THE KINGDOM OF FUNGI IN PRIMARY SCHOOL: AN EDUCATIONAL RESEARCH IN BIOLOGY FIELD

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Abstract

This educational research has been conducted since a concrete situation which characterizes the teaching of Science in the Italian school system was found. Although scientists demonstrated for a long time the effectiveness of socio-cultural and cultural-historical constructivist theories on which scientific learning models are based, today we find that the teaching of Science in schools is not always based on these paradigms. In particular, it often happens that the laboratory is designed as an appendage of the theory or as a physical space, while it should be considered as a way of working, where the teacher plays the role of the director and s/he encourages children to be actors and not spectators. Therefore, we decided to conduct this research with the aim of validating the usefulness and the effectiveness of the teaching laboratory in the teaching-learning process of Biology in primary school and to assess the possibility of introducing the discussion of the Kingdom of fungi in the program. The present work involves the design and the construction of a project on the Kingdom of fungi, with particular reference to classification and morphology. We decided to approach this subject because in various Italian regulatory documents, including the recent National Guidelines, there has been a complete lack of interest in microorganisms and fungi. In order to confirm the effectiveness of the teaching laboratory, we chose to deal with this theme first by using a transmission method and then proposing numerous laboratory activities, thus providing the opportunity to develop a comparison between these two teaching methods. At the end of this research, it can be stated that the analysis of the results confirms the experimental hypothesis. It was found out that the pupils fully learned the concepts and, despite the difficulties, developed critical attitudes towards phenomena, showing a significant improvement between the first and the second assessment. Regarding the discussion of the Kingdom of fungi, it appeared that this type of project allows the pupils to develop a deep interest in these organisms, thus demonstrating the importance of introducing this fundamental topic of Biology in primary school.

Keywords: Primary school, scientific method, competence, fungi.

1 INTRODUCTION

Nowadays, we are witnessing the spread of a process called "scientific illiteracy", due to the deep separation between school and science. This phenomenon is caused by the widespread decline in enrolment at scientific faculties and has several negative consequences for society [1]. Among the effects of this reality, there is a widespread lack of biological knowledge which greatly affects both the choices and the behaviours of citizens. In fact, the scientific culture "does not consist in possessing much knowledge of biology, but in having curiosity about nature and the ability to retrieve knowledge when needed" [2].

This concrete situation requires teachers to review the teaching methods and to promote the generation of interest, as it has been found out that scientific subjects are considered tedious and arduous. In order to be able to get children interested in Biology, teachers must be interested, because those who are not passionate will never stir their pupils’ interest. In addition, Biology is a discipline which provides the opportunity of experiencing multiple feelings ranging from passion to horror and therefore this science has a strong "emotional resonance" which can be exploited by the teacher to engage the pupils [3]. A further strength of this discipline consists in intriguing both passionate children and those who have difficulties. There are not pupils who are gifted at science and pupils who are not, because Biology is not difficult but it is within the reach of everyone since childhood. Finally, the study of Biology is not a field of investigation far away from children’s daily lives, because each pupil has a constant and direct contact with the living world. Therefore, it can be said that the encounter with science happens “more «out of» than «in» school” [4].
A further fundamental aspect of Biology teaching is the laboratory dimension. The effectiveness of laboratory activities has been demonstrated by multiple researches, which state that learning by doing with companions facilitates the learning process. These experiences do not require complex instruments and special laboratories [5]. Therefore, if there are no state-of-the-art tools at school, teachers should not be excused from deciding not to propose practical activities, as they can use the "poor lab", which consists in building educational itineraries using simple or inexpensive instruments [2].

This research was proposed to primary school children attending the fourth grade and it was elaborated from two hypotheses.

The first aim was to enhance the usefulness and the effectiveness of the didactic laboratory in the teaching-learning process of Biology in primary school. Therefore, the course was conceived to compare the didactic laboratory with the transmission teaching, which is still very widespread in schools.

The second aim was to evaluate the possibility of introducing the treatment of the Kingdom of fungi in the biology program. Some activities regarding these organisms were designed and carried out, with particular reference to classification and morphology. We decided to address this issue because in the Italian documents, including in the recent National Guidelines, there is a complete lack of interest in microorganisms and fungi.

