Students’ Response to Einstein-First Programme

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Abstract

The Einstein-First project brings new curriculum materials to introduce and teach school students, from age 11 upwards, modern physics. Through models and analogies, we found that students easily grasped concepts, that adults, indoctrinated with Euclidean-Newtonian concepts, find difficult and confusing. This paper reviews the Einstein-First project, its methods and results of studies. We show that most students demonstrated improved conceptual understanding and attitude to physics and that female students who entered the programme with lower scores than male students, increased their performance to be level with them We also found that the programme has lasting impact on students’ conceptual understanding.

1 Introduction

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.

The question arises: Is Einsteinian physics only understandable by physicists? Do students need to continue learning Newtonian physics, which does not work in real life? 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 approach is to reverse the current approach to teaching science.

The Einstein-First programme has developed simple and inexpensive models and analogies to teach the Einsteinian physics concepts. To teach the concept of how matter creates a curvature in space, we used lycra (spandex) sheet and golf balls. This model is the basis of other experimental investigations such as gravitational lensing, photon trajectories and many more. Similarly, to teach the concept of photons, we used Nerf gun bullets as analogue photons. These models and analogies are described in detail in two different papers [1], [2].

2 Methodology

To measure any change in students’ conceptual understanding and in their attitude after attending an Einsteinian physics programme, we have developed the conceptual pre/post and attitudinal pre/post questionnaires. To see the effect of Einsteinian physics on students’ memory, another questionnaire known as delayed retention test was developed. Simple, multiple choice questions and Likert scale items were asked. All the questionnaires were designed carefully under the supervision of physicists and educationalists. Several programmes of different durations (one-day to 10-week) were run by different instructors with students of different age groups. This paper focuses only on a 10-week programme with Year 9 students.

3 Results

A ten-week programme was run with sixty academically talented Year 9 students. The results are presented in Figure 1 below.

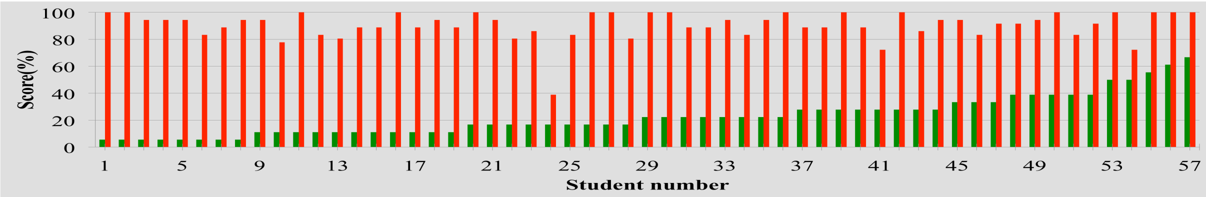

Fig. 1 A typical set of pre and post-test scores designed to measure students' conceptual understanding of basic concepts of light, space and time before and after a 20-lesson programme on Einsteinian physics in 2014. The histogram, ranked in order of pre-test score, shows that almost all students achieved a high level of conceptual understanding, rather independent of their pre-programme understanding which was generally low.

The figure shows that, in the pre-test, 8 students who scored less than 10% increased their mean score to 94%. This exceeds the mean score of the class, indicating that the learning outcomes are rather independent of the students' prior knowledge. We also found that the two students (student number 1 and 2) who had the lowest scores in the pre-test achieved 100% in the post-test. The 5 students who scored more than 40% in the pre-test achieved a mean final score of 94%. In the post-test, only one student scored below 50% (student 24). The paired sample t-test confirmed that there was a statistically significant increase in scores from pre-test to post-test.

We also found that females entered the programme with lower attitude as compared to male students but after attending the programme, their attitudes are comparable to males. Students' interest in physics was determined by asking the question "I think physics is an interesting subject". We found that male students showed high interest (80% students agreed) in physics in the pre-test and hence there was not much difference found after the programme. While, initially females were not as enthusiastic towards physics (40% agreed) but after the programme, their interest is higher than male students' in the pre-test.

To see how much students remembered about Einsteinian concepts, a delayed retention test was developed. Students' retention was tested after three years of the programme. The retention results show that students still remembered the name of the activities they did to learn the concepts of curved space, experimental geometry on curved space and photons.

4 Conclusion

The Einstein-First programme 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 programme 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.

References

[1] T. Kaur, D. Blair, J. Moschilla, W. Stannard, and M. Zadnik, *Teaching Einsteinian Physics at Schools: Part 1, Models and Analogies for Relativity*, Physics Education **52**, *065012*, 2017.

[2] T. Kaur, D. Blair, J. Moschilla, W. Stannard, and M. Zadnik, *Teaching Einsteinian Physics at Schools: Part 2, Models and Analogies for Quantum Physics*, Physics Education ***52,*** *065013*, 2017.