higher salaries for physicists. At least we have to bring the salaries at par with doctors and engineers. The nation must commit itself to the task. The career in physics should be made respectable.

PROBLEMS OF CURRICULUM

Part of the current challenge to physicists is to introduce the subject in a way that inspires and motivates the students to think about the subject seriously. It is our duty to make it interesting and stimulating. Both, the books and the curricula play a vital role in making physics an interesting subject.

Physics is the most basic science, not only because its theories have retained an acknowledged validity over time and the concepts of physics are applicable to other sciences, engineering, medicine and other applied sciences. Physics is a dynamic science which comprises an ever changing body of knowledge that at each instance has to be looked at in a coherent and unified way according to current understanding. Books introduce students into the exciting world of physics in an intellectually honest and pedagogically consistent way. Our recommended texts²⁻⁴ for schools and intermediate colleges do not serve the purpose well.

The text² recommended for schools is full of mistakes, misleading statements and written in sloppy languages. Many examples can be cited. A strange statement is given on page 314, "AB of a lens is known as its aperture". A wrong statement about the theory of light is given on page 334, "At present there are two theories of light ...". Misconceptions may arise through ill teaching or inappropriate textbooks.⁵ Misleading statements are more dangerous than evident mistakes and they hamper the ability of the students to pursue higher education.

The texts^{3,4} recommended for the intermediate level are nearly 16 years old. The new editions differ from the earlier editions only in the print line showing the date of publication. No new information appears in a new edition of a textbook. The correct units help in clarifying the relations involved, incorrect units are often an indication of fuzzy logic. The case of books^{3,4} cited here are used for first year and second year intermediate college courses. The system of units in both these books is not compatible. The prefixes of the SI are not systematically discussed and often confuse the students.

Text for schools does not contain any modern physics except a chapter on nuclear physics. Texts for intermediate level do contain modern physics but the presentation is not adequate. Our books are staid and predictable. The concept and subject matter of modern physics - the very ideas that excite the imagination of the young students are not well presented. It can be concluded that the recommended books are not good enough to generate interest and enthusiasm for the subject.

The absence of modern physics in our introductory courses is a measure of our failure to stimulate the bright students. The 20th century has witnessed a burst of discovery in physics. Although relativity and quantum mechanics are nearly 80 years old, introductory courses in our institutions essentially ignore them. The basic contents of introductory physics has remained the same for decades. It still contains mechanics, heat and thermodynamics, electricity and magnetism and optics. Even when we do introduce a few selected topics in modern physics, we discuss them in isolation. It is essential to encourage the introduction of modern physics in our curricula.

It is important to teach an appreciation and understanding of Newton's theories but we cannot go on ignoring all the physics of this century. The concepts and applications of energy and momentum conservation laws as fundamental principles of physics can be introduced using nuclear or particle physics data. We need to convey to our young students our excitement about physics and we want our students to view the world differently. We have to introduce the current topics, especially particle physics and cosmology because these are exciting, provocative and stimulating and enhance interest in physics that students bring with them to the schools.

Educationists are of the opinion that the originality and creative faculties of the students will be stimulated to a higher degree if they are taught in their own language. In Pakistan we have a strange system, the English medium schools play a prominent part in fostering class conflicts. English is the medium of instruction for physics at intermediate and university levels. The language used by a student at home and at the institution is completely different. As most of the students find English a bit difficult to understand, so they memorize the physics by heart and this tradition is not helpful at higher level of education where real knowledge of the subject is required. Students usually find it difficult to ask questions and then to understand the answers. Grasping the lectures delivered in English is a tough task and the production of good scientists suffer from this differentiation. It is a serious problem. Physics is being taught through a foreign

language (English) and the problem of making a student correctly comprehend the laws and concepts of physics is a real one. One can never expect to make a good physicist out of a student who has not clearly understood the subject. This is one of the reasons why the number of physics knowing people is large in our country, but the physics doing peoples are very small.

It is a common observation that the talent is distributed uniformly in the population of the country. Education in physics through Urdu will provide all with an opportunity to develop their talents. A changeover from English to Urdu will be a welcome development, but not before the relevant machinery for translation, compilation and writing of educational materials are set in motion with adequate funding. It is impossible to achieve the target with the present commitment of less than 1.6% of GNP for education.

TRAINING PROVISIONS

Education is a process of learning from the experience of the seniors. A teacher portrays the role of a senior in a formal educational system. The function of teaching can be considered, the reproductive function of a society, to reproduce its type as exactly as possible. A teacher has to transfer his knowledge of the subject to his students. A teacher has to be fully aware of his subject.

