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The role of models in science: an experience with *Drosophila*

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Abstract

Model organisms play an important role in conveying biological concepts. They are more amenable to asking certain questions due to their simplicity of structure and features. The fruit fly *Drosophila melanogaster* has been the most popular eukaryotic organism used in classrooms, with a short life cycle of two weeks, making it possible to study numerous generations in a short period. The use of *Drosophila* is a powerful tool also in teaching Life Sciences. In fact, it allows the observation of sexual dimorphism, of mutants and of the life cycle.

Keywords: conveying biological concepts; Drosophila Melanogaster; teaching Life Sciences; Italy; life cycle

1. Introduction

The Board on Science Education of the National Academies conducted during 2007 a study for analyzing some common places on the potentialities of children to learn the sciences and - accordingly - on the priority of the sciences in the elementary schools (Duschl et al., 2007). Adults play a central role in promoting children's curiosity and persistence by directing their attention, structuring their experiences, supporting their learning attempts, and regulating the complexity and difficulty of levels of information for them. In the sciences, both teachers and peers can and must fill these critical roles. To be successful in science, students must be engaged in carefully structured experiences that extend their learning well beyond that which could usually be achieved in traditional approaches. All children bring basic reasoning skills, personal knowledge of the natural world, and curiosity, which can be built on to achieve proficiency in science.

Students' knowledge growth and reasoning are components of a large ensemble of activities that constitute "doing science." These activities include conducting investigations, sharing ideas with peers, specialized ways of talking and writing, mechanical, mathematical, and computer-based modeling, and development of representations of phenomena. To develop proficiency in science, students must have the opportunity to participate in this full range of activities.

All children have the intellectual capacity to learn science. Even when start school, children have a rich knowledge of the natural world, perform causal reasoning, and are able to distinguish between sources of knowledge

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reliable and unreliable. In other words, children arrive at school with the cognitive capacity to engage seriously in the enterprise of science. However, it emerges that the student at the end of high school, posses the scientific knowledge that seem founded on the common sense and daily experience, rather than on what has been taught to school. Despite their love of gadgets and technological wizardry, too many young people see science as being uninteresting, distant and, above all, ‘uncool’. This has translated into a gradual reduction in the numbers of young people pursuing science and technology studies and careers, with a great loss for the economic and social system.

The reason of this data is a science too specialistic and based on merely factual knowledge, a great deal of information and a scarce attention to the direct experience. It is necessary rethinking science! The science must become attractive and captivating to the eyes of student. How? How to stimolate the scientific learning? First of all, must modify the way to do science. Some teacher underline the importance of experimentation, others the importance of the planning, some have a preference for a playful formulation or the historical profile of the science or still the existing bonds between sciences and society, others still attribute a lot of importance to the direct intervention of the researchers in the classroom. Practically all arrange on the importance of the activities of laboratory; the importance of such approach has been shown through experiences what “La main à la pâté" (finger in the pie). Interactive demonstrations strenghten students' abilities to observe, and stimulate questions and discussion, a pedagogic approach called "Hands on" (Haury & Rillero, 1994). Afterwards, the simple “hands on” must widen and develop into “eyes on” and above all “mind on “.

In order to draw people (especially young people) to the world of science, has been created the European Researcher’s Nights. This event, launched in 2005, under the "Researchers in Europe" initiative, offered to a large public a unique opportunity to discover researchers and their magic world.

In the framework of the European Researcher’s Nights 2009, the event “A night in the lab-2” with his/her interactive laboratories, has taken place on September for all the day at Indro Montanelli Park in Milan, Italy. The purpose of this initiative was to allow ordinary people to meet researchers in an informal setting. The main aim of the proposal was to bring researchers, involved in biomedical research, closer to the large public, without any distinction of age, gender, level of scientific training or social category. The proposed action intended to oppose the stereotypes about researchers and their profession, giving the opportunity to perceive them as ordinary people (Pealez & Gonzalez, 2002). On the other hand, in the last years, people have asked to biomedical researchers for more information about their work and the effect on public health.

