THE ROLE OF FRICTION IN ROLLING BODIES: TESTING STUDENTS' CONCEPTIONS, EVALUATING EDUCATIONAL SYSTEMS AND TESTING THE TEST

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Rotational motion forms an integral part of the physics curriculum in higher secondary schools of India. A host of novel concepts are associated with this topic: center of mass, moment of inertia, vector nature of angular velocity and acceleration, angular momentum and its conservation, torque etc. There are other concepts which are carried over, sometimes in modified form, from particle mechanics. We call them transitional concepts. One such transitional concept is the force of friction.

We have prepared a small but carefully designed inventory of multiple choice questions to probe students' understanding of the role of friction in rolling bodies. The Friction in Rolling Bodies Inventory (FRBI) was prepared after consulting a host of text books and references (Puri, 1996; Salazar et al, 1990; Barvos and Musiova, 2004; Pinto and Fiolrais, 2001). The content validation of FRBI was done by an independent group of experts in the field.

We then studied the students' response to our FRBI. The students were from variety of backgrounds and from different parts of the country. The first group of students were from semi-urban background who have studied physics in their regional language (Group I). The second group of students came from urban background and have English as the medium of instruction (Group II). We have probed a third group of students, namely those who have undergone extensive tutoring in expensive coaching classes. As is well known, there is a parallel educational system in the country. Students attend their schools as a mere formality; they invest their time in these coaching classes in the belief that the extensive tutoring provided by these classes will help them in securing admissions to highly competitive professional courses. We have administered our FRBI to this section of students also (Group III). Finally we had a select group of the top 250 students who were chosen from a national exam in which over 25000 students participated. These students are from urban background, mainly from schools in which the medium of instruction is English, and have also undergone training in coaching classes (Group IV). Thus the survey probes not only the students' misconceptions about friction but also evaluates education systems such as traditional schools and elite coaching classes.

An additional question of concern relates to the goodness/efficiency of our inventory. For multiple choice questions one would like to develop better questions and better combinations. There exists statistical measures in education measurement theory which can be employed to test the goodness of the questions. We have evaluated the difficulty level of the question by relating it to the percentage of students who select the correct answer choice. The smaller the percentage, the more difficult the question. Another indication of the goodness of the question is the presence of an effective distractor. The effectiveness of a distractor is measured by the percentage of students selecting a particular incorrect answer choice. We have also examined students' response to the

two related questions in our inventory. A correct response to both questions constitutes a consistency check. It implies that the students' understanding is good. Contradictory responses indicate the presence of guess work or deeper misconception on student's part.

In addition to the above mentioned traditional method, we have employed an analysis based on item response theory (IRT) to measure the goodness/efficiency of our FRBI. We draw on the work of Drasgow et. al. (1995) who have fitted polytomous item response theory models to multiple choice tests. IRT permits us to numerically estimate the difficulty level of a question, the discriminating nature of the various choices in the question, and the presence and extent of possible guesswork in answering the question. We evaluate the efficiency of questions in our inventory based on IRT (Lord, 1980). We find that the FRBI diagnostic test should be improved.

We have surveyed over a thousand students. This is perhaps the largest survey for testing science misconceptions at the higher secondary school level. Our work constitutes a revealing commentary on student types, educational systems and on the test itself.

Acknowledgment

This work was supported by the Science Olympiad Programme and the National Initiative on Undergraduate Science (NIUS) undertaken by the Homi Bhabha Centre for Science Education - Tata Institute of Fundamental Research (HBCSE-TIFR), Mumbai, India.

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