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Rethinking Higher School Physics

School Education Programme in India has been subject to several revisions in the last fifty years. While such an exercise usually makes the education more and more meaningful, in our country, unfortunately, it does the opposite. As there are many schemes of school curricula (State Board/Council of Education, ICSE, ISC, CBSE, Delhi Board etc) running in India, any change in one affects all others as they must meet a common objective. The objective is to prepare the students uniformly for the graduate (technical or medical or general) programmes of the country. While this is understood and must be met with, at times, in certain quarters, there is the wishful thinking that our children are not learning enough. Revisions, therefore, follow and follow only in one direction. That is, to add more and more things to the existing syllabus. This makes the syllabus unduly heavy and defeats the very purpose of school education. It cannot be to make our children a learned lot. It must help nourish and activate their basic instincts by giving them the irreducible minimum. Material is to be delivered slowly, systematically and in small quanta so that their minds can adjust to it, absorb it and cultivate it. When these are denied, the syllabus becomes a deadly load, and the education, pointless. From this angle, an ideal revision of the system is certainly not attained yet, not even tried in all earnest.

Consider, for example, the Higher Secondary curriculum as one has it now in West Bengal. All other Indian States have their prototypes. When first introduced in 1960, it was a three-year course, and the requirement was that the students, having studied all the basic subjects upto class VIII, opt in class IX for science or arts or technical or commerce streams. Here, we shall deal with the science stream only, and of it physics, in particular. In class IX, the students faced for the first time an exact science, where everything is based on given laws and every learnt thing verifiable by experiment or daily experience. Things they qualitatively knew from the lower classes now began to assume definite quantitative forms developed by a chain of hard reasonings. The adaptation was not easy. But given the three years and a slim syllabus to tackle, the students had no trouble digesting the basic physics. The syllabus was not foolproof, – some felt, a little bit of calculus and vector could do, – but that never posed any serious problem. In a word, the original HS Curriculum was quite a success. The only change one could consider, if at all, was to add elementary calculus and vector algebra, which would not be a burden to the students. If the lessons in mathematics and physics were coordinated well, well and good, but no matter. By and large, it equipped the students with the basic things of physics without weighing them down with unnecessary things.

A major overhaul of this system was brought about in the mid-1970s following a decision at the Centre. The curriculum was split in two: Secondary at the end of class X, and HS at the end of class XII. In Secondary, students had to continue with the subjects that were earlier terminated in class VIII. Both the syllabii (Secondary and HS) were loaded with things drawn from modern developments as also from the-then Three-year degree course. For the latter, it

was argued that a huge gap existed between the HS and the Three-year Degree Course and that must be bridged.

If we consider carefully, the gap was not much. Those who did the Degree course after the HS of old would remember, their physics teachers at colleges devoted a few classes to introduce basic calculus and vectors before taking up their subjects proper. And there were no problems. Yet the change took place. One doubts if it was only to keep the students from crowding the job market for a year. That year got added to their school-life.

Not that this extra year at school did them any good. Between the announcement of the Secondary Examination results and the commencement of the HS Examination, they had to themselves a little less than a year and a quarter to cover a lot. A fall-out of this terrible imbalance was that the teachers at schools got exasperated, they gave up teaching but not the job. Market was flooded with thick-volume textbooks. Students desperately flocked at private tutors' doors. Coaching centres mushroomed. As a result, students lost their mental and temporal freedom as also the balance. The growth of their analytical ability was stunted. It divested a large section of students of the faculty to think on their own. It caused a grave damage.

A simple remedy could be to slowly revert to the old system or to redesign the syllabus and shed some load. Instead, the concerned authority went for yet another change. The syllabus was arbitrarily divided between Classes XI and XII. With it came the ruling that at the end of class XI the HS Council would hold an examination which the students must qualify, and, at the end of class XII, another – the HS Examination – over the syllabus covered there. This examination alone would decide a student's career. This is where the structure stands today.

