# THE DIDACTICS OF BIOLOGY IN PRIMARY SCHOOL: AN INNOVATIVE APPROACH TO SKELETAL SYSTEM TEACHING IN FIFTH CLASS BASED ON COMPARATIVE VERTEBRATE ANATOMY

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## Abstract

If the primary target of school is to train enthusiast and curious students, able to life long learning. Therefore its responsibility is to look for methodologies and practices to do this. In the last years, the didactic research demonstrated that children learn more efficiently through an active and experiential learning. In fact, the traditional methods do not permit to children to become protagonists of their learning process. In this view, we projected and conducted a learning unit about the study of the skeletal system in vertebrates in a Primary School of the province of Padua (Italy). The purpose of this experimental research was double: first of all, we wanted to confirm the effectiveness of laboratory approach for the teaching of Sciences; moreover, we wanted to verify that Comparative Anatomy could be also dealth in Primary School. The learning unit was realized in two fifth grade classes and I used two different approaches: a traditional method (control group), based on a mnemonic learning and on a study from the school book, and a laboratory approach based on the scientific method (experimental group). In the experimental group, the skeletal system has been studied comparing some bones from different species of animal (chicken, duck, pig and cow). The manipulation and the direct observation of biological material allowed students to observe morphological similarities and differences in vertebrates, better understanding the structure of vertebrate skeleton. The obtained data confirm that the laboratory approach, if opportunely applied, allows to have good results or anyway better. In the first lesson of the learning unit, the experimental group showed to possess scarce abilities to pay attention and a bad self-control compared to the control group, that showed to have good abilities. However, results demonstrated that at the end of the teaching pathway the two groups reached a similar level of competence. Furthermore, the use of Comparative Anatomy allowed students of experimental group to better understand differences and similarities of the vertebrate skeletons. So, this discipline helped students to mature a more complete and qualitatively better knowledge about the skeletal system. From the analysis of the self-evaluations, it emerged that almost the totality of the children appreciated the laboratory activities. Also those from control group, where a lesson with laboratory approach has been realized at the end of the experimentation, preferred the direct observation and the manipulation of the biological material than frontal lessons. Therefore, the Scientific Teaching can be progressing towards gradual improvement, under the stimulus of the desire for innovation.

Keywords: comparative anatomy, life sciences, primary school, scientific method, vertebrate animals.

## 1 INTRODUCTION

In the World and European scene, many studies analysed what are the most significant approaches to improve the learning [1-8]. Nevertheless it was found that these practices aren't used in the Italian school [9]. Fiorentini [10] says that the methods and practices of the traditional scientific teaching are the main cause of this inefficiency, because they are outdated. Therefore the current studies stresses the need for an active didactics at the expense of a traditional didactic, that makes students protagonist of their own learning process.

So, the central question becomes: what is the active didactic?

The active didactic start from the direct experience to study new knowledge. This method permit students to become the protagonists of their own learning process. Euridice realized an interesting research regarding the Science teaching in Europe and in this document it affirmed that the main objectives of this subject are: "the science permit to the students to understand better the world. It encourages the curiosity and the critical spirit. It underlines the relationship between the man and the nature, and the study of this subject reminds us that the natural resources are not boundless" [11]

So the Science teaching, should be treat in a rich context of instruments, materials and resources of information. Cisotto [12] said that the laboratory is the best context where it's possible to realize good practices and to organize exciting situations. People use the personal resources to develop new competences and the collaboration improve the students' learning.

If "the objectives of the experimental approach in the Science teaching are: to motivate the students, to develop manipulation skills, to favour the learning of knowledges, of methods, of scientific attitudes" [11], the active didactic and the laboratory method could be the right way to realize them.

## 1.1 Purpose of the Research

We chose to realize a didactic experimentation in a Primary school, with the purpose to confirm the effectiveness of the laboratory approach applied in the Science teaching (first experimental hypothesis). The studies, in fact, confirm the validity of this method, and the experts underline the importance to promoting its use inside the school programs and the teaching. Our purpose was to discovery the benefits and the problem to use this method.

