Roots

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Education and technology: Responding to a global pandemic

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Cover Photo: A family interacts with a DBG instructor during a live virtual program (Denver Botanic Gardens/Scott Dressel-Martin)

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Authors: Antonella Grano, Luigi Forte and Mario C. De Tullio

← *Kids playing Game 1 ©Giovanni Signorile*

Botany is beautiful, but we need new ways to make it more appealing. Too many names and details that are hard to remember are often discouraging, especially for kids. The best way to overcome this problem is to get acquainted with plants directly in the wild, or in botanic gardens. Alternatively, we can use interactive computer games (serious games) to learn about botany with a bit of fun. Let's play!

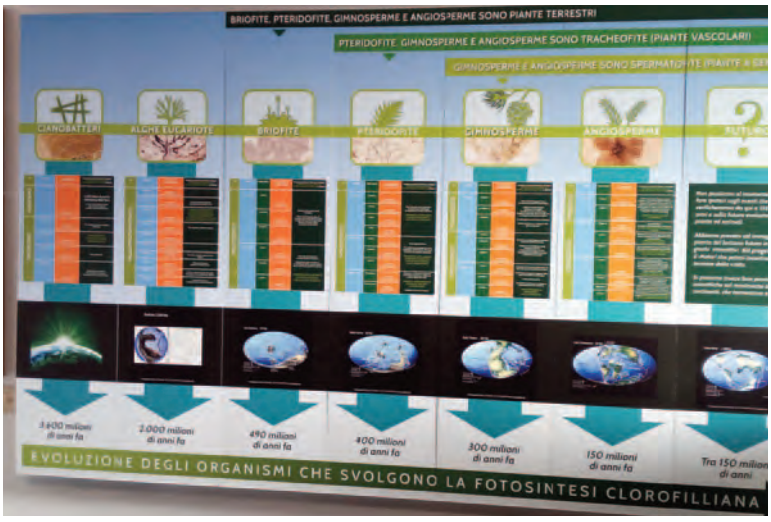
FUN AND SERIOUS: AN EXPERIENCE WITH INTERACTIVE GAMES IN TIMES OF DISTANCE LEARNING

Even though plants are everywhere around us and we all use them for the most diverse purposes, the psychological attitude known as plant blindness is surprisingly widespread. The definition of plant blindness (Wandersee and Schussler, 1999) includes the inability to perceive plants as living organisms, let alone appreciating the remarkable biodiversity found in the plant lineage as a consequence of a billion years of evolution. Spreading botanical education as a way of addressing plant blindness is a primary goal of botanic gardens, and should be a priority for all educational agencies and institutions. As part of the science communication activities of the Botanic Garden Museum of the University of Bari (Italy), we started the *E-Mo.Ve!* project, an acronym of the Italian *Evoluzione del Mondo Vegetale* (literally "Evolution of the Plant World"). Evolution was chosen as the main topic of this educational project because of its value as a strong unifying theme in natural sciences, especially relevant for developing "botanical literacy" (Uno, 2009). With the help of a small competitive grant from the Italian Ministry of Education, we set up a permanent exhibition with interpretive panels that place the phylogenesis of photosynthetic organisms in the general context of the changes that occurred during the evolution of planet Earth. Additional panels briefly trace the debate on biological evolution (from Linnaeus' immutable species to Darwin's concept of variation and selection), define the framework of evolutionary biology, and discuss the basics of molecular systematics.

↑ *Silurian landscape with horsetails*
Design: Mario De Tullio, Pooya srl.

"The game on flower development has been very useful to understand how gene expression works, and what a mutant is" Marco, 19 yo, 1st-year University student

↑ *Jurassic landscape with Cycas plants*
Design: Mario De Tullio, Pooya srl.



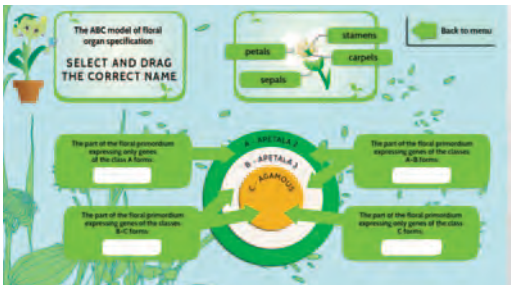
Since the very beginning of our project, we decided to include interactive computer games within the exhibition as a way of reinforcing key messages to visitors. However, we designed the games as stand-alone elements, so that they could also be used outside of the exhibition context. After several attempts, three games were produced. The first game was titled "**The time machine**" (in Italian, "La macchina del tempo") because it involves travelling back in time to see plants from past ages. Each level starts with a question that introduces Cyanobacteria, Eukaryotic Algae, Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms respectively. We did consider whether the addition of many algal taxa into the "Eukaryotic Algae" category would be too much, but in the end, we included these for the sake of clarity. After selecting one of the choices, the player travels to the desired geological era, going through the animation of a "time-tunnel", where tabs with the names and symbols of the six major groups of plants considered in the game are shown on repeat. One of the main challenges encountered by many Botany students is being able to remember the names of plants they have never heard of before. By repeating the names of the six groups, the players are more likely to remember them at the end of the activity, or at least the names become more familiar. Each activity is set in a scenario showing the main features of each geological era, and where possible the most representative animals of that time. Small animations and sound effects help to attract the attention of the player.

