STUDY OF PLANTS THROUGH LABORATORY TEACHING BASED ON THE SCIENTIFIC METHOD WITH PRIMARY SCHOOL CHILDREN

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Abstract

The research project has been carried out with a class of 19 students of the second grade of the primary school, at a Comprehensive Institute. The project consists of an innovative didactic intervention in the field of sciences.

The objective is to verify the validity of the didactic project structured according to an experimental methodology for pupils' learning. It consists of an observation path of vegetal elements, the plants, and the analysis of their structure and characteristics. Therefore, the aim is to confirm the effectiveness, for the students' development, of laboratory teaching based on the scientific method. In addition, it aims to expand the feasibility of a scientific approach and a laboratory format in teaching biology at school, even in a situation full of restrictions such as that due to Covid-19. The promotion of practical activity can induce the pupils to become active subjects in the construction of their own learning. Practical activity may also increase pupils' interest and curiosity towards the world of plants through understanding the importance and the necessity of plants protection. In addition, they may get the scientific method as a method to approach reality.

The path, linked to the plexus project "A classroom in the garden", made it part of the annual program. Among the reasons for the choice of this research project, the desire to instil in children a passion for science and nature stands out. Furthermore, the goal is to ensure that kids maintain their consideration of the discipline, which, arousing wonder towards nature, favours the development of the scientific culture. An adequate scientific culture is fundamental for our society nevertheless it is, unfortunately, missing in the "average citizen". The referential theoretical framework consists of the specific disciplinary contents relating to the subject. To encourage inclusion, several theoretical, pedagogical normative, and didactic references are identified.

The project, divided into eight meetings lasting two hours each, presents multiple laboratory activities that constitute a linear path of discovery of the life cycle of plants: from seed germination to its formation. The management methodology adopted is mainly based on practical experiences; It consists of manipulation and exploration through the senses, cooperative work, playful activities supported by technological assistance. In addition, another common element of the proposed activities is the application of the classical scientific method. It starts from the systematic observation of a research object, it then passes through the collective discussion, the hypotheses formulation, the experiment design and implementation, the results analysis, and the final discussion. It concludes with the formulation of the conclusions and the knowledge construction.

Thanks to various tools, in compliance with the trifocal evaluation, the experimentation results have been collected. Furthermore, besides competencies development, it resulted in fundamental the acquisition of the scientific method as a method of investigation. It has been seen that this approach increases pupils' interest and curiosity about the world of plants, from the data analysis to the development of knowledge in the biological field. During all the experience pupils used always participated actively and gladly.

Keywords: primary school, scientific method, nature, inclusion, laboratory activities, investigation, plants.

1 INTRODUCTION

70% of students consider studying scientific disciplines as boring and difficult [1]. The problem lies in the teaching method. It is necessary to find didactic approaches that are based on "doing", on practical experience: scientific subjects are those that lend themselves most to experiential teaching. Generating interest is one of the primary objectives of the teacher because it favors the student's motivation which is crucial for effective learning. Children are naturally interested in discovering the world that they can explore first-hand, and the teacher will only have to give them the opportunity to be protagonists of their

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own learning. The approach to science must be seen as a discovery of the world based on direct observation, not as explanations to be studied in books [2-11].

Teachers often do not use an active approach due to lack of time. Carrying out laboratory activities requires a certain commitment to procure the material and a lot of time available; teachers say they never get enough. The consequence is the choice of a more formal teaching and the elimination of practical activities, the potential of which is greater.

Bronfenbrenner's bioecological model of human development, describing the complex ecology in which children grow up as a set of interconnected environments, demonstrates that human development is a function of the set of variables that make up its ecology [12].

As shown in the image of Fig. 1, the systems of the theory are:

- The microsystem, which includes the most intimate relationships in which the child is involved, the groups with which he has direct contact such as the family and school;
- The mesosystem, that is the relationships between the different microsystems, for example the teacher-parent relationship, kinship, the communities with which the families are linked, which have a direct influence on the child;
- The ecosystem, which concerns the elements of the social context that indirectly affect the development of the child, who does not have a direct relationship with them. We therefore refer to the parents' working environment or to the teaching staff that defines the rules of the school attended by the child;
- The macrosystem, which contains the social, cultural, political, ethical, and structural factors that influence the child indirectly, these elements determine the expression of the other systems. These are, for example, family and social health policies, collective beliefs and social discourse on childhood;
- The chronosystem, which refers to the historical time that determines the development: all the previous environments are in a different historical-social context in which they are influenced by factors of the present time, but also of the past and the future.