Fun, hands-on, interactive activities as well as informal dialogues on topical issues had been offered at each event along with a variety of cultural expressions. These innovative and exciting activities were allowed for public engagement and meetings with researchers in relaxed and festive environments. The events aimed at showing that researchers are ordinary people with extraordinary jobs and that research is all about communication and international cooperation. Children and adults had the opportunity to understand science by experiencing its day-to-day practices, by frequenting the spaces and places where research was carried out and by coming into contact with its machinery and equipment, but above all by talking to those directly involved. The public participating had been actively involved in hands-on experiments, in a relaxed and friendly atmosphere, using also an accessible wording for non scientists. This project can be done with just about any age group and topic.

Therefore, showing a researcher from inside, stressing his/her ordinary features could help in attracting people to scientific careers and rise the perception of the role of researchers in our society. The proposal foresees the organization of a high impact event, giving an opportunity to young and adult people to meet researchers involved in biomedicine and nano-medicine, to see them at work and to work with them, taking part in real laboratory activities. Buffet, music and a drama show entitled “The day of a researcher” created an informal and pleasant atmosphere. Local institutions supported the event. Sophisticated instruments had also been shown and used during the laboratory activities. The “scientist *in piazza*” is a common outreach model that seeks to bring to students the content expertise and enthusiasm of practicing professional scientists to stimulate student learning, interest in science, and consideration of science careers. In a short-duration activity the scientists may give a presentation, lead a hands-on activity, or discuss scientific careers with students.

Students engaged in a group scientific experiment to answer a question of their choice pertaining to the current topic of study. Students went through all steps of scientific inquiry that scientists go through when they do research. Students used the scientific method to answer their question engaging in cooperative activities to complete their goals. Students need to know how to use the scientific method. They also need to successfully work together in a cooperative group to complete this task, and engage in other skills, such as writing, producing graphs, and making artwork for their display. At the end of the experience students will have their own "science fair" within the class. Parents often appreciate being invited either to a classroom science fair during the day or to a repeat performance of the science fair during the evening. A topic of inquiry may be chosen and students will choose a research question related to that topic. For instance, the current experience took place on the *Drosophil*a model and students choose a research question pertaining to *Drosophila.* Short-duration intervention strategies are based on a change model (Seymour, 2002) with the premise that developing interest and enthusiasm around science, having positive experiences with science, meeting science role models will translate down the road to more students pursuing advanced science education in high school. In the scientific community animal models are an important mechanism for advancing scientific understanding (Gilbert & Boulter, 1998). Science instruction should be designed to engage students in making and using models where possible. Significant parts of scientific investigation are carried out on models rather than on reality itself because by studying a model we can discover features of and ascertain facts about the system the model stands for; in brief, models allow for surrogative reasoning (Swoyer, 1991).

If scientists use models as 'thinking tools', shouldn't students also use them? Teachers can use models to help students make sense of their observations, and understand abstract ideas through the visualisation of objects that are too big, too small or positioned so it is difficult for them to be seen easily or of processes that cannot easily be seen directly and of abstract ideas.

When using a model of any type with groups of students it should be made clear to them that it is a model they are using. A teacher cannot guarantee that the way he sees a model, or wants the students to see it, is actually the same way that the students do. It is important to introduce the idea that models can change over time and that models need only be 'good enough' to explain a particular concept or idea to meet the needs at that time.

Science students who become actively involved in using models in their learning have been shown to gain a deeper understanding of the concepts and processes about which they are learning.

The fruit fly *Drosophila melanogas*ter, a little insect about 3mm long, has been used as a model organism for research for almost a century. Today several thousand scientists are working on many different aspects of the fruit fly and it is so popular it would be almost impossible to list the number of things that are being done with it. It was recognised by the award of the Nobel Prize in Physiology or Medicine to Thomas Hunt Morgan in 1933, to Hermann Muller in 1946 and to Ed Lewis, Christiane Nusslein-Volhard and Eric Wieschaus in 1995. The use of *Drosophila* is a powerful tool also in teaching the Life Sciences (Sinadinos, 2009) for the reason that a short vital cycle and large progeny make it possible to study numerous generations in a scholastic year; for the facility and low cost of growing in school laboratory in small tube; for the availability of several mutants; for the very long history in biological research. In fact it allows the observation of sexual dimorphism, of mutants and of the life cycle. Moreover it permits the realization of crosses aimed to demonstration of sexual linked characters and crosses aimed to establish if a mutation is conferred by a dominant or a recessive gene. *Drosophila melanogaster* has been a primary tool for geneticists since the early part of the twentieth century. The popularity of *Drosophila* as an experimental organism ensures that its genome sequence will be a valuable resource for research in genetics and medicine. *Drosophila* offers a way for teachers to help students make connections between populations, the organism, the cell, the chromosome, the gene, and the DNA (Siyad et al., 2005). We feel that the major value of doing the fly lab lies not in the genetics, *per se*, but rather in the opportunity to expose the student to a living animal which they rear and manipulate to generate real data. Often, a student will initially find a vial seething with larvae to be disgusting, but later that student will be found to be staring, fascinated, through the stereoscope/microscope at just such a vial. We made available to them several strains, including mutants (Fig. 1).