The graphic part of the games required careful consideration. Among the different possibilities, we opted for a cartoon-like layout to make the game more appealing for kids. The activities vary for each level, but they are all based on a "drag and drop" mechanism. After being instructed on the purpose of the activity, the player clicks on one detail (picture, name) and drags it to the right place on the screen. In case of error, the detail bounces back to its initial position, otherwise it sticks where the player placed it. For example, this mechanism is used in one level (Cyanobacteria) to discriminate between planktonic and benthic species, or in another one to classify three Bryophytes belonging to liverworts, hornworts, and mosses, respectively. After completing each level, a general description of each group appears on the screen. Completing all six levels opens the way to a seventh one: The Future. We tried to imagine what direction plant evolution may have taken, 250 million years from now, suggesting the possibility that some plants will develop the capability of metabolizing plastics and other man-made pollutants. The game is aimed at primary school kids, but it is also suitable for undergraduates studying Natural Sciences and Environmental Sciences as a tool to learn basic information about the diversity of the plant lineage.

← *Panels describing Earth evolution are reproduced (with permission) from the Paleomap Project by Christopher Scotese (www.scotese.com" www.scotese.com) ©Mario De Tullio*

"An enjoyable, yet effective way to approach complex topics"
High school student, 16 yo

↑ *One level of the quiz game (Game 2) solved Design: Mario De Tullio, Pooya srl.*



↑ *The ABC model of flower development as described in Game 3 Design: Mario De Tullio, Pooya srl.*

"I liked The Time Machine, because I could see plants I have never heard of before"
Primary school kid, 10 yo

"The games offered a helpful visual feedback that really worked especially in on-line classes"
Giulia, 19 yo, 1st-year University student

The second game, **Biodiversity and plant evolution** follows the format of a quiz show. The player reads the description of a plant, and selects the corresponding picture and scientific name. The six levels correspond to the same plant groups considered in the first game. The game is designed for middle school kids, and anyone else interested in plant trivia.

We also designed a third game, **Gene expression and floral morphology**. By regulating the expression of genes involved in the determination of flower shape (ABC model), the player interacts with the development of the *Arabidopsis* flower. The four whorls of the *Brassicaceae* flower in wild type plants (sepals, petals, stamens, and carpels) are described. The player is then asked to observe some mutants with unusual flowers. In the next level, the player has a choice to switch three genes (class A, B and C) on and off, and see the sketch of the phenotype resulting from the expression of the genes chosen. This game, which requires some basic understanding about gene expression, is designed for high school students/undergraduates.

The efficacy of the three games has been tested with many visitors, mainly school children and their teachers. Most of them are positively surprised: the smile we have observed on their faces when they use the games is the best reward for our efforts.

The games proved especially useful in times of distance learning, during the recent viral pandemic that, in Italy and many other countries, prevented in person classes from taking place. Botany classes for first-year students in Natural Sciences usually include, among other activities, a visit to our Botanic Garden to provide an overview of plant diversity, and a lab activity to learn about flower morphology. Those activities were replaced with on-line classes, using games 1 and 3, respectively. Each game session involved 80-90 students. The majority of the students we interviewed very much appreciated our games as teaching tools. In particular, the "visual feedback" they received whilst using the games helped them in their learning process. Of course, the games are not a substitute for contact with living organisms, but they can still provide a complementary approach.

The debate on the use of educational (serious) computer games is growing (Riopel *et al*., 2019), and our experience confirms their usefulness in delivering effective science communication. We are now planning to update the games that have been produced, and to develop new ones on different aspects of plant science. The Italian version of the games is available at www.botanicalconnections.it

← *The time machine: the game begins*
Graphic design; Mario De Tullio, Pooya srl.

↑ *Kids visiting our exhibition are instructed on the use of our games ©Giovanni Signorile*

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