Teaching Science with Toys.
Toys and Physics

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Abstract. Physics is frequently rejected by Spanish secondary school students because of the science curriculum difficulty. As a result, secondary school students do not appreciate the importance of physics and technology in many aspects of their lives. Only students that understand the importance that physics has in our society will study sciences or technology. The lack of curiosity and attention to physics (part of chemistry and physics subject) is difficult to tackle and is normally accompanied by a loss of general motivation to learn science. The purpose of this article is to present and discuss the educational experience “teaching physics with toys” a strategy to introduce physical and scientific knowledge to the secondary school physics classrooms. Finally, participant students work as a team in disseminating their knowledge in several presentations: to the classmates, to the Badalona secondary school scientific days and to the parents.

Keywords: Physic concepts, Scientific toys, Secondary school students, Spreading science.

1. Introduction.

The Spanish policy on education [1] differs in each one of the 17 Spanish Autonomous Communities with their own independent education system.

Our results derive from Catalonia [2, 3] students. In primary school education (children up to the age of 12 with 6 levels) hasn’t any mechanisms to promote science. In contrast, the science curriculum established for secondary education includes several subjects such as Biology, Chemistry, Physics, Maths, and Technology.

Secondary education in Spain is divided in two periods. The first, which covers children up to the age of 16 (four levels with a chemistry and physics as a unique subject), is compulsory. While the second, involving 16-18 year old students (two levels with two separated subjects, chemistry and physics), is comparable with high schools in several countries. After completing this stage, students sit a common university entrance exam.

Nowadays, a decrease in science motivation is present when students are learning science in general and physics as well. The heart of the problem lies in their lack of interest in science [4] in physics for us. We have to consider at least two factors that can explain the lack of interest in physics: the loss of contextualization and the difficulty to realize experiments.

In this way, good teachers start instructing on physics with what is familiar and known by students, and build on what is unknown, “to teach a child, find out first what they know and then build upon it” [5, 6].

In addition, physics’ teachers spend less time doing experimental activities and spend more time talking in the class. In some cases, physic experiments show some questions very far to students’ lives but end up playing the method of a lecture class, more as a physic experiment. It is known that experimental work and new technologies (developed in the classroom or school laboratories) are valuable resources to increase motivation of students in science as well in physics.

It is essential to promote physics among young people if we want to improve their understanding on this field of science.

Consequently the purpose of this article is to implement a new educational experience with the aim to relate physical knowledge and toys among secondary school students in their last compulsory year. By building a real bridge between physics and these special students is an excellent strategy to introduce scientific knowledge to the secondary school physics classroom.

2. Toys

Discovering things by playing with toys is common in childhood and is the first approach to science “children know that things fall down onto the floor. Why? Because they had proved it by playing at home”. We define a toy as an object which presents several characteristics, elasticity, color, movement, etc, which stimulates children activities. The relaxation function of playing with toys are also remarkable, using them like a didactic resource is synonymous of diversion.

Furthermore, several popular toys have had adaptations to the cinema: G.I.Joe, the store of Mr. Magorium, Toy Story, Toy Story 2, Doraemon and the toys’ factory, and more. All together leads us to start with this approach on physics and toys.

3. How are scientific explanations built?

“How teaching physics with toys” is a teaching resource that not only introduces scientific knowledge to the secondary school physics classroom, but also it allows students to build a scientific explanation about some daily physical activities [7], events and processes in the world.

It is generally accepted that for building natural physical explanations the next steps are required.

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It begins with the event observation followed by its description; students had to answer many questions like “When…where… how does this phenomenon happen?” The observations are psychological phenomena and then they have to be described, written or verbalised in an understandable language and finally in a mathematical way.

Afterwards, it must be distinguish or guess the relationship/s between all the event components by answering “Why… how is A related to B?” Then, the experimental design is arranged, measurements and results analysis from experimental part are used to confirm the relationship predicted. Thus, students prepared their experimental approach by answering “How is A known…how could A law be demonstrated…how can we do it?”.

Finally, if results confirm the previous hypothesis (prediction) a generalisation will be made, a model will be proposed to represent this phenomenon [8] and it can be used to solve new situations. Figure 1 shows us the steps from observation to generalization that secondary school students had developed and understood in the whole of their attempt.

4. Students activities.

“How teaching Physics with Toys” switches on the crossing point of physics and education. Students perform a series of key secondary school activities with toys related to physics’ laws. The participation of the students, aged 15 to 18, is voluntary; this activity was not evaluated in students’ formal curriculum.

Students enrolled in this venture were divided [9] into groups of two; each one studied and presented 4 to 6 toys or common objects. Every student had to prepare, at least, two of them.

4.1 Methodology.

The methodology attempt consisted in a series of toys or common home objects that were given to voluntary students. These toys and objects are supported on the basic laws of physics. Then students tried to explain the physical laws related with each toy or object by answering many questions. Here we present the most important ones such as:

- Question (toys/objects and the physics’ laws related with them)
- Can our senses lie to us? (Two equal figures seem one taller than the other).
- Why do you seem different according to the side from the spoon in which you are
• How does the thermometer of Galileo work? (Thermometer of Galileo; relationship between density and temperature).

• How is mechanical energy transformed into movement in a tin train with a coil spring? (tin train, tin car both have a coil spring that store energy and then release it to maintaining the train or car movements).