A further purpose of the research was also to verify that comparative anatomy could also be treated in the Primary School (second experimental hypothesis). In Italian school, students usually study the human skeletal system, leaving aside the other living beings. So, with this experimentation, we tried to mature a better and broad level of knowledge of the skeletal system in the students.

Children could also see homologies and differences among different kind of vertebrates, in morphological and physiological key but also evolutionary. However, the anatomy comparative uses habitually techniques of macroscopic and microscopic observation, but students only used the first one in this experimentation.

In order to provide these two hypotheses, we conducted a learning unit regarding the study of the skeletal system in the vertebrates. The didactic experimentation was conducted inside two fifth grade classes of a Primary School in the north of the Italy.

Besides we conducted an investigation on the science teaching therefore we delivered a questionnaire to sixteen science teachers in the institute where the research was realized. With this questionnaire, we want to investigate if and to what extent the laboratory approach was already adopted in that school and if the comparative anatomy was already adopted in the Science teaching.

## 1.2 Theory

The Science teaching is based on the scientific method. The scientific method in biology, unlike other scientific disciplines, can be applied through two different approaches: the experimental method and the observation - comparative method. The first one is traditionally divided in the following phases: observation of the reality, formulation of hypothesis, realization of an experiment to verify hypotheses, collection of results and final evaluation [13]. In the second method, scientists observe and compare the biological material to macroscopic and microscopic level and it replaces the realization of the experiment.

During the research there were applied both. Through the application of the experimental method, the students studied the molecular composition of bones, while, the observation – comparative method was applied to observe the biological animal material for the study of the morphology and functions of bones. In this way, students understood easier morphological homologies and differences in vertebrates. If student should study the characteristics and the similarities from the textbook, they would memorize a lot of things. Instead, the observation and the manipulation permitted to the students to understand better the subject of study. So the application of the scientific method through the laboratory approach it allowed to the students to do activity about the reality.

Finally, children learned through an active didactic approach so, they are involved from more points of view: practical, because they had the possibility to manipulate some materials and to use different instrumentations; reflexive, because they developed an own thought; social, because they discussed, they chose the best hypothesis together, during the experiment and they agreed or not agreed with other peers; experimental, because they conducted experiments with the purpose to confirm or deny some hypothesis; cognitive, because they reflected on the topic.

We used a lot of strategies during the didactic experience: to increase the collaboration, the discussion, the thinking. Anyway, a favour communicative context is an efficient context for the learning, so it was important to increase this skills.

The protagonist of the traditional lesson wasn't the student, but a teacher- speaker so there was a teacher- speaker during the learning unit of the control group. We explained contents to the student in a clear and sequential way [9]. We explain verbally the topic and we read some texts from the students' textbook. After the reading, we used to discuss the topic with the students so we did some questions to them and they asked me something about their doubts. We used a lot of didactic strategies like: collective reading, the teacher listening, the common thinking, the autobiography conversation [12] and the supported discussion [14].

However, this method wasn't so efficient and there were many students who often didn't understand. Also, students were forced to memorize the knowledge, but how we know, children couldn't learn through the repetition.

The science teaching in the experimental group, instead, started from concrete experience on the observable facts of the world, therefore a learning process extremely anchored to the reality. Nevertheless, the topic of study is not often compared with the reality and it is forgotten in a short period of time [15]. For this, every lesson of the experimental group started observing and thinking about some events and we started the study of the vertebrate skeletal system. Besides, to know the considerations of the children about the topic, we asked them a lot of questions. After all, the children in contact with the reality, improve their personal innate scientific curiosity [13], while, children who learnt though a frontal lesson, didn't have the possibility to satisfy their curiosity [15].

Numerous authors underline the value of questions, for example [16] said "without questions there is no science, but only an assertive discourse and without hypothesis, a description" useless.

