CENTRE OF MASS IN MOTION - CONCEPTION AND REALIZATION OF A SCHOLA LUDUS EDUCATIONAL PROGRAMME

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INTRODUCTION

A typical SCHOLA LUDUS programme is a complex educational module consisting of four complementary parts, each one of important function within the entire educational process:

- Interactive science theatre/show as a motivating activity with respect to a subject to be learned,
- Interactive exhibition as an activity stimulating to experimentation,
- Creative-discovery workshop for development of creative and complexity thinking skills and building systematic knowledge,
- Game-competition as a complex assessing activity.

Educational conception and realization of SCHOLA LUDUS programmes are based on theory of teaching and learning [1, 2 and 3]. The goal of SCHOLA LUDUS is to form complex teaching-learning units focused on chosen basic physical concepts including current science topics supported by modern technology and applications. In past years, we have prepared and realized educational modules centred on different topics, such as surface tension, Archimedes principle, motion and its visualization, sound and centre of mass [4].

In this contribution we present briefly the conception and realization of the creative-discovery workshop on "Centre of Mass in Motion" module addressed to secondary schools. Shortcuts of basic SCHOLA LUDUS educational concepts are as follows:

- CDW (Creative-Discovery Workshop)
- TLC (Teaching and Leaning Cycle)
- KC (Key Case)
- PC (A set of Parallel Cases)
- TC (Top Case).

CONCEPTION

A CDW [3] is a core activity of a SCHOLA LUDUS programme dedicated to students´ conceptual changes. The design of CDW is based on SCHOLA LUDUS TLC [2]. The KC of TLC on "Centre of Mass in Motion CDW" - motion of a strongly inhomogeneous symmetric box in the air is applied systematically in each level of TLC. The stages of the TLC are following:

1. Description:
   The box is thrown repeatedly (KC) - observation, drawing and description of the KC strange motion.
2. Mapping:
   Observation and sketching of motion of similarly thrown bodies: the strong inhomogeneous box, a perfectly homogeneous box and a rubber hammer (PC) (Fig. 1). Are body motions similar in some way? What are the differences?
3. Modelling:
   Observation and sketching of trajectories of the inhomogeneous box points – its corner, geometric centre and a specific point (centre of mass) (PC). Specific point trajectory is similar to a bullet's trajectory but it is definitely not the geometric centre trajectory (Fig. 2). What kind of special point is it?
4. Abstracting:
   Solving the mass distribution of the inhomogeneous box. Comparing the trajectory of the inhomogeneous box centre of mass with a bullet and its centre of mass trajectory (PC). Can we represent the motion of a body by its centre of mass motion?
5. Imbedding:
   Dealing with the stroboscopic photographs of balls, a hammer and a pen motion in the air (PC) (Fig. 3) [5] - compound motion. A moving body can spin around its centre of mass and move itself "straight" at the same time. A decomposition of the body compound motion with respect to its centre of mass is valuable when describing/understanding and/or predicting/constructing the system behaviour. Let us use concept of compound motion to a system of several bodies, like a system of Earth-Moon-Sun!
6. Appropriation:
   Students' appreciation of compound motion is gained by dealing with the Earth and the Moon around the Sun motion (TC). Students´ task is to sketch, step by step, in this order:
   - Trajectory of the centre of mass of Earth-Moon system around the Sun,
   - Trajectory of the Moon around the Sun and
   - Trajectory of the Earth around the Sun.

Having in mind the concept of the centre of mass students get a surprising result – the Earth is "waving" around the Sun (Fig. 4)! Of course, the scaling is not correct but the effect is present and sometimes also very important, e.g. at spacecraft navigation.

REALIZATION

All series of parallel cases are demonstrated by a facilitator. He or she throws objects repeatedly in a way of projectile motion. Students observe/deal with the processes and draw the pictures of them into their work sheets (See examples in Fig. 1, 2 and 4), formulate their own findings and conclusions.

Realization of the TLC on centre of mass in motion is supported with multimedia presentation including sequential pictures and slow motion video recordings of rubber hammer in the air and animation of Earth-Moon motion around the Sun.