The curriculum, now torn asunder in an insignificant and a significant part, has bred more ill effects than good. Most of the students now somehow passes out the insignificant class XI examination. While he/she appears for the significant one, much of the things taught in class XI is not seriously learnt. It is a common complaint of the present-day teachers at colleges and universities that the majority of the students' basic physics is extremely poor despite their high marks in the HS Examination. This is a new effect. The authority may one day decide to require that the results of Class XI and XII together will decide the final grade of a student.

Let us now consider the split in the syllabus itself and try to understand the arbitrariness it entails. Take the syllabus for Class XI in mechanics, for example. It includes: Physical world and measurements (units and dimensions), particle dynamics (rectilinear motion only, vectors, rudimentary kinematics, relative velocity and acceleration, projectiles), Newton's laws of motion (force, impulse, conservation of linear momentum, Statics, Work-Energy-Power).

Recall that in olden times, all the three "integrals of force" (namely, impulse, work and torque) were introduced at once in the lesson on 'force'. Only the first and the last are now treated in class XI and the second, except for a rudimentary definition, relegated to class XII. It is argued that students find it difficult to grasp rotational motion. But taking a look at the mathematics syllabus we find, trigonometry is taught in class XI. Students are therefore familiar with the definition of angle and the relation $s=r\theta$. Once that is known, comprehending angular displacement, velocity, acceleration and their relations with the corresponding physical quantities in the rectilinear domain cannot be a problem. Students would also realise thereby that translation and rotation together make the most general motion, a fact they experience in ordinary life. How without the idea of a torque will a student understand in class XI (statics) the conditions of equilibrium?

There are two ways the load can be lessened. By redesigning the syllabus, and by dropping some topics. Let us consider the first. The energy theorem (equivalence of work done and the

kinetic energy gained) could immediately follow the definition and examples of Work (with the sign convention) in class XI. The students could be asked to work out the cases of path-independent work. One could thereafter float to them the idea of conservative force and the notion of potential as also the relation between the two; if it has to invoke elementary calculus, let it be; there is no virtue in keeping calculus, learnt in their mathematics class, idle in physics class. In fact, it would constitute a good application. Frictional force could come immediately after this, obviating the need for a separate lesson. This would have the advantage of making it apparent to the students that not all forces of nature are conservative.

It is a pity that gravitation, being the most tangible of all forces, is relegated to class XII. It could come next to the lesson on Force in class XI. Acceleration due to gravity, ample use of which is made a priori in connection with projectile or motion on an inclined plane, could be covered here as also its variation with height above and below the earth's surface. With the concept of potential already introduced, the students would realise that calculation of potential at a point inside the earth is very different from that of potential at a point outside.

One could multiply such examples to make a case for an integrated syllabus. Apart from effectively reducing the load, it would help the students see how much can be reaped out of a given amount of material.

To physically reduce the load, such topics as have no natural connection with what is already learnt were best dropped. In Modern Physics which is a recent addition, one learns Bohr theory of Hydrogen atom. That is all right. But, teaching them band structure of solids is an absurd proposition. It fails me how without quantum mechanics can a teacher explain to them the energy bands or working of semiconductors.

It thus appears, there is an urgency as also room for a restructure of the higher school curriculum were we to meet our objectives. In this connection, mention may be made of a recent development having most of the desired merits. The National Institute of Open School (NIOS) has come up with an integrated higher school curriculum for those not going to schools. The entire course comes in several modules. Each module, divided into several lessons, is complete at the intended level. Appropriate text-books have been brought out in four sleek volumes, – three on theoretical and one on experimental physics. These are written so that a student can learn on his own and check one's own progress with occasional help available at any registered 'Centre'. I am not overlooking the fact that this programme, unlike the time-bound HS one, has the advantage of being open-ended, – a student can take examination when he thinks he/she is fit for it. This flexibility notwithstanding, it has several features worth emulating, which, with a careful exercise, can be incorporated in the regular higher school physics curriculum.

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