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Making a fun Cartesian diver: a simple project to engage kinaesthetic learners

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Abstract
Students in the normal technical stream are generally less academically inclined. Teaching physics to them can be a challenge. A possible way to engage such kinaesthetic learners is to encourage them to fabricate physics-based toys. The activity described in this article shows how a group of three students were able to come up with a creative version of a Cartesian diver that incorporates game elements and physics principles, as well as uses only recyclable materials.

Introduction

Teaching physics to students in the normal technical stream remains a challenge in Singapore. These students are less academically inclined and are kinaesthetic learners by nature. Teachers find it a challenge to tap into their preferred learning styles in order to fuse these into their physics lessons. The students need to be given opportunities to engage in hands-on and minds-on activities that would allow them to express their creativity.

A possible way to deal with this is to encourage the students to make physics-based toys [1]. In a recent article in this journal, Fischer stresses that creativity breeds the best physicists [2]. Students who make these toys can express their creativity in a number of ways, for example, by incorporating a play element into their design. Whilst doing this they encounter the physics principles behind the operation of the toy.

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This adds value to the existing structured practical work done in the laboratory.

This article illustrates how a simple Cartesian diver is interpreted by a group of three students as they set out to reproduce it using simple recycled materials. A group activity was selected for two reasons: to capitalize on the synergies arising from the joint interactions during brain-storming sessions and to harness the innate technical skills of the students. Incorporating science in the design [3] allows students to blend physics principles with design elements.

A number of Cartesian diver toys are commercially available—for example, the Sea Diver and Dyna-Diver [4], and the Hook Cartesian Diver [5]; they can also be made from materials such as ketchup sachets and polyethylene (PET) bottles [6].

The fun Cartesian diver described in this article is similar to the Hook Cartesian Diver in that it not only demonstrates some principles of pressure and density but also incorporates a game

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Figure 1. A version of the fun Cartesian diver.

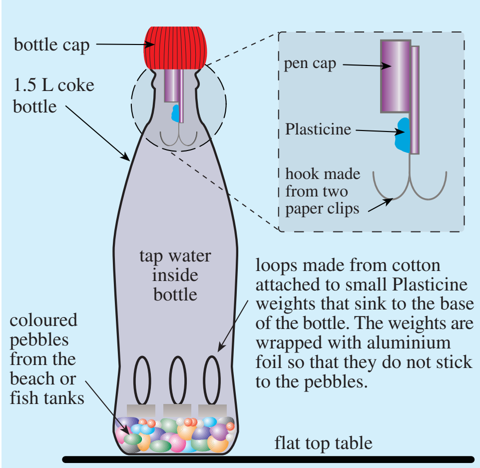

Figure 2. Details of the fun Cartesian diver.

element into the design of the toy. The differences, however, are in the design and difficulty level of the game. The version described in this article is made entirely from recycled materials and the difficulty level is raised further. In contrast, the Hook Cartesian Diver retails at US$19.95 [5] and is straightforward to play as a game.

Methodology

The three students were shown a working model of a simple Cartesian diver (made from a plastic bottle and ketchup sachet) and given a demonstration of how it works. They were then asked to use their ingenuity and practical skills to transform the demonstration into a game using everyday materials. At the end of the project, the students had to hand in a short portfolio and poster describing their fabrication process and the science they had learnt while making the toy.

The fun Cartesian diver that they came up with is shown in figures 1 and 2. The following materials were used in making this toy:

- 1.5 litre Coca Cola™ PET bottle (plus cap);
- pen cap from a ball point pen (the kind with small holes at the top);
- two paper clips;
- lump of plasticine;
- cotton thread;
- coloured pebbles;
- masking tape;
- tap water.

The pen cap is partially submerged in a beaker of water and the holes at the top sealed with plasticine; this traps a column of air inside and allows it to be used as a Cartesian diver in the bottle of water. Additional pieces of plasticine are stuck to the sides of the pen cap so that it floats upright just below the surface of the water in the beaker. It is then transferred to the bottle of water. The rest of the details of the set-up inside the bottle are shown in figure 2.

The series of plastic-aluminium foil loops (four in number) need to be of small enough mass that the upward force exerted by the ascending Cartesian diver (pen cap, plugged with plasticine and linked to a hook) is sufficient to lift them from the pebbles. This has to be determined by trial and error, and is one of the learning aspects that make the design of the toy challenging. As the loops may not be vertically or angularly aligned for easy hooking by the Cartesian diver, it makes the game more difficult. In contrast, in the commercially available Hook Cartesian Diver [5], a wire is used in place of the string and this allows for straightforward hooking by the diver.

The objective of the game is to grab as many loops as possible within a set time. To someone

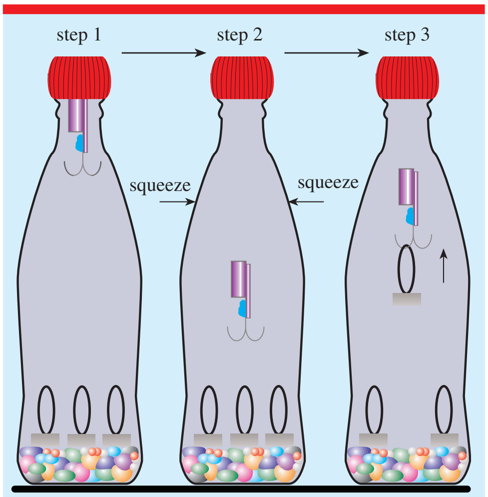

Figure 3. Retrieving the loops adds a play factor to the invention.

who is not familiar with the concept of pressure in fluids, it is not easy to retrieve the loops because no amount of turning the bottle in random directions would make the pen cap with the hook (the diver) sink to the base of the bottle.

To lower the diver, the player squeezes the bottle which makes the diver move downwards (figure 3). The player then tries to manoeuvre the hook to grab as many of the loops as possible. Getting one is fairly easy; more can be challenging but is not impossible. By carefully controlled squeezing of the bottle, it is possible to manipulate the hook to grab a number of loops.

Discussion

We have seen that it is possible to engage normal technical stream students in an entertaining yet instructive physics-based activity that suits their learning styles. The play element raises the level of challenge of the activity and offers tremendous scope for the incorporation of creative elements in teaching science.

The study underscores the value of using an approach that builds on a variation of a demonstration. Just asking students to create something from scratch can be a formidable exercise—they may not know where to start as they are not equipped for the task. On the other hand, if they are asked to create a variation of something that they have already been shown and given instructions on incorporating play elements, the creative effort need not be overwhelming.

The students performed well when they were able to fuse their design and technical skills into their invention. They seemed very proud of this toy and improved its appearance by shaping masking tape in the form of sea weed and fish, and sticking these onto the bottles. This invention made it to the final round of a prestigious toy invention competition in Singapore. It shows that given the right opportunity and environment, normal technical stream students can display their ingenuity in applying physics principles through a hands-on design approach.

This project also had a positive impact on the students' attitudes towards learning physics. As the students built the toy they also learnt the concepts of density and pressure in greater detail by reading books and browsing the internet. They also enjoyed staying after school hours to complete this project; the students took about a week in coming up with a working prototype and assembling their portfolio and poster. The students have also expressed interest in taking up courses in science and engineering after leaving school.

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