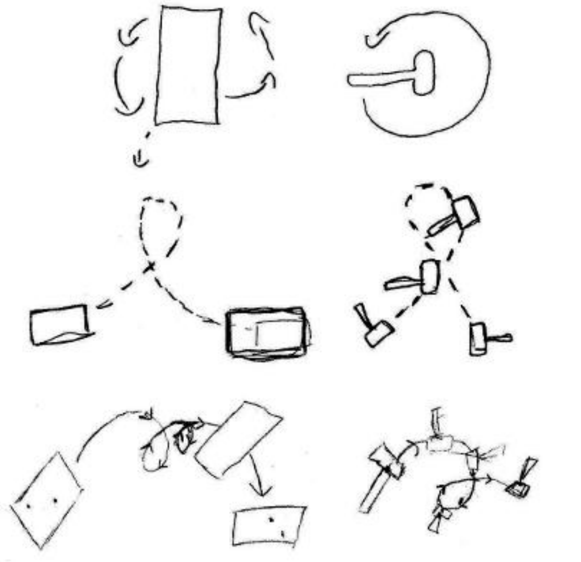

Fig. 1. Example of three students' drawings of homogeneous box and rubber hammer motion in the air (mapping level of TLC). Different motion visualizations.

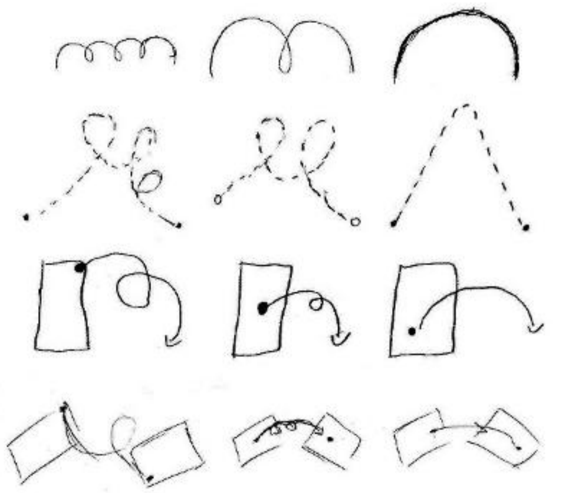

Fig. 2. Example of four students' drawings of trajectory shapes of inhomogeneous box corner, geometric centre and centre of mass (modelling level of TLC). Different trajectory visualizations.

CONCLUSIONS

During the CDW realization, students effectively understand the centre of mass as an outstanding physical point of the body/system of bodies with respect to its motion, as a representative point of the body "straight" motion, and a point around which the body rotates. In this way, students deepen their basic concepts of translation and rotation motion towards the complex motion based on the relationship between body motion trajectory and its centre of mass motion trajectory.

In addition, students are improving their pro-scientific thinking, developing their systematic creative cognition skills (by making use of analogies and models), visual thinking skills (by making their own sketches, understanding photo sequences), etc.

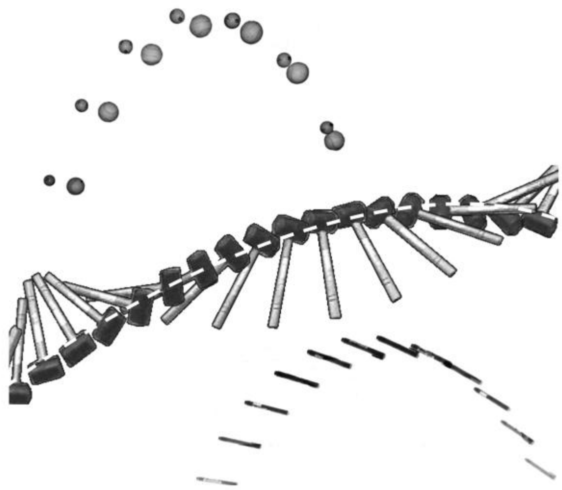

Fig. 3. Example from multimedia presentation. Stroboscopic photographs of balls, a hammer and a pen motion in the air (embedding level of TLC).

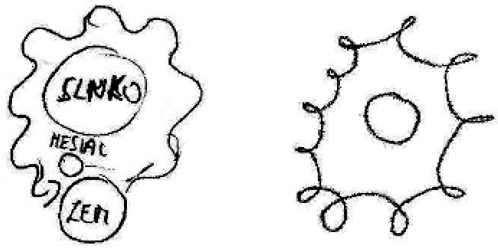

Fig. 4. Top Case problem solution. Example of students' drawings.

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