Quantum Mechanics, Ordinary Language and Mathematical Language.

It is not possible to reduce the quantum universe to everyday ways of thinking (usually called "common sense"). In fact, in order to understand the ideas and implications of the theory we have to adjust all of our ways of thinking at the most fundamental level.

Imagine, for a moment, that you are attempting to understand a new culture. If you are serious about it, the first thing you would do is to learn the language appropriate to that culture so that you can put your experiences in the proper context.

Understanding the universe of quantum phenomena is much like understanding a new culture where the appropriate language is mathematics and the experiences we are attempting to put into context are macroscopic experiments.

We have to use a mathematical language to describe the quantum world since ordinary language, which was developed to explain everyday occurrences (experiments on macroscopic objects), will turn out to be totally inadequate. There are no "models" or "classical analogues" that will ever give us any insight into the workings of the quantum world.

Since it makes no sense to attempt any understanding of the nature of quantum phenomena without first learning to speak and use the language of the quantum world, one should spend some time very early on in learning the appropriate mathematics, in particular, the subject of linear vector spaces.

The adjustment of our ways of thinking at the fundamental level that will be needed is not simply a mathematical matter, however. The development of the necessary mathematical language will not come into conflict with our everyday modes of thinking in any major way. Although, the mathematics of linear vector spaces is very elegant, you will be able to understand it without much difficulty and without having your basic view of the world changed at any fundamental level.

You will be troubled, however, when you apply the mathematics to physical systems that develop according to quantum rules. You will need to attach physical meaning to the mathematical formalism in ways that will conflict with your well-developed views(I will call these "classical views") about how the world works.

Dirac was able to join the conceptual structure with the mathematical structure. He invented a mathematical language (I purposely do not use the word "notation") that directly embeds the philosophy of quantum mechanics into the mathematical structure used to do calculations. The new language directly exhibits what is being said about nature in quantum mechanics. Dirac language exposes the internal logic of quantum mechanics in a way that mere words cannot possibly accomplish. It displays the sense, the physical meaning of the theory in every equation one writes without the need for further explanation or any need for inadequate models.

It is very important to understand that the Dirac language is not simply a new notation for quantum mechanics(as many physicists seem to

think). It is not merely a way of writing. A way of writing expresses a way of thinking. Dirac language is a way of thinking.

It will allow us to use the physical ideas of quantum mechanics to develop the appropriate mathematical language rather than the other way around. This allows the very mathematical quantum theory to be more closely connected to experiment than any other physical theory.

Dirac language expresses the quantum mechanical way of thinking. With it one can proceed from the philosophy of the subject to its mathematical expression rather than the other way around. That is the way one should study quantum mechanics. One should proceed from meaning and Dirac language is perfectly suited to this task.

Meaning does not reside in mathematical symbols, however. It resides somehow in the thoughts surrounding these symbols. It is conveyed in words, which assign meaning to the symbols.

Dirac language is able to take notions expressed in words and replace them with simple mathematical statements that we are eventually able to place within a complete and logical structure that allows for a fundamental understanding of what quantum mechanics means and is saying about nature.

This task is impossible without mathematics. Mathematics is the true language of all of physics. Words alone only suffice for thinking about the physics of everyday objects.

These statements about the importance of understanding the mathematical language appropriate to the physics under consideration do not only apply to the quantum world. It is true, I believe, for all areas of physics and other sciences. One should always learn the appropriate language before studying any field that relies on that language for its understanding.