Education in Natural Sciences:  
A Journey Through Time

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Abstract. In the present study, the subject studied is the course of Natural Science education over time and the educational tactics of major educators, up to the trends of modern teaching. Education was the basis of the development of Natural Sciences, based primarily on the translations of the Greek writings in the Middle Ages. Then came the educational practices of the great educators from the 16th to the 19th century, such as Comenius, Rousseau, Pestalozzi and Herbart. Then followed the pedagogical approaches of the 20th century with pedagogues such as Steiner, Dewey, Decroly, Montessori, Cousinette and Freine, while in the second half of the 20th century, didactic is officially introduced with pedagogical trends affected by pedagogical psychology. Finally, at the threshold of the 21st century based on the experience of the past, modern trends in teaching are reflected in the curricula of each country and in national studies, concerning education.

KEYWORDS: Natural Sciences, Education

MIDDLE AGES
In the Middle Ages, when translations from Greek were the scientific writings of major European universities, many of them consisted of physics courses that included all sorts of physical changes, Cosmology and Astronomy and Mathematics [1]. Aristotle's studies, systematically studied at Medieval Universities, were, among others, "About the Sky and the World", which dealt with the movements of the celestial and earthly objects, the "Meteorological" that described and explained a wide range of phenomena such as the wind, rain, lightning, thunder, and even comets and the galaxy [1].

16th-18th CENTURY
Major Teachers of the 16th-19th century consider Natural Sciences to be an integral part of education. John Amos Comenius (1592-1670), a forerunner of transnational education, in his deeply religious text, makes a very detailed account of the birth of the world by God, starting with the sun, the moon, the stars, and throughout the work there is plenty of reference
to nature and many examples of it [2]. Like the work of Comenius, Rousseau's work (1712-1778) is full of references and examples from nature, and in many points it refers to the teaching of Natural Sciences. He claims that man is formed through education and equates the purposes of education to those of nature [3]. An infant in its first movements tries to "measure" everything that surrounds him and discover every object with his senses; in short, his first study is something like experimental physics related to his own existence and through that he recognizes his space on Earth [3]. Also, Rousseau makes an extensive reference to the teaching of Physics; he speaks of the law of gravity, contraction, magnetism, hydrostatic pressure, barometer function, and others. He argues that the teaching and the experimental process should be done with simple daily means without necessarily entering a scientific laboratory. He firmly believes that the scientific atmosphere kills science [3].

At the end of the nineteenth century, pedagogue Petalozzi (1746-1827) was responsible for the dissemination of heuristic methods - a study of the science of discovery [4] - the need of which was already essential for educational practices [5]. Like Rousseau, Petalozzi encouraged learning through the senses and introduced the teaching of "a lesson through the study of an object", study of its material, its function and its usefulness, which always resulted in an ethical lesson [6]. Ritter, who has been one of the most important geographers of the time [7], stated that Petalozzi made him understand the notion of "natural method" (ie that the exact knowledge of the world can only be acquired through the direct observation of the natural phenomena) [5].

Johan Friedrich Herbart (1776-1841) divides Natural Sciences into three categories: «Geography», including «mathematical Geography», «Physical Geography» and «school travel», «Science» which includes «object study» and «Natural Sciences» and «Mathematics» that include «arithmetic» and «geometry». According to Herbart’s teaching methods, teachers should have what the child sees as the starting point of teaching science [8].

**20th CENTURY**

In the twentieth century, the following pedagogues stand out:

Rudolph Steiner, whose schools use science courses as a way to serve an holistic education related to the environment, attempts to preserve pupil’s relationship between child and nature or re-activate it with a teaching method adapted to his future mental structures. This resulted in finding common ground with the current concerns of natural philosophy about the problem of ecological education [9]. According to Steiner, there are four kingdoms of nature, minerals, plants, animals, and humans with man gathering all four worlds inside
him, which marks the completion of creation [9]. John Dewey (1859-1952), influenced by Darwin, Rousseau, Pestalozzi and Herbart, claimed that education should be placed within the natural development of the human species. Man and Nature should be reconciled and coordinated as man is an organism that interacts with the environment [9]. Dewey argues that Nature and Earth should be treated and taught as equivalent terms and admits that the study of Nature has been separated into other study objects and thus has lost its integrity. These pieces will have to be reunified and the study of nature will be an integral part of the educational process [10].