# 2 MATERIALS AND METHODS

## 2.1 Background

The experimentation has been realized in a Primary School in Padua, in the school year 2015 -2016. Having two groups class, we decided to use a traditional method in a group and the laboratory method in the other, so in my research there was a group of control and an experimental group. Obviously the knowledge transmitted was the same in two classes.

The same teacher taught mathematics, sciences in both of classes, so they usually followed the same didactic planning. There were twenty-two students in the group of control, fairly divided in males and females. Before to start the research, teachers told me that the classes were significantly different. They said that the group of control had a lot of positive characteristics, for example the maturity, the respect and the unit climate. The other class, instead, hadn't a good behaviour during school from their point of view. In both of groups there were children with certification.

## 2.2 Preparation of Bones

We used a significant quantity of biological material (Figure 1) belonging to different species of vertebrates. Students observed bones of: chicken, duck and pig. In particular, we took the skull, the clavicle, the shoulder blade and the femur from the pig. Besides, the butcher of trust gave me a part of backbone of pig and a part of femur of cow which has been sectioned in three parts. All the anatomical parts that contained bones are been boiled for a long time (the skull has been boiling for about 4 hours) to facilitate the separation of bones from the meat. However we didn't complete this process with bones of chicken, because we used them to study the articulations, therefore it was necessary to preserve the cartilage.

*Fig. 1: the biologica material used during the learning unit*

## 2.3 Activity

The learning unit was composed of five lessons in every group, for a total of 18 hours (Table 1). As we know, the traditional approach don't waste the time because the teacher can speak about something in a short time. Therefore, the learning unit of the control group was shorter than the learning unit of the experimental group. However, we chose to do some laboratory activities in the control group, after the assessment phase. In this way we didn't penalize this group and we could compare two different approaches, applied in the same group of students.

We divided the learning unit in 4 steps:

1 Survey of the pre-existing knowledge

2 Acquisition phase

3 Assessment phase

4 Follow-up phase (only for the control group)

*Table 1. Presentation of the topics*

| | Control Group | Test group |
|---|---|---|
| First lesson | Survey of the pre-existing knowledge and introduction of the topic. | Survey of the pre-existing knowledge and introduction of the topic. |
| Second lesson | Acquisition phase:<br>the functions of the skeleton, the classification, the morphology and the composition of the bones. | Acquisition phase:<br>the functions of the skeleton and the articulations. |
| Third lesson | Assessment phase.<br>Follow - up phase about the articulations and the composition of the bones (experiment). | Acquisition phase:<br>the classification, the morphology and the composition of the bones (experiment). |
| Fourth lesson | Conclusion of the experiment and direct observation of biological material. | Assessment phase.<br>Conclusion of the experiment and self-assessment test of students. |
| Fifth lesson | Self- assessment test of students.<br>Distribution of test corrected by the teacher. | Distribution of test corrected by the teacher. |

We chose to adopt the same approach to survey the knowledge already acquired by students before to start the learning unit. Therefore, the experimental group and the control group did the same activities during the first lesson. From the following lesson, instead the learning unit was significantly different. Students did a self- assessment test to understand student opinions in the last lesson.

We introduced the topic human body in the first lesson. Firstly, students shared their pre-existing knowledge. We ask to students to think about some words to describe the human body and they wrote down the words on post-its. After that, students read and memorized the meaning of apparatus, system and the name of some bones. We realized the same activities to introduce the human body in the experimental group. In the control group we chose to explain the topic to students, instead in the experimental group we start from the observation of some pictures of the textbook to discuss together the topic, so, the new knowledge come from their thinking, and not from the teacher.

In the experimental group we reduce as far as possible the use of traditional method. We used the laboratory approach so we started with the observation of authentic biological material, to think about the topic. With the collective thought and the discussions, students developed new knowledge. At the same time, we use a dialogue approach with the purpose to improve the thoughtful and cognitive skills of the children. We use a lot of strategies, for examples conversation about the real life, problem solving and we ask them a lot of questions. Every stimulus was an opportunity to think together about the topic. We became a learning community, who discuss, think and learn together.