Figure.1: The drawings made by children during “A night in the lab-2”. Wild type male (A) and *Drosophila* mutant (B)

Cooperative groups of 3 preferably needed to be made. One approach to providing collaborative opportunities for students of biology is cooperative learning, a theoretically grounded and well-researched approach in education that can increase students’ learning of subject matter and improve their attitudes toward both academics in general and the subject matter specifically (Johnson et al., 2000). Many students claimed initially that they cannot see the difference between their stock and wild-type. They then continued observations. The basic scientific skills of reliability, consistency, and especially careful observations are strongly reinforced by these labs. Students later will do a search for current scientific informations on their topic and analyze these informations on how it relates to their topic. Students were invited to proceed to write a procedure for an experiment that answered their research question and to perform the experiment. To conclude the project, students prepared their finding for a classroom science fair, including a group presentation of their research and a display board. A formal write-up of all steps of the process has been a requirement, and helps students to realize the importance of written communication in the scientific process.

Statement of the problem being pursued is the question: what are the special characteristics of life of the living system *Drosophila*? A set of prelab questions were assigned through the class teachers 1 wk before the *Drosophila* laboratory: how work a living system? Have an unknown insect that you want to identify?

We provided fruit flies (Fig. 2A): one vial of each type of flies and sponge for every lab pair. It takes about one week for the flies to hatch upon fecundation, and two weeks for each subculture to increase the fly population to reach the size necessary for classroom use.

We proposed to students some activities:

-Drosophilae are moved from the test-tube where they live to "anaesthetic" tube“ where they are left few minutes whith CO_2 (alka seltzer tablets or dry ice). Have the flies pre-sorted into vials of 20 or so before lab. These flies can be immobilized when class starts. Chilling flies using crushed ice requires 5-10 minutes before they are manageable. Keeping them on ice afterwards also slows their revival.

-Flies are left on a thin cardboard and observed under a stereomicroscope. Students observed *Drosophila* sexual dimorphism: the female is bigger than male and abdomen is lighter than the male. The male has got a dark spot on posterior extremity of the body and a structure like a comb on the anterior leg to block the female during the copulation (Fig. 2B).

-Observation of *D.melanogaster* mutants: regarding the colour of the eyes, regarding the colour of the body, regarding the structure of the wings.

-Observation of the *Drosophila* life cycle.

At school students performed crosses. Crossed wild type (*wt*) male and female Drosophilae in a test-tube, made a series of passages in other test-tubes on the 2th, 4th, 6th, 8th and 10th day, and, after 10 days, they observed embrions, larvas, pupas and adults in different test-tubes. The *Drosophila* egg is about half a millimiter long. It takes bout one day after fertilisation for the embryo to develop and hatch into a worm-like larva. The larva eats and grows continuously, moulting one day, two days, and four days after hatching (first, second and third instars). Over the next four days, the body is completely remodelled to give the adult winged form, which then hatches from the pupal

case and is fertile within about 12 hours at 25°C. After the students have studied their flies for the 1- month period a discussion of data comparing results should occur.
What question does this activity help students answer?
1. How can I keep them alive? What do they eat?
2. How can I show my classmates this insect?
3. What unusual characteristics does my insect possess?
4. What is the result of crossing wt male with a mutant female?
This activity can be incorporated into several areas: health, bioethics, and genetics. Consisting of both a laboratory experiment and an in-class debate, we have found that this is one of students' favourite activities.
Laboratory exercises using *Drosophila* crosses are an effective pedagogical method to complement traditional lecture and textbook presentations of introductory biology. In addition, they allow instructors lacking *Drosophila* expertise to use this organism as a pedagogical tool.

Figure. 2 Students at work with *Drosophila* during " A night in the lab-2", Milan 2009.

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