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Speech by Dr. Toh Chin Chye, Minister for Science and Technology at the Science Teachers' Association Annual Dinner held on Saturday 15 March 1975 at Mandarin Hotel

A criticism directed at science students is their weakness in articulating or setting out their thoughts in spoken or written language which can be understood by non-scientists. This weakness is more apparent among students who are accustomed to being taught in symbolic language such as in mathematics, physics or chemistry. Biological subjects, on the other hand, are descriptive and qualitative so that biology students suffer less from linguistic weakness. At the University of Singapore, undergraduates in the Faculty of Science have since 1969 been required to read a course serviced by the Faculty of Arts and Social Sciences for three years. Beginning in 1975/76 session, they will be required to take a test in the English language on admission. Those who do not pass this test will be asked to take a three year course in English especially designed for them. Those who pass the test can, if they so wish, choose to continue with this special English course for the duration of their studies in the Science Faculty or to opt for another specially designed arts course. Such a policy serves several purposes.

1. It impresses upon science students that a scientist is not a mere storehouse of facts but that he must be able also to assess what facts are relevant and to be able to assemble in a comprehensible manner the evidence for arriving at certain conclusions. For this a command of

English is necessary.

Those who aspire to teach science must have this faculty of mind otherwise they are a menace to or the despair of their students. Equally scientists who wish to influence policy makers must be able to communicate in a language which non-scientists can understand. In the book "Brighter than a thousand suns", it has been related how nearly the United States government lost the race in making the atomic bomb during the war because President Roosevelt was not impressed by a letter signed by Albert Einstein which warned of the military implications of the discovery of a chain reaction in uranium. It was left to Alexander Sachs, banker and scholar, to convince Roosevelt that possession of the atomic bomb could change the course of the war just as Napoleon could have changed the history of the nineteenth century if he had accepted the offer of an American inventor Fulton to build ships without sails which could land in England regardless of weather conditions.

2. The need for science students to read an Arts course is also an attempt to provide science students with occupational mobility. Not every science graduate will become a professional scientist but his analytical training supplemented by a knowledge of other disciplines that concern the affairs of human society will give him a

good grounding in administrative or other fields. Outstanding problems with which the world are pre-occupied today and will be for a long time in the future include environmental pollution, population explosion and food, the energy crisis and the limits of resources. These problems are bringing together minds trained in science and technology and the social sciences. In order that such problems can be formulated in comprehensible terms, communication between the natural scientist and the social scientist is indispensable. If language literacy is important for the scientist, then an ability for the social scientist and the politician to understand the significance of scientific discoveries is also necessary. In 1944, the physicist, Niels Bohr, who understood the enormous political leverage of the atomic bomb had misgivings about future relations between the United States, Britain and Soviet Russia. He wrote a memorandum to both Roosevelt and Churchill suggesting common control of all applications of atomic energy before the bomb was completed and tested. It was recorded that Churchill granted an interview to Bohr, listened to him for half an hour in silence, and then suddenly ended the audience by turning round to his scientific adviser Lord Cherwell. With a shake of his head Churchill asked, "What is he really talking about? Politics or Physics?".

It seems late to have to conduct remedial English courses for science students at the university. This is mainly due to the fact that the university has been admitting students from the Chinese school stream whose comprehension of English is weak but weakness in the English language is also noticeable among some English school stream students. In a way this weakness has been imposed by the nature of the curriculum at secondary school level. It streams students into two separate cultures, one for the Arts and one for Science. It is encouraging to note that there is increasing response to acquire breadth by breaking out of the straight jacket of arts and science. This has been begun by re-adjusting the curricula at pre-university class level. In 1974, 85% of the students at pre-university I offered mathematics as a single subject instead of pure mathematics and applied mathematics and 67% offered physical science instead of physics and chemistry. This arrangement provided them the opportunity to study an arts subject and biology or another technical subject. What impact students with such a combination will make can only be known in the next few years, but it will be interesting for them to know that the author of "Future Shock" is not a scientist but was a graduate in English, who took audit courses in science in his undergraduate years.

Curricula changes by themselves are meaningless if the objective behind these changes are not understood by students and teachers. Innovations in

teaching methods are being continuously pushed out. Science teachers should be the last to fear innovations but there is a case for teachers to be critical and discriminative before putting into practice every innovation that is being marketed as the results of educational innovations will not be known until a few classes of guinea-pigs have been exposed to them. The modern cliche in education is "learning by discovery". It sounds exciting as it appears that students are being given the freedom to exercise his curiosity. We need, however, to remember that the level of curiosity differs at different mental ages and varies from individual to individual. Some children may be curious in other directions while others may not even show curiosity so that without guidance they will neither discover nor learn. Mathematics is an invention. It was not discovered. But since the vogue is for children to learn through discovery, a new mode of mathematical education for elementary and secondary schools has appeared under the guise of "New Mathematics".

In recent years there is a growing doubt on the value of new mathematics as industrial firms are dismayed that children reared on new mathematics are incapable of performing computational arthmetic required in offices or on the workshop floor. Until a child understands the simple meaning of addition, subtraction, multiplication and division, teaching him how to punch the keys of an electronic calculator is to reduce his thought process to blind faith in a machine. Absurd answers may be displayed on the calculator and it may

not even occur to the child that he has punched the wrong keys.

Learning through discovery does not mean that teachers stand idly by while children are allowed to do their own thing. On the contrary, the burden for making children learn through discovery is the greater. Charles N. D'Argustine, author of "Multiple Methods of Teaching Mathematics in the Elementary School", has listed the following conditions for success:-

1. The teacher must have a superior gist of the subject matter in order to be able to recognize and focus on significant things discovered by students.
2. The teacher must have sufficient grasp of the subject matter to recognize when students are at the end of a blind alley and need to be redirected to more productive avenues of thought.
3. The teacher needs to have the ability to interject just the right question at just the right time in order to produce a discovery.
4. The teacher needs to have the ability to sense when the inherent discoveries have been exhausted.

It will be a relief and a comfort if we can be assured that all our teachers do fulfill the conditions which I have just listed, but teachers unequal to the task can turn children off from mathematics and science in spite of the availability of laboratories and teaching aids. I believe that the Science Teachers'

Association have a professional responsibility in holding colloquim and experimenting with teaching techniques which are suitable within our local context. Your Association can reinforce its membership by including science and technical teachers not only from the schools but also from the universities, the Polytechnic and the Ngee Ann Technical College. It deserves encouragement if necessarily by a grant in order to enable it to promote its professional objectives. I hope the Science Teachers' Association will make full use of the Science Centre which is due to open in 1976. Young minds require to be nurtured but young scientists and engineers will never emerge without advice and encouragement from the old.