Through the laboratory approach it was possible to use the scientific method, which has been declined in both two forms. Every new discovery has been integrated with the pre - existing knowledge possessed by the students. We used a lot of questions to stimulate this process. Every child, in fact, possesses a repertoire of personal knowledge that spontaneously increases [17] and they should be considered as point of departure to build new knowledge.

We spoke about the articulations and the functions of the skeletal system in the second lesson. To understand the first function of the skeletal system (the skeleton determine the form of the body), we used the interactive whiteboard and we projected some images of vertebrate skeletons. We ask them “how you managed to understand what animal had this skeleton?” and students had easily understood that the skeleton determine the form of the body. To treat the importance of the skull and the role that it assumes in the protection of the brain, we used a real skull of a pig. We sectioned the skull along the sagittal axis to observe the inside. We saw and touched the bone, we found the place where the brain was and we see the cranial suturing through an analytical observation. To understand the role of the skeleton in the movement, we put two elastic along my arm and the students understood that without bones, the body could not move. In the last part of the lesson, we observed the visible articulations between the bones, so the cranial suturing from the skull and the mobile articulations from a thigh of chicken.

In the first part of the third lesson we realize an experiment, with the purpose to understand what substances compose the bones. The bones, like shells and limestone are composed by calcium carbonate so we decide to plunge a chicken bone in a glass of limescale remover, to prove that bones are composed by the calcium. We also decide to plunge another chicken bone in a glass of lemon juice because this material is an acid. Before to do this, we projected some images to explain the reason why we do this experiment. After that, we divided students in five groups, they did an activity of direct observation to understand the classification and the morphological structure of the bones. Five islands have been recreated with the benches and to the centre of every place, we put some biological material. In every place it was also a list of questions to focus their attention on the most important aspects. The lesson finished with a collective discussion of our feeling with the purpose to conduct a moment of recapitulation and consolidation about the direct observation.

In the fourth lesson, students did the final test. The structure of the test was the same for the group of control. After that, students have completed the last step of the experiment, so we extracted the biological material from the liquids and we proceeded with the checking of the hypotheses. We wrote results in the book and the explanation of the phenomenon. Finally, students answered the question about the self- assessment, an activity to investigate the opinions of the students and their doubts regarding the learning unit.

Actually, at the design stage we put the realization of the experiment in the second and in the third lesson, to finish the learning unit with the test and the self-evaluation in the fourth meeting. Nevertheless, students were very undisciplined on the second lesson, so we couldn’t do this activity. We chose to postpone the experiment, aware of students would observe results on the fourth lesson.

As regards the group of control, we used the traditional method the first the second and the third lesson. Students did a test on the third lesson, to verify their knowledge.

We divided the second lesson in in three parts: we explained the functions of the skeleton in the first part, we introduced the classification of bones in the second one and the morphology and the molecular composition in the third one. Also in this case, we projected some images representing the skeleton of some vertebrates and we asked to students what animals were. After, we explained the functions of movement and protection carry out by the skeletal system. To treat the classification of bones, we asked them to observe the images of the skeletons and we asked to the students if every bones had the same form. Students understood that the bones could be divided in the three categories: short, flat and long. To treat the last matter (the morphology of the bones) the class proceeded with the reading of the textbook. They copy a picture of a long bone and they memorized some words: ossein, mineral salts, periosteum, epiphysis and diaphysis. Students answer questions to increase the learning, at the end of the lesson.

In the third meeting the control group did a test to verify the learning. In the second part of the lesson, students started to conduct some laboratory activities. Firstly, students studied the articulations, which didn't previously treat in detail. To explain this topic, we used two bones of chicken so we started this activity with the observation of the real biological material. In the last part of the lesson, students did the same experiment conducted by the experimental group, to verify the presence of the calcium and the other mineral salts inside bones. We wrote the hypotheses about the result of the experiment in the book. In the fourth lesson we verified the hypotheses and we wrote results and the conclusions in the book. After that, students have been divided in 6 groups and they participated in an activity of direct observation of some bones. We distributed a lot of biological material used with the experimental group and students could match the knowledge built during the frontal lessons to the knowledge from the observation of the reality.