Before conducting the experimental project, we conducted a preliminary investigation to find some information about local practices in order to support the experimental hypotheses.

2 METHODOLOGY

2.1 Background

This research was conducted in the fourth grade of the "Dante Alighieri" primary school (Comprehensive Institute "Giovanni Gabrieli" in Mirano, Venice, Italy). The class was composed of twenty-six pupils. It was a well-balanced class with thirteen girls and thirteen boys who formed a homogeneous and cohesive group. The pupils welcomed all the teachers' proposals and they were active and curious during the lessons.

The Table 1 shows the competence, the learning objectives and the contents of the project.

| Competence [6]: basic competences in science and technology. |
| Learning objectives: |
| - Know some characteristics of fungi. |
| - Know the structure and the growth of fungi. |
| - Know mildew structure, growth and propagation. |
| - Know the morphology of yeasts and their propagation. |
| Content: |
| - Definition of fungi. |
| - Classification of fungi (Chytridiomycota, Zygomycota, Ascomycota and Basidiomycota). |
| - Morphology of fungi. |
| - Reproduction of fungi. |

This research was divided in two phases: in the first phase, the topics were discussed with the traditional method, while in the second phase with the laboratory method. The goal was to compare the two teaching methods.

The learning unit (one lesson) of the traditional approach was shorter than the learning unit (six lessons) of the experimental one. At the end of both steps, the same test was presented to the group. The Table 2 summarizes the activities.
### Table 2. Phases.

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<td><strong>PHASE 1: Traditional approach</strong></td>
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| **First lesson** | - Survey of the pre-existing knowledge.  
- Observation and comparison between plants and fungi.  
- Observation and comparison between animals and fungi.  
- Viewing of a film on Saccharomyces cerevisiae yeast. |
| **Second lesson** | - Preparation of a suitable place for mildew growth. |
| **Third lesson** | - Macroscopic observation of a fungus and its parts.  
- Macroscopic observation of a fungus and its parts using a lens.  
- Observation of spores using an optical microscope. |
| **Fourth lesson** | - Macroscopic observation of mildew.  
- Observation of mildew using a stereomicroscope. |
| **Fifth lesson** | - Observation of a small amount of yeast using an optical microscope.  
- Cultivation of yeast and mildew through some Petri dishes and plating techniques. |
| **Sixth lesson** | - Macroscopic observation of mildew and yeast. |
| Final assessment of knowledge and self-assessment. |

### 2.2 Assessment

Assessing a pupil’s competence is not a simple assignment because it is not directly observable. That is why it was decided to use an evaluation rubric, which is a device through which you can specify the dimensions, the criteria, the indicators and the levels of mastery and which provides an indispensable framework for the development of evaluation tools [7].

After conceptualizing the competence, it was decided to analyse the experience through the framework for the assessment of skills, which focuses on the construction of competence and defines three perspectives of analysis: the subjective, the intersubjective and the objective dimension [8].

The subjective dimension refers to self-evaluation and therefore to the meanings the subjects attach to their learning path. The self-evaluation process did not represent a compilation of the provided tools, but a metacognitive activity to make pupils aware that their learning was guided. Overall, both the self-evaluation of the product and the self-evaluation of the learning process were proposed. At the end of each meeting, the pupils were asked to express an opinion on the activities by reporting both negative and positive aspects and self-assessment. At the end of the course, they were asked to think over the experience and to indicate the level of mastery achieved in the two specially prepared sheets they had received.

The intersubjective dimension concerns the expectations of those involved in the learning process. It was decided to confront with the teachers, to consider the interaction among the pupils during the activities and to observe the pupils during all the meetings, paying attention to the dimensions that constitute the subject of observation.

The objective dimension concerns pupils’ performances in relation to their knowledge and their skills. Therefore, an initial evaluation to detect the pre-knowledges was carried out; the works done by the
children were analysed and a structured test to investigate the knowledge learned was provided. It was decided to provide this type of test because it gives the opportunity to easily verify the achievement of knowledge and understanding goals, providing pupils with an objective measurement.

2.3 The scientific method

The scientific method is the most established way in which Biology investigates reality in order to define objective and shared knowledge and its teaching should be every teacher’s primary goal. However, in schools there is frequently an erroneous application of this method, which heavily threatens pupils’ motivation and learning. It often happens that teachers, after asking some questions and after formulating hypotheses based on the pupils' responses, give them very detailed protocols they have to follow to carry out the experiment properly. This process leads pupils to conduct activities in a passive way, focusing only on the teacher's precise instructions.

Scientific exploration is structured in six well-defined phases:

1. Making systematic observation: the researcher observes and analyses the phenomenon.
2. Asking a question: starting from observation, a question which constitutes the starting point of the inquiry process emerges.
3. Forming a hypothesis: the researcher formulates a hypothesis that consists in a possible answer to the above-mentioned question.
4. Conducting an experiment: The researcher defines the working method through which refuting or rejecting the formulated hypothesis.
5. Analysing the data: The researcher processes the collected data and confirms or denies the hypothesis. If the hypothesis is confirmed, it will be possible to define a new theory.
6. New hypothesis: If the data does not confirm the hypothesis, a new hypothesis will have to be defined.

Biology teaching is based on the scientific method, which has many strong points which can be decisive in the teaching-learning process. Indeed, the teacher can engage pupils in designing experimental activities and they can allow them to think over and confront themselves with the infinite possibilities of investigation. But in Biology the scientific method does not correspond to the experimental method: there are the observational-comparative method and the experimental method.

2.3.1 The observational-comparative method

Evolutionary Biology is based on the observational-comparative method, which has the evolutionary theory as explanatory paradigm. This method has the function of investigating remote and evolutionary causes related to the physiological characteristics of an organism [9]. The observational-comparative method should not be considered marginal compared to the experimental method since “observation is an element of primary importance” [10], especially in school. Indeed, the ability to observe is a very basic skill which cannot be acquired in a short time, but it requires specific education which is developed during school years.

In this research, we proposed multiple macroscopic and microscopic observation activities using different instruments such as lenses and an optical microscope.

2.3.2 The experimental method

Functional Biology is based on the experimental method; it has molecular biology as a paradigm and concerns the study of the physiology and the functional relationships between the organism and the environment. The experimental method was introduced owing to the studies of Galileo Galilei.

This survey methodology has four phases:

1. Observation of the natural phenomenon.
2. Formulation of the hypothesis.
3. Experimentation: the scientist checks the validity of the hypothesis through an experiment.
4. Theory and law: if the hypothesis is rejected, it becomes a law and it is recognized as a theory.
3 RESULTS

As described above, this research path was divided in two phases: in the first one the traditional method was used, while the laboratory method was used in the second one.

3.1 The traditional approach

At the beginning of the course, we proposed a short introduction to the pupils in order to present the research path, its aims and the motivations.

Then we started a discussion asking some questions (e.g. "What are fungi?", "Where are they?", "How do they reproduce?") with the aim of detecting the pupils' pre-knowledge. We conducted this oral survey using the clinical conversation and the related techniques.

Thanks to this oral survey, we could see that all the pupils believed that fungi were plants and had confused ideas about these organisms. Therefore, this conversation was extremely important, as it allowed the pupils' pre-knowledge to emerge, and this discovery was fundamental to be able to guide their change and to start the process of building knowledge.

Then we proposed a theoretical explanation of the Kingdom of fungi. This lesson was frontal and the contents were presented in a linear and sequential manner. The desks were arranged two by two and organized into four or five rows and three columns. In order to make the explanation appealing and to facilitate communication, we opted for a PowerPoint presentation.

Finally, we gave each student a summary of the treated content, which was read and analyzed together. We also proposed to read the pages of the book dedicated to the Kingdom of the fungi, in order to strengthen the knowledge and to clarify their doubts.

3.2 The experimental approach

The second phase was divided in six lessons of about two hours each, with the exception of the last one, dedicated to the final test. In each lesson we used the scientific method by making the pupils active, engaging them in designing activities and enabling them to think over and confront themselves with each other.

3.2.1 First lesson

In the first lesson the pupils discovered some characteristics of fungi and we proposed three different activities to explore these living organisms.

The first activity concerned observation and comparison in small groups of fungi and plants, in particular, the comparison between *Armillaria mellea* (honey mushroom) and *Petroselinum crispum* (parsley). In this meeting, the aim was to make the pupils think over some of the peculiarities of the fungi that led the scholars to incorporate them into a king, as well as the ways in which it would be possible to test them. We started a discussion asking some questions, (e.g. "How can we check that fungi are not plants?"). This question aroused a heated debate among the pupils, who began to confront themselves with each other and express hypotheses. During the discussion, a pupil proposed to the class to try to extract chlorophyll from the fungi to show that they do not own it. This proposal was analyzed and it was decided to accept it. Subsequently, the pupils were divided in five groups and were given some fungi (*A. mellea*), parsley (*P. crispum*) and a sheet. Once the hypothesis was formulated, we invited the students to carry out the experiment, which consisted in extracting the chlorophyll from *P. crispum* and then from *A. mellea* using a mortar, a pestle and 95% alcohol. This experience allowed the pupils to observe that chlorophyll is not present in *A. mellea* and that fungi are not plants.

The second activity involved the comparison between fungi and animals. Furthermore, we started a discussion about the differences between these two types of organisms. It was decided to check whether the fungi could move, a feature that distinguishes them from animals. In order to allow an accurate observation, we delivered lenses to each group. After formulating the hypothesis, the pupils started the observation activity. At the end of the activity all pupils realized that the fungi cannot move.

In the third activity, it was found out that fungi may be both unicellular and multicellular. We started then a discussion about the formulation of relevant hypotheses asking some questions. Then we proposed the viewing of a film about *Saccharomyces cerevisiae* (the beer's yeast), which is a unicellular fungus.
At the end of the activity, we invited the pupils to think over the observations and the considerations developed during the last two activities to understand that fungi are not animals, as they can be both unicellular and multicellular and as they cannot move.

3.2.2 Second lesson
The second lesson was devoted to the preparation of a suitable place for mildew formation and growth.

Therefore, we started a discussion asking some questions: (e.g. “What is mildew?” , “Where is it?” and “How can we study it?”). Thanks to the pupils’ interventions, it was possible to find out their pre-knowledge and it was found out that everyone had seen mildew on bread, fruit or cheese at least once, but they did not know how it grew and propagated. Therefore, it was required to formulate hypotheses on the various working methods that which could be used to study this particular fungus and it was decided to cultivate it. Two containers were used: a lemon, a carrot and an orange were put in the first container, while a little bit of bread and a wet cookie were put in the second one. Once this food was placed inside the containers, they were closed and covered with a black cloth for about two weeks.

At the end of the activity, the pupils planned four observations of mildew over a two-week period and were asked to record the collected data.

3.2.3 Third lesson
For this meeting, the help provided by the Mycological Group "Bruno Cetto" in Mestre (Italy) was very valuable. They contributed to the research by providing some species of fungus present in our territory such as *Leccinum duriusculum*, *Pleurotus eryngii*, *Daedalea quercina* and *Russula delica*. These fungi were analyzed by the pupils who focused on their different components.

At the end of this exploration, the pupils were divided in groups and were given *Agaricus bisporus* (fungus). This time, the pupils were asked for a punctual observation of the fungus first with the naked eye and then using a lens.

Then the pupils had the opportunity to observe the spores of a fungus using the optical microscope. All the pupils were excited about this instrument and therefore they had the chance to observe the spores more than once for an accurate analysis and at the same time in order to satisfy the desire for exploration they manifested.

When the activity ended, we proposed to watch a documentary which illustrated a reconstruction of the budding and growth of many fungi.

Then we brought up a treated stump of *Agrocybe aegerita* in the classroom. This substrate were observed over the next few weeks and it allowed the pupils to explore closely what they had seen in the documentary. The pupils observed the budding and the growth of some fungi. It is important to clarify that the strain was not kept in class, but in the school garden.

3.2.4 Fourth lesson
In this lesson the topic was the detailed study of mildew, which had been introduced in the second meeting. We invited each pupil to read the data collected over the weeks and we started a discussion to understand what happened to the food in the containers and to formulate hypotheses. To answer the questions, it was decided to observe the mildew on the bread using the stereomicroscope. Each pupil had the opportunity to see small filaments on the mildew and to understand their role in the reproduction cycle.

3.2.5 Fifth lesson
The focus of this lesson was a particular fungus: *S. cerevisiae* (yeast). We started a discussion asking a question: “Do you think that yeast is a single or multicellular fungus?” . The aim of this question was to solicit the recovery of the knowledge built during the previous experiences. Once the hypotheses were formulated and written on the blackboard, it was decided to check them by observing Saccharomyces cerevisiae using the optical microscope. After the preparation of the instrument for the analysis, each pupil could observe the yeast.

Like in the previous meetings, the pupils were enthusiastic about using the optical device both at the beginning and during the activity. This reality captured their attention and kept their concentration high.
Subsequently, we proposed a discussion about the breeding cycle of this particular fungus, which had already been introduced in the first meeting. The pupils were asked to think about possible working methods that would allow this fungus to be studied. It was decided to breed Saccharomyces cerevisiae. For this operation, we decided to use some Petri dishes and the platinum technique. Given the availability of many dishes, it was decided to cultivate on a dish even a small amount of mildew. Finally, the pupils wrapped their dishes with a blanket and they were asked to formulate hypotheses on the growth of these organisms.

3.2.6 Sixth lesson

In this meeting the reproduction cycles of fungi were analysed more deeply, especially the cycles of mildew and yeast.

Before inviting the pupils to retrieve the Petri dishes wrapped in the blanket, we started a discussion about their contents asking some questions (e.g. "What will happen inside the dishes?"). Once all the hypotheses were written on the blackboard, Petri dishes were opened and their observation started. The colonies which had grown were observed only from a macroscopic point of view, as the time available did not allow to propose more accurate and precise observations with the help of lenses. Nevertheless, it was possible to think over the observations, and to introduce the concept of colony. After macroscopically analysing the colonies, the pupils were asked to graphically illustrate what they observed.

A further discussion was then launched about the different production cycles of fungi, mildew and yeast.

4 DISCUSSION AND CONCLUSIONS

In the World and European scene, many studies analysed what are the most significant approaches to improve the learning [11-20]. Nevertheless it was found that these practices aren’t used in the Italian school. Analysing the results, we concluded that both the interest in fungi this type of pathway aroused in the pupils and the remarkable improvement of the results, recorded between the first and the second verification test. In fact, the activities were conceived paying attention especially to the dimension of motivation, since learning "becomes easy and fun when the concrete situations that have to be considered, realized, discussed together are the subject of curiosity and common interest" [21]. In this sense, Biology is different from other disciplines, because it has a strong emotional resonance, which can be exploited by the teacher to capture the pupils’ attention. Involving the pupils emotionally stimulates reflection and makes what is experienced and what is learnt meaningful, the chance that what pupils learn will be part of them forever [3].

Regarding the content, the analysis of the results and the comparison between the two verification tests make the recorded progress quite explicit and evident. At the end of the course, it was established that all the pupils fully learned the concepts and, despite the difficulties, they developed critical attitudes towards phenomena. Conversely, such content had not been fully acquired at the end of the first stage of the path as the numerous errors detected in the tests show.

It can therefore be stated that the experiences proposed in the second phase allowed the pupils to build solid knowledge on the Kingdom of fungi and in this sense the macroscopic and microscopic observation activities proposed, the consequent use of tools for observation, such as lenses, the optical microscope and the stereomicroscope and the equipment for breeding were indispensable. Using these tools, the pupils could explore the microscopic world avoiding abstractness, that is often a source of profound misunderstanding. Yeast, mildew, and spore observation activities allowed them to first find out that beer yeast is a unicellular fungus, that spores are cells through which fungi reproduce and they could explore the peculiar structure of mildew. Similarly, the extraction of chlorophyll and Agrocybe's treated strain have been significant experiences which stimulated the construction of stable and secure knowledge. Throughout the path there was a constant reference to exploration in all its varieties, involving the pupils in a process of building knowledge, conceived as a "discovery of the world based on […] direct observation" [22].

In conclusion, in the light of the reflections and the results obtained, the importance of proposing the treatment of the Kingdom of fungi to schools through the exploration of all the main aspects that which characterize these organisms is clear. Moreover, it is evident that this topic, like many others in the biological field, has to be discussed using a didactic laboratory where the pupils are at the center of
their learning process. In fact, the laboratory is often conceived as an appendage of the theory, thus neglecting its enormous potentialities.

REFERENCES


