Einstein First: Changing the paradigm of school physics education

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Abstract

The detection of gravitational waves from coalescing black holes and neutron stars is the proof that the Einsteinian model of space and gravity is the best description of our universe. The term Einsteinian physics comprises of special and general theory of relativity and quantum physics. Einsteinian physics has immense importance in modern technology. For example, the working of Global Positioning System (GPS) depends on the knowledge of time warp around the Earth.

In almost all countries, Einsteinian physics has rarely, if ever, been part of school science curriculum. Only students who go on to tertiary physics learn the modern worldview of Einsteinian physics. Internationally, most science curricula are still based on Newtonian physics and Euclidean geometry. For example, students are still learning Newton's laws of motion and gravity and that the sum of the angles of a triangle is 180^0. However Newtonian physics was long ago replaced by Einsteinian physics as our best description of space, time, gravity and mechanics. The question arises: Do students need to continue learning Newtonian physics, which does not work in real life? Is Einsteinian physics only understandable by physicists?

While many educators believe that every student has the right to know the reality, there are also many others on the opposing side, who believe that Einsteinian physics is highly mathematical and not suitable for young students to learn. For many years, a group of educationalists in Western Australia have been developing an "Einstein-First" curriculum for schools. Our aim is to reverse the current approach to teaching science. We introduce the modern paradigm of curved space, warped time, photons, quantum weirdness and the uncertainty principle as the primary conceptualization of reality at an early age (11 - 13) of our students. From these foundations students can make the transition to the Euclidean - Newtonian worldview, which is presented as a special case and useful approximation.

To enable this research program, we have developed simple activities often based on analogies that make the various topics interesting and understandable to young minds. We have tested the efficacy of these activities in pilot studies. From the pilot studies, we have found that young students easily accept many of the concepts that adults find difficult. Students generally believe that they are not too young to learn Einsteinian physics. The Einstein-First program has shown that it is possible to present Einsteinian concepts of space, time and gravity to school students. Students' conceptual understanding improved significantly, and their attitudes changed towards physics. Females entered the program with lower performance and attitude than the male students but universally showed a greater improvement than male students. This is evidence that modernising the school science curriculum will have significant benefits for gender equity in physical science.

In this talk we will present an overview of the Einstein-First program, including illustrations and videos of the curriculum content, plus testing results, that show that it is possible to present this material in a way that all students, whatever their ability and background, can be introduced, in appropriate ways, to our best scientific understanding of the Universe.