## 2.4 Assessment

The principal topics of the skeletal system were: the functions, the classification and the morphology of the bones, the memorization of the name of principal bones and the classification of articulations. We treated these disciplinary matters in both of groups, nevertheless they have been introduced through a different chronological order. The teacher of the class was used to assess her students through some structured or partly structured tests: questions true or false, cloze and tests to multiple choice. We have chosen to adopt three different typologies of test with the purpose to respond to the habits of the students and to detect the students' competences.

The assessment has been divided in three parts and every of them analysed a different topic. In the first part we gave a picture of a human skeleton to the students, and we asked them to write the name of eight bones in the corresponding empty window. The options were suggested. In the second part we gave to students a text with some missing words about the morphology of the bones. The suggestions weren't given. Finally, in the third and last part students answered some open questions. In both the classes we used the same structure, nevertheless we changed the formulation of some questions in the third part. In fact, the topics were treated in different way in the two classes during lessons. This diversification happened because the laboratory approach want to make the students protagonist of their own learning and active agent in the decision making. So, during the learning unit, students took an active interest for the articulations and it was necessary to study this topic in a particular way to respond to their interests. In planning time, we hadn't consider this topic as main point, but during the activities with the class it has been analysed and taken back a lot of times and it became one of the principal thematic. In the group of control, instead, we respected the planning so, we didn't change the assessment. In the assessment of the experimental group, we included two open questions about the articulations.

# 3 RESULTS AND DISCUSSION

The majority of the sixteen teachers who completed the questionnaire are in favour of the laboratory method because they know how this method is efficient. However, they said that it's difficult to apply this approach. In the Italian schools very often there are: scarce materials, lack of suitable instruments, lack of contributions and the fear of their parents school. These problems force them to use a traditional method. Nevertheless, numerous teachers said to use poor materials and easily available with the purpose to realize meaningful and significant activities.

As regards the textbook, teachers often try to integrate it with other materials. Although they don't have many resourced and supports to disposition, so they involve the participation of students through discussions, didactic games and collective thought.

We feel that this survey could help us to understand the context where the experimentation was done. It's clear as scientific teaching is evolving toward an improvement, stimulated by the wish of innovation in the teachers. So the laboratory approach isn't adopted in that school yet and neither the comparative anatomy but teachers would like to do this. It is difficult to individualize the reason why the didactic improvement is slow and it will be necessary to do other surveys. It results puzzling however that all the teachers, who are not tenured teacher, were contrary to the introduction of animals.

The first objective of the didactic experimentation was to confirm the effectiveness of the laboratory approach applied in the Science teaching. Unfortunately the two groups were very different between them:

- There were two children with behaviour certification and disturbance in attention in both groups, but they affected the lessons in a different way.
- There were two children with social and economic disadvantage in the experimental group and some students with hostile behaviour
- There were two opposite behaviours in groups: the control group liked to study Sciences, on contrary to the experimental group who wasn't respectful and passionate.

Therefore, the experimental group was a problematic class.

However, it will be impossible to have two classes with the same characteristics, we decided to proceed with the research, choosing the class with a problematic behaviour as experimental group, with the purpose to improve its ability of attention, the enthusiasm of the discipline and the performance.

Results of the final test confirm that both the groups had a good knowledge of the name of the bones.

Observing the rates of correct response to the questions about the third part, it emerged that students belong the control group possessed a better knowledge regarding the concepts more difficult to memorized ("What is the difference between apparatus and system?"), while the experimental group had a better knowledge who learned though the direct experience. For example, the control group has got a worse result than the experimental group in the question of the classification of the bones, because of some inaccuracies of the control group (some students wrote "round bones" or "small bones" to the place of "short bones", or "great bones" to the place of "long bones"). Generally the research has shown that the experimental group completed the answers with a lot of exemplifications, while the students of the control group of control wrote only the definitions. So the experimental group has shown to possess a qualitatively and better knowledge (although not quantitatively) about the topic, richer and less stereotyped than the control group.