Ovide Deckroly (1871-1932) in 1901 founded a special education institute, but he was quickly convinced that these pedagogical methods also fit normal children [9]. In Deckroly's programs there are many references to Nature and many concepts are linked to it in order to be understood by the students [9]. In addition, the notions of «good» and «beauty» are of great importance in the work of Deckroly that derive from Nature and natural life and are presented as non-disputable [9]. It is clear, therefore, that Deckoly's pedagogues’ work examined above is characterized by a connection of pedagogical concepts with Nature and a special emphasis is placed on minerals and the study of the universe.

Maria Montessori (1871-1932), who was an Italian doctor and anthropologist, became widely known as a great pedagogue. She supported her Ph.D. in Pedagogy and Anthropology at the University of Rome [9]. In her special institute for children, students learn to respect others, care for and not spoil the classroom and the environment. In Montessori’s institution, education is based on the teacher and the environment [9]. In Montessori schools the method of scientific observation, is widely used and the natural environment was the first thing to be studied and examined [11]. The child should study the natural phenomenon (rain, snowfall, storm, space and others) and learn from it [11]. Children become masters of the land by planting, watering and observing, with their mothers observing discreetly and lovingly their children's occupation with the land that is now their favorite conquest [11]. It is observed, therefore, that the concepts of Nature and the environment are diffused in the Montessori methods, and even the first contact with education is based on them.

Other significant teachers such as Roger Cousinet (1881-1973) and Célestin Freine (1896-1966) give priority to group work. Students have several books and materials at their disposal, while there are no curricula [12]. Experiments are carried out in the classes where the children firstly observe the plant, the animal, the natural phenomenon (rain, temperature, storm), minerals, simple machines and all things they have at their disposal depending on the
science subject of the course [9]. Célestin Freine, like Cousinet, advocates observation and rejects programs.


In 1950 the didactic of Natural Sciences was born. The fact that marks its birth occurred on October 4th 1957, the day the Soviet Union set the first artificial satellite Sputnik in orbit around the Earth. This fact, apart from surprise in England and America, has also led to changes in teaching Natural Sciences [13]. Then, at least three competing views on Nature and aims of Physical Science were introduced in schools: 1) a practical, technically applied approach, 2) an innovative, holistic, humanistic approach, 3) a specialized, theoretical, scientific approach [14].

In the 1950s, the predominant learning theory in psychology is «Behaviourism», whose basic characteristic is that knowledge is treated as «something» that can be transferred from the teacher to the students. Behavior theorists define learning as nothing more than the acquisition of new behavior based on environmental conditions. The teaching of Physical Science is based on lectures by the instructor, enriched by demonstration experiments; the book is the basic learning tool and assessment is based on the knowledge that the student must recall [13]. Natural Sciences are considered as a list of events that «must» be taught and the most effective teaching strategies are those that the teacher tells the students things that «must» be learnt; therefore emphasis is placed on closed teaching strategies where there is a flow of information from teacher to students [15].

"Discovery learning" is the following teaching technique based on inquiry learning which is placed between 1960 and 1975, when Americans and English recognize the need to create - through the educational system - skilled engineers and scientists in the field of Physics. Science teaching is based mainly on laboratory activities designed to encourage students to behave as scientists and at the same time train them in these activities. Natural Science teaching has a central role in the development of skills such as: observation, classification, measurements, space-time relationships, communication, predictions, reaching conclusions, introducing definitions, assumptions, interpretation, identification and control of variables, experiments, skills that are considered to be skills of a Natural Science scientist. The student is the center of the educational process and it is very important to interact with the laboratory materials. The «mistake» of the student continues to be considered a product of his lack of attention, a view that is a remnant of «Positivism» that continues to dominate [13]. The theoretical basis of the «Discovery Approach» is in line with modern learning theories.
and serves not only the gain of knowledge but also the exercise in scientific processes. This approach ignores the ideas of the students and does not use them in the teaching process which averts its establishment in the teaching of Natural Sciences [15].