In school level physics teaching, the demand for content mastery, expertise with equipment and preparation time for laboratory experiments and demonstrations are high. A physics teacher is often alone in meeting these demand. The tragedy of our system is that there is often no physics teacher. The usual tradition for the appointment of a teacher is that we hire high school teachers and junior school teachers on very poor salaries. A high school teacher can be a science teacher. A science teacher can be assigned to teach physics irrespective of his choice. The situation is such that even teachers with basic training in biology are teaching physics in Karachi schools. It is a common practice in the rural parts of Sind that teachers with a background in social sciences act as a physics teacher. How it is possible to generate interest in physics in these circumstances is left to anyone's imagination.

There is a shortage of science, especially physics teachers in our schools and colleges. The teacher who should be enviable has become pitiable due to manifold social, economic, political and other reasons. Situation is such that no sensible Pakistani who can command influence will want to become a teacher.⁶ As a result, only the average students join the teaching profession and they do not teach physics properly and often discourage the learning of the subject. A teacher who is ill informed himself cannot teach the subject in an interesting way. Most school teachers are not aware of the technicalities of modern physics and find it difficulty to answer the intriguing questions of brighter pupils. Often they try to hide their lack of information and provide confusing answer which can result in a wrong concept in the student's mind and he will find it difficult to master the subject. It is therefore desirable to provide compulsory training to all high school teachers before posting.

The position of teachers training college is not very clear as well. Although they appoint special teachers for physics with training in the subject, the physics teachers are not assigned to teach physics. They may be forced to teach other subjects like education and psychology. The school science teachers are not familiar with the teaching of modern physics, for example, a science teacher in one of the teachers training colleges in Karachi was not aware of the word "Quarks".

College teachers usually do not receive a proper pre-service training and they join the teaching profession directly after finishing their M.Sc. programme. Only those university graduates who are at the bottom or near bottom level take to teaching. They become absolute master of the classroom and give a packaged formal presentation that does not encourage questions or comments from the students and in the process kill the thinking faculties of the young students. It seems that we have nothing ahead of us but chaos.

The way our education is being imparted only suggests that we have given up all possible ideals and we have learnt to live with backwardness. It is the result of the meagre allocation of finances for education by the Government. It appears that the nation has mortgaged their education to the developed countries. The situation has been confused and confounded by increasing bureaucratisation of education. The purpose of our own universities is to produce low grade college teachers rather than the man of science, but our universities are not even doing this properly. Although we try to teach a lot of physics to our students in universities, we do not expose them to teaching methods or practices. The graduate assistantship is an essential element in the training of a professional physicist. Not only is it a valuable part of the student's physics education, it provides real teaching practice. Unfortunately, we do not have any such scheme in our university programme.

CONCLUDING RECOMMENDATIONS

A group of physics and mathematics teachers in Karachi who were aware of the poor situation of physics education in the city has decided to help willing teachers to enhance their knowledge and understanding of the problems of modern physics. The group decided to arrange a workshop on physics teaching in 1985. A brochure was mailed to all physics teachers and 50 college teachers attended the first workshop. Some of the participants were senior physics teachers and the others were less experienced. A similar workshop was arranged in 1986 and some senior scientists reviewed selected topics in classical and contemporary physics. A third workshop (this time on a national level) is being planned. Important recommendations of the last two workshops are summarised below:

- » Physics teachers lack social status and adequate rewards. This is liable to reduce the effectiveness of the profession as a whole. Teachers must strive for professional competence and expertise and should be provided assistance by the authorities. Society must recognise the importance of a teacher's role in the educational process.
- » Funds should be made available immediately to enable school and college physics departments to replace and upgrade equipment to meet the requirements of modern syllabi.
- » Government should provide incentives to industrial companies to become more seriously involved with schools and colleges in industry-education initiatives.
- » Government should spearhead a campaign to make the public more aware of the importance of physics for our future.
- » In-service training should be compulsory for all teachers to learn new techniques and methodologies.

- Teachers should be assigned educational assignments during summer vacations to improve their efficiency. Open university service can be utilised for this purpose.

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TABLE 1. NUMBER OF STUDENTS PASSING PHYSICS IN S.S.C. EXAMINATION

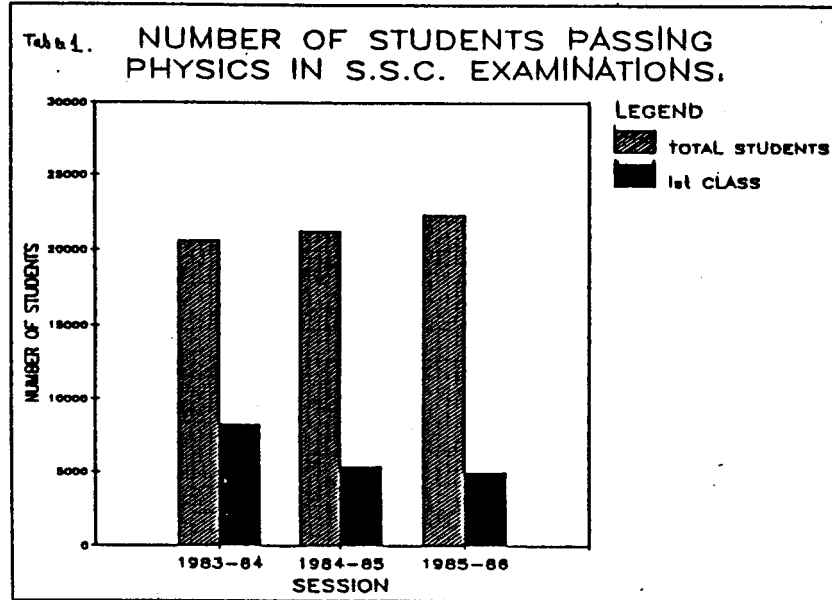


TABLE 2. NUMBER OF STUDENTS PASSING PHYSICS IN H.S.C. EXAMINATION

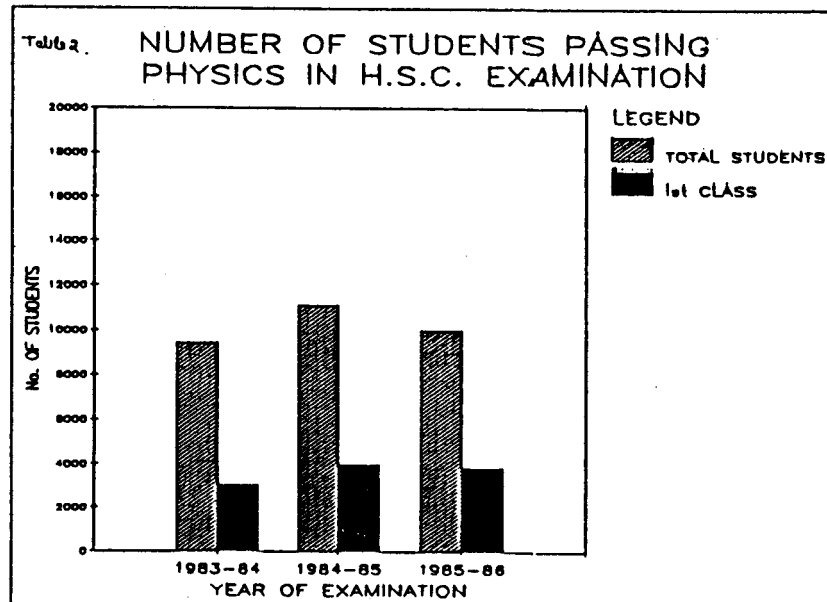


TABLE 3. NUMBER OF STUDENTS PASSING PHYSICS IN M.Sc. EXAMINATION

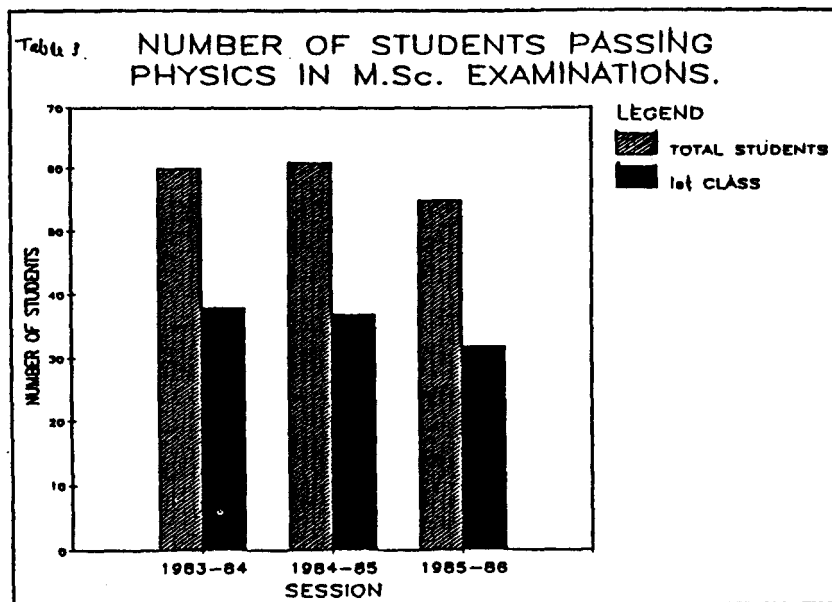


TABLE 4. PERCENTAGE OF S.S.C. STUDENTS GETTING M.Sc. PHYSICS