As we know, one of the benefits of the laboratory approach is to make the students protagonist of their own learning process. So, we chose to involve them in the assessment process also. We realized a test of self-assessment that allowed to the students to express their own opinions and considerations regarding the learning unit. From the analysis of the answers it emerged that some students (in both the classes) started to appreciate this discipline. Besides, almost the totality of the experimental group preferred the third lesson, when we did the activity of observation and manipulation of the bones and the experiment. This data is very important because it allows us to formulate some considerations about the research and to the laboratory method. There are three reason why students preferred the third lesson: the first is the pleasure of the manipulation of bones that has been expressed by the majority of students, the second is the experiment and the third motivation lies in the fact that students had the possibility to collaborate with the peers during lesson. In fact, students were divided in 6 groups to do the activity of direct observation on the biological material. So, this organization was very appreciated by the students because the participants have been involved in active way. Therefore, beyond the results obtained by the students in the assessment, we can affirm that the laboratory approach did the difference in this context. This method improved the curiosity and the pleasure of the discovery in the students.

From the answers formulated by the group of control in the self-assessment to the question "What is your favourite lesson?", the totality of the students, preferred the activities conducted during the follow-

up phase (laboratory activities). Also in this case, children gave the same motivations of the experimental group.

At this point, from this research we can affirm that the knowledge concretely acquired isn't an option but a necessity, since it allows fixing the concepts in more solid and lasting way. The activities of manipulation and observation increased the motivation in the students and they felt involved.

So we can confirm the potentialities of this method, which excellently helps the acquisition of the knowledge. It allows maturing a complete, integrated and implementable knowledge and it doesn't impose clean borders to the curiosity of the students. It is an efficient method because it stimulates children to use their skills. Besides it is a method that allows acquiring the necessary competences for a lifelong learning, [18]. Finally the use of the experimental method makes lessons stimulating, motivating and involving for children.

The second experimental hypothesis of the didactic research was to verify that comparative anatomy could also be treated in the Primary School. Actually, children of Fifth grade class study only the human body and not the mammals or the vertebrate animals. In this way, they can't do any activity of direct observation, because it is complicated to bring true human bones in class. Extending the activity instead to all the vertebrates and particularly to the mammals, students could observe and manipulate some real biological material building knowledge through an active and significant approach. There are numerous homologies between the skeletons of the man and the other animals.

To study all the systems and apparatuses of the body of the vertebrates through the anatomy comparative give numerous possibilities to the Science learning. Also we can use this subject to introduce the biological evolution in primary school.

Students developed an integrated and complete learning regarding the skeletal system. The study of vertebrates like the kangaroo or the rabbit permitted to observe some structural characteristic that there are only in these species of animals. So, we study also the binomial form and function in this learning unit, that it's one of the founding nucleuses of biological knowledge [13, 19]. Finally, the comparative approach was useful to apply the observation- comparative method. The activity of "macroscopic and microscopic observation of the organisms is an excellent way to approach the students to the biological world", so this method improve the passion and interest who student could have for this subject.

## 4 CONCLUSIONS

In conclusion of this paper, we can confirm that the human body is a topic that is open to the study although the laboratory method. The use of the scientific method (experimental method and observation-comparative method) permitted to have a sound knowledge, based on the direct observation and the collective thought. Moreover, we cannot forget that that the experimental group and the group where it was applied the traditional method, did similar results, despite the great difference between them. In addition, the application of comparative anatomy permitted to students to understand the skeleton system in an efficient and significant way.

It doesn't matter if the schools hadn't scientific laboratories, the most important thing is to have teachers who want to do efficient lessons with authentic material easily located

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