The "Constructive Approach" is the following dominant approach of the 1980s and the key feature that differentiates it from the previous is that it takes into account and exploits the students' pre-existing ideas for concepts and phenomena. The entire decade of 1980s is characterized by an extensive study of students' pre-existing ideas, on every single sector of Physical Sciences. An important feature of the «Constructive Approach» is the introduction of the metacognitive process; the term «metacognition» means the student's awareness of the cognitive procedure that has followed. In this approach, there is a tendency to create scientists, and the student's "mistake" is considered an alternative form of knowledge, due to his pre-existing knowledge and his interaction with teaching [13]. Since 1985, new trends have emerged concerning the teaching of Physics. The aim was no longer the production of scientists but "Natural Sciences for All". There was no longer the need for scientists or engineers, but the need for literacy in Natural Sciences. Within this trend individual approaches were distinguished such as a) stimulation of communication between different cultures resulting in the introduction of new aspects on Physics and Natural Sciences’ correlation with the local community b) creation of citizens familiar with the use of technology and finally c) creation of informed and sharp-witted citizens who can decide on issues of modern social and environmental problems [13].

The «Constructive Approach» includes the stages of orientation and introduction to the lesson, the stage of highlighting students' ideas where students express their ideas verbally or in writing, the reconstruction phase, where students are encouraged to control their ideas in order to expand, develop new or replace pre-existing ones with others. The pursuit of the teacher is the voluntary shift of children from their own ideas to other ideas that are closer to the scientific model. Subsequently there is the stage of application where children relate what they have learned to the experiences of everyday life, and finally the review phase where students have to recognize the importance of what they have learned [15].

Other learning models developed in order to improve science teaching are "R. Karplus's Learning Cycle," which includes the exploration stage, the invention and the application stage, the «Osborne’s and Freyberg’s» model which includes the preliminary stage, the focus stage, the challenge stage and the practice stage and other models. The common features of constructive approaches are group work and discussion in the group.
There is also the teaching method of learning through «Small Investigations» which is an inquiry-based learning model, based on the «Discovery Learning» of 1960s. It aims to create a learning environment that encourages students to seek information about a question that they are interested in and to carry out investigations or small inquiries in order to answer it. It uses advanced practices that come from the model of «Discovery Learning», such as «free discovery», but now the goal is smaller and therefore more realistic with the questions to be explored, minor, more feasible and more interesting for the students. This learning is aimed at exercising students in scientific processes and can be integrated into the model of «Constructive Learning» that applies mainly to the reconstruction phase [16].

TODAY

Modern teaching trends are reflected in the national curricula which are designed for each country (England, France, America, etc.), but also by national studies such as Project 2061 of the American Association for the Advancement of Science, which promotes a modified teaching of Natural Sciences in schools.

The American Association for the Advancement of Science published (and since then is continually being updated) an extensive national study in 1985 entitled Project 2061 to motivate and promote a modified teaching of Natural Sciences in schools (2061 is the year that comet Halley will be visible again from Earth). Five discussion groups with academics, educators and educational staff held some meetings and were asked to choose the content of teaching Natural Sciences by considering a) its usefulness, b) its indigenous value, c) its philosophical value, and d) benefit to pupils’ lives. The first report of these groups supports science literacy for all students in American schools and the curriculum structured in such a way as to encourage scientific thinking (Matthews, 2007). Project 2061, discusses the knowledge that pupils should have at various stages of their school career. Students at the end of secondary education should be aware of experiments that take place under the same conditions and may have different results and this is something that should be investigated. They should also be aware that even in cases with the same results, research should be repeated several times. They should also be aware that scientific knowledge is subjected to constant changes since knowledge and information are constantly increasing, but sometimes scientific knowledge is still applicable despite its antiquity [17]. In addition, according to the 2061 announcement, which is continuously being updated, students should be aware that although significant discoveries in the fields of science, mathematics and technology have
been made by people of different tribes, different cultures, in different ages those findings are available all over the world.

In the National Curriculum of England, which is somehow the adversary of the American educational approach, a high-quality science education, in secondary education, must lay the foundations for understanding the world. All students must acquire basic knowledge of the methods, procedures and uses of science. Also, students should learn to give reasonable explanations of natural phenomena and feel the curiosity to interpret them. Education in Natural Sciences should encourage them to explain what is happening, to predict the consecution of phenomena and to analyze the causes [18].

In secondary education, starting with Key stage 3: ages 11-14, students should gain a deeper knowledge of Natural Sciences and scientific thinking. Teachers should be free to choose various examples they will teach to promote the scientific purposes of education, how scientific ideas have been born historically up to how they have evolved and are used in modern ages. Students should learn to use scientific vocabulary, nomenclature and mathematical representations.

They should also be taught about the force of gravity that is different on the various planets, the gravitational forces between Earth and Moon and between Earth and sun, the sun as a star, the other stