Enacting planets to learn physics

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Abstract. The Solar System motivates students to interest themselves in sciences, as a large number of concepts may be easily introduced through the observation and understanding of planet's motion. Using a large representation of the Solar System at a human scale ("a human Orrery"), we intend to show that the participation of the learner and its cognitive activities are enhanced as he enacts planets. In the last three years, we have conducted different activities with 10 to 16 years old children. Their impact on motivation and learning of science will be presented and discussed.

1 Introduction

In 2013, a program called "kinaesthetic activities in teaching science and humanities" was granted by Sorbonne University, France, connecting UPMC (departments of physics and biology), and Paris Sorbonne (departments of sports, Italian, and ancient Greek). A "human Orrery" was thus created (Figure 1, [1]), allowing the learners to enact the planets' movement with correct relative speed. Topics such as inertial movement, velocity-duration-distance and force-velocity relations, known to be difficult, can be refined and perceived by the learners' body.

The Orrery has been used in France and in Lebanon in different pedagogical contexts with 10 to 16 years old pupils [2]. This empirical work is based on the cognitive science theory of enaction [3] that is already well known and widely used in Science and Mathematics Education [e.g. 4; 5; 6].

Fig. 1 The "Human Orrery": Pupils enact planets (Mercury to Jupiter), asteroids and comets (in black) along their orbits around the Sun

2 Pedagogical sequences

Convinced by the attractiveness and usefulness of the "Human Orrery", our objectives are to advocate its use within the French national public schools and to evaluate its impact both on motivation and learning. Topics of different sequences tested since 2015 are described briefly.

(i) Construction of a human Orrery. The description of the Solar System involves different length scales from the diameter of the planets to the distance between planets and the length of one orbit. It also involves different duration scales from the rotation to the orbital period. The construction of a Solar System implies a choice of length scales and orientation and the drawing of ellipses. The links with mathematics is obvious, including placement on a 2D plan, Euclidian division and simple geometry. The momentum generated by such an activity is impressive particularly with struggling pupils.

(ii) Enacting planets to learn physics. In the last 3 years, planets have been enacted by undergraduate students in Paris as well as pupils of six schools in Paris, Nantes, and Beirut on their own Orrery or on Sorbonne University one. Through the eccentric orbit of a comet, students have realized why force and speed are not related, what is the meaning of the work-energy theorem… 16-year-old students have observed, measured and plot Kepler's laws… 12-year-old pupils have experienced that a larger distance may be travelled in a larger amount of time if the velocity is smaller… and 10-year-old pupils have made a movie about shooting stars (encounter of Earth and a comet during the night).

3 Results

The Human Orrery has been used in seven places and is the object of a teacher training session in 2018. We have used questionnaires and interviews to quantify the amount of learning and the motivation. In [2], we have observed an enhanced understanding of kinematics concepts through an experiment conducted during three years with 16-year-old students. The motivation scale developed by [7] will be used in current and coming sequences to ensure a higher reliability of the results. During this talk results from [2] as well as new results from different sequences applied in 2017-2018 will be presented.

References

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