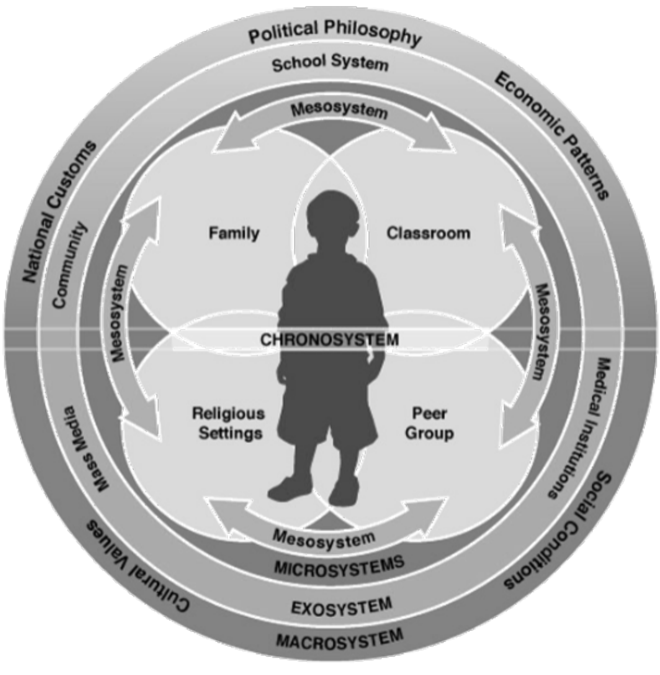

Figure 1. Bronfenbrenner's bioecological model of human development (image taken from the site http://olms.cte.jhu.edu/mah-m03-wrapup).

The didactic intervention presented here uses an experimental methodology [13-18]. It consists of a path of observation of the plant elements, of the study of the structure and characteristics of the plants. The aim is to confirm the effectiveness of laboratory teaching based on the scientific method, and to demonstrate the feasibility of a scientific approach in teaching plant biology, even in a restrictive situation such as that dictated by Covid-19.

2 METHODOLOGY

The research project has been carried out in the months of March and April 2021 with a class of 19 students of the second grade of the primary school of the Comprehensive Institute I of Castelfranco Veneto.

Due to the advent of the Covid-19 pandemic, with the establishment of the red zone on the territory from 15 March 2021, part of the project was proposed in the classroom to only 6/7 children in the class. Of these, four were stable, while the other two/three varied from lesson to lesson. The students at home were able to follow the path through the Classroom digital platform, and eventually carry out the experiences independently with the support of parents.

With the return to the orange zone, all class members were able to return to school in early April, when the final assessment and questionnaire was carried out.

This research project presents a multiplicity of laboratory activities which, following one after the other, constitute a linear path of discovery of the life cycle of plants from the germination of the seed to its creation. In all the experiences, the phases of the scientific method were applied starting from observation and arriving at the formulation of a conclusion.

Table 1. Macro-planning-teaching experiences: each meeting lasts 2 hours.

Meeting	***Contents***	
1	Seed and germination	Interrogative and active method Format: interactive lesson, active lesson and laboratory
2	Germination of seeds, roots and stem	Interrogative and active method Format: integrative lesson, active lesson and laboratory
3	Roots and stem	Interrogative and active method Format: interactive lesson, supplementary lesson, lesson with technological support and laboratory
4	Leaves	Interrogative, affirmative and active method Format: interactive lesson, integrative lesson, frontal lesson and laboratory
5	Photosynthesis and flowers	Affirmative, interrogative and active method Format: interactive lesson, frontal lesson, lesson with technological support and laboratory
6	Reproduction	Affirmative, interrogative and active method Format: interactive lesson, supplementary lesson, frontal lesson, lesson with technological support and laboratory
7	Dissemination and fruits	Affirmative, interrogative, and active method Format: interactive lesson, frontal lesson, lesson with technological support and laboratory
8	Test	Interrogative and affirmative method Format: interactive lesson, frontal lesson, and laboratory

3 RESULTS

3.1 First meeting

At the beginning of the first meeting, the topic was introduced by administering a questionnaire to investigate the children's foreknowledge and misknowledge of plants. Some pupils, for example, confused the germination of the seed with the growth plant. We then took the children to the school's garden and vegetable garden to show the plants present. Back in the classroom, we started a discussion on the type of plants observed and their characteristics, summarizing the children's responses on the blackboard. We asked the children about the origin of those plants, guiding them to formulate hypotheses regarding the role played by seeds.

The workshop activity took place in small groups, in which children in pairs were directed to the observation of some seeds (corn, bean and lentil), guided by an observation card. Finally, the observations made were shared in the class group, asking each child to write on a post-it an element they deem necessary to ensure that a seed becomes a plant. From the analysis of the answers, seven important elements were hypothesized (soil, water, air, heat, light, space and love) which were reported on the billboard. For each of these seven elements, an experiment was started to verify their importance for the germination of the seed.

For the earth element, one half of the children placed a seed in a plastic cup containing wet cotton, while the other half put a seed in a plastic cup containing soil (Fig. 2).

For the water element, the children divided into pairs put corn seeds and water in a glass, so that some seeds were completely immersed, others only slightly wet and others completely dry.

For the air element, seeds were placed in the ground inside two closed jars of two different sizes: a larger one in which the ground left room for a certain amount of air, a small one in which the ground left little space in the air.

For the heat element, each child put soil, water, and some seeds in a plastic cup. Some glasses were placed on top of a radiator, some were placed in the refrigerator and others were left on a counter.

For the light element, some plastic cups containing soil, water and seeds were left in the light, while others were placed in the dark inside a wardrobe.

For the space element, in a large container some seeds were sown very close to each other while in another container of the same size the seeds were sown very far from each other.

For the love element, the children proposed planting some seeds in a glass that they would take care of, checking that it receives light, giving it water if necessary and saying a few loving words in turn.

Figure 2. Seeds in earth and cotton.

3.2 Second meeting

After a week, the children (who had already observed the changes in the previous days) were involved in a discussion, verifying the validity of the hypotheses made before the experiments. They were able to verify that:

- The soil is not an indispensable element for germination, because the seeds have germinated in all glasses, even in those containing cotton;
- Water is necessary for germination but must be in the right quantity, because only seeds that are in contact with both air and water have germinated;
- Air is very important for germination, because the seeds have germinated only in the largest jar;
- The right temperature is needed for germination, because the seeds in the refrigerator and in contact with the radiator have not germinated;
- Light is not important for germination, because even the seeds in the dark inside the cupboard have germinated. This experiment particularly shocked the pupils as everyone was sure that

without light the seed could not germinate, confusing the growth of the plant with the germination of the seed.

- Space is not important for germination, because the seeds have germinated equally both close together and distant;
- Love does not accelerate germination, because the seeds that have not received love have sprouted anyway.

The results obtained in the experiments were summarized on the blackboard and in the scientist's diary (Fig. 3).

Subsequently, the children were invited to better observe the shoots and in particular the presence of the stem and roots. We then guided them to formulate some hypotheses about their function. For the roots, the assumptions were that they absorb other substances in addition to water and that they always grow downwards. We then planed two experiments, one by comparing the growth of the seedlings contained in the cotton wool within the earth, the other by placing some seedlings horizontally. For the stem, the hypothesis put forward was that it brings water to the various parts of the plant and we inserted three celery stalks in three jars with water that we colored with drops of dye (red, blue and black).

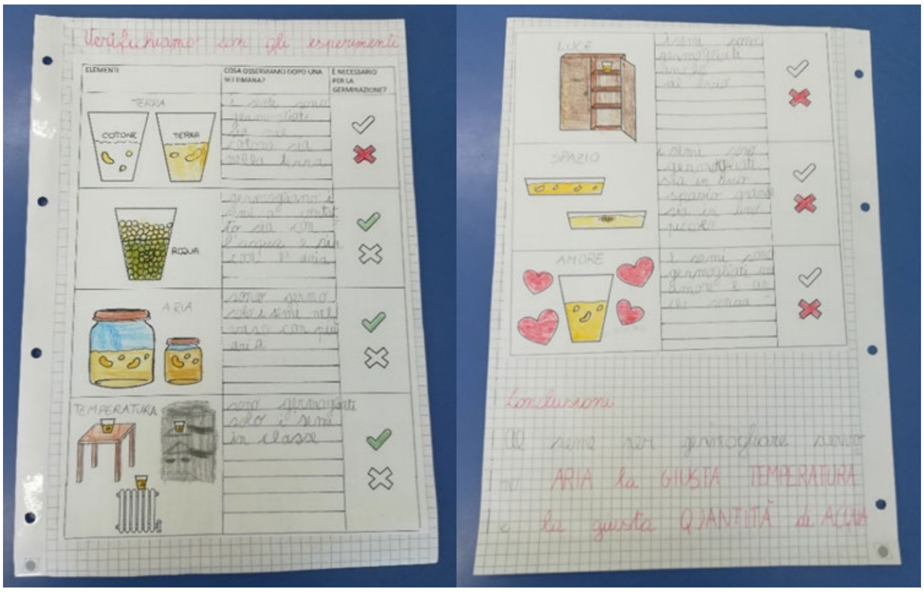

Figure 3. Pages of the scientist’s diary.

3.3 Third meeting

After a week, the children (who had always observed the changes that occurred in the previous days) were involved in a discussion, to verify the hypotheses made before the experiments. In particular, they concluded that:

- The roots can absorb other substances besides water because the plants in the earth had grown more than those in cotton, so have absorbed something that was not present in the cotton. The initial hypothesis was confirmed.
- The roots always grow downwards, because in the pot placed horizontally, they have curved to orient themselves in the right direction.
- The stem carries water to the various parts of the plant because the leaves are slightly colored the same color as the dyes dissolved in the water in which the stems were immersed. For confirmation we observed thin cross sections of celery stems under a microscope, and the children were able to observe the dye contained in them.

The results obtained in the experiments were summarized in the scientist's diary.

Subsequently, the children were taken to the garden to discover different types of stems, and then returned to the classroom where, in pairs, they continued to observe the stems of other plants (bamboo cane, succulents, ivy, onion) (Fig. 4).

Figure 4. Different types of stems.

3.4 Fourth meeting

The fourth meeting was dedicated to the observation of the leaves. The children were involved in the observation of some leaves to highlight some of their characteristics. Pupils observed the difference between the upper and lower page: the top was smooth and darker in color, while the bottom was lighter and rougher. The children reported the leaf on a white sheet using the frottage technique. They discovered some terms such as "margin", "veins" and "stalk" and discussed their functions.

A laboratory activity was then carried out to check for the presence of different pigments in the leaves by placing a green leaf on a piece of filter paper and repeatedly passing a stone over it to leave a green trace on the paper. The piece of paper was placed inside a glass in which we poured a little alcohol so that it was in contact with the edge of the paper. The alcohol, being absorbed by the filter paper, displacing the green color, and bringing out the yellow color (Fig. 5), which is a different pigment from chlorophyll, which gives the leaves the yellow color in autumn when the chlorophyll degrades.

During the same meeting, the theme of the classification of leaves based on margin and shape was also addressed, first involving the children in a game and then in an activity in pairs of cataloging some leaves.

Figure 5. Separation of different pigments.

3.5 Fifth meeting

In the fifth meeting the concept of chlorophyll photosynthesis was addressed, through a group discussion and watching a video, explaining to the children that this process serves to create nourishment for the plant. From the discussion also emerged the hypotheses that the plant needs light, water, and air to live. For each of these three elements, an experiment was started to verify their importance for the life of the plant.

For the light element, a plant adequately supplied with water and air was in the dark inside a wardrobe.

For the water element, a plant was left without water but adequately supplied with light and air.

For the air element, a plant was left in a hermetically sealed bag but adequately supplied with light and water.

As a check, a fourth plant was left in the light and air and watered daily.

While waiting to verify the results of the experiments, the children were presented with another element of the plant: the flower, that was observed through the five senses. By observing some flowers, the children noticed that the flowers can be very different from each other, but they also have some common characteristics. The names of some of their parts were also presented, such as the stem, the calyx, the corolla, the petals, the pistil, the stamens, and the pollen utilizing a game like that of the previous lesson.

3.6 Sixth meeting

After a week, the children were involved in a discussion, verifying the validity of the hypotheses made before the experiments. In particular, they were able to verify that the plant needs both light, water and air to live, because the plants that lacked even one of these elements were dying (Fig. 6).

Subsequently we faced the reproduction of the plant, starting from the morphology of the flower up to the function of pistil, stamens and pollen. The group discussion was accompanied by the individual observation of these three components of the flower, to then move on to the dissemination of pollen from one flower to another, and to the role that wind and insects play in pollination. We watched two videos.

The results obtained in the experiments were summarized in the scientist's diary.

Figure 6. Plant without air.

3.7 Seventh meeting

The children were explained the fertilization and illustrated the formation of the fruit that contains the seed, which has the task of germinating and giving life to a new plant. The fruit serves to protect the seed and promote its spread away from the mother plant. They were told that seeds are also spread by wind and animals.

Through discovery activities were studied of the different types of fruit. Different classification criteria (colour and more) exist and subsequently we identified the difference between fleshy, dry and mixed fruits.

3.8 Eighth meeting

During the last meeting, a review of the contents of previous lessons was carried out through the scientist's diary and then the children took the verification test.

4 CONCLUSIONS

The didactic project shown here according to an experimental methodology has proved to be functional for pupils' learning about the life cycle of plants and their characteristics.

The results obtained confirm the effectiveness of laboratory teaching based on the scientific method.

This methodology has allowed pupils in the first years of primary school to acquire specific knowledge in the biological field, advancement in the development of skills, the acquisition of the scientific method as a method of reasoning and, above all, the increase of interest and curiosity towards the plant world, understanding the need for environmental protection.

The essential point of teaching biology at school is in fact the need to generate interest in pupils by also developing new teaching approaches, without forgetting, however, the interest of teachers, which is fundamental for their motivation for the profession [1].

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