• How do radios and torches work without batteries? (Radios or torches, without batteries; mechanical energy transformed into electromagnetic energy).

• How do we study the waves with springs? (Coloured springs, springs and dynamometer; wave’s rules and Hooke’s law).

• What happens when two balls contact in an elastic shock? (A basketball, a ping-pong ball and Newton’s pendulum; energy conservation and laws of motion demonstration).

4.2 Toys and Physics Demonstrations.

Experiments about physics increase students’ interest and generate a positive reaction from students. They understand that physics’ laws are discovered by experiments and, by new experiments their could be changed (a little bit).

Students worked on how our event’s observation could be erroneous; the reflection laws; temperature and density; mechanical energy changed into movement; torches without batteries, Newton’s pendulum and elastic shock; springs, dynamometer and Hooke’s law; equilibrium, balance and gravity centre position; a twister into a bottle and so on.

Here we present some of the studies performed by secondary school students last year.

In figure 2 you can see an example how our senses can lie to us. These two figures appear to be one taller than the other one but, in fact, they are the same size. This example showed us how important measurements are in science experiments, or in physical ones for us.

In figure 3 the student face is reflected in the two spoon sides, in Fig 3a in the concave side and in Fig 3b in the convex side. These images are completed with the graph that shows us how the image is obtained in a concave mirror and also in a convex one.

In Figure 4 you can see two Galileo’s thermometers, one of the first apparatus that could measure the temperature. It is interesting to explain how it works; temperature is measuring by de difference of density between several liquids inside the Galileo’s thermometer. Obviously, it could be used to study the density of liquids and its properties.
In figure 5, several moments in a tin train motion you can observe. The coil spring transform mechanical energy into movement. When the coil spring is winded up and you let go of the tin train the mechanical energy is transform into motion.

In figure 6 a torch without batteries can generate light by transforming mechanical energy into electromagnetic energy. Here you can see the different parts of the torch, A shows us the mechanical elements, B the electromagnetic ones and C the torch in use.

In figure 7, a Newton’s pendulum was used to study the energy conservation in an elastic shock and laws of motion. Students moved one ball against the others or two balls together and shocks and movement were analyzed.
4.3. Students as teachers.

These interested students collaborated in how better to understand the physical processes and in the final presentation with the video recording their experiments. Finally, they worked as a team in disseminating their knowledge in several presentations: to the classmates, to the Badalona secondary school scientific days and to the parents.

It has demonstrated the importance of the argument in science teaching [11]. We have also tried to use this methodology for developing students’ abilities. Thus making arguments with students opens their minds to present and discuss more questions related with a unique physical event that they have worked with toys.

When working on physics with toys is finished we trained our students the necessity of teaching physics to everybody. It is very important to spread science between society in general with the purpose of creating a scientific culture. For this reason, we persistently wanted to collaborate with students to disseminate their investigation-work in three different ways.

1. So they became physics teachers in their owner class, they explained toys and physical laws to classmates. This activity is a valuable experience because students have to prepare a written work, have to understand the physical event and, the most important thing, have to teach their three-four months work to the classmates in a comprehensible language. It is the first step in reinforcing their knowledge in physics.

2. During the “Badalona secondary school scientific days” [10] students prepared a video showing toys and objects functioning and it was explained at the conference room. At that moment they had to present the video recorded with their own explanations, to other students and science teachers from several secondary schools. Finally, students answered correctly many questions placed by the audience. This experience is the second step in reinforcing their knowledge in physics.

3. Finally, Spanish secondary schools have an “open day”. This gives to students the opportunity for a new public presentation. Toys and physics laws were presented and also explained by the students in front of the futures secondary school students and their parents; they were coming from different schools (primary and secondary ones). This meeting was conducted in the school physics laboratory. A good dialogue and discussion about play with toys and learn physics was supported by a relaxed atmosphere and took place among these “new physics teachers”, parents and futures secondary school students. There is always a science teacher supervising this event. This meeting is the third step in reinforcing their knowledge in physics.

5. Conclusions.

M. Clara San-Bento wrote [12] “creation, transmission and appropriation of Science require effort, methodical work, persistence,... sometimes sacrifice, always triggered by curiosity or necessity”. With our experience we can change these words by “learning and transmitting physics require curiosity, methodical work, effort, persistence and sometimes sacrifice” with this point of view the educational approach was developed.

This educational work has contributed to:
- Using toys and objects commonly found at home, students developed their research without special laboratory material.
- Observing and understanding common physical phenomena were easily created from these toys and objects and wake up students’ curiosity.
- Emphasizing the presence, interest and study of physics topics in secondary school classroom.
- Increasing students’ implication in their activity, preparing written and oral presentations. Students have to realize a methodical work.
- Reinforcing the interest and general study of science.

As a consequence:
- The use of the toys within the classroom with the purpose of teaching physics is, without a doubt, an excellent didactic procedure and it wakes up the curiosity in students fomenting its creativity and participation.
- This activity leaves the classroom because families and friends are implicated in students’ project, it is very important to spread science between the public in general with the purpose of creating a real scientific culture.
This is an approach that science secondary school teachers could directly apply in their classrooms of physics. The final objective is that the young people, our future society, incorporate and propagate basic physics knowledge that in the future allow them to make their own decisions on the resolution of scientific problems in our society. “Teaching physics with toys” could help us to achieve our aims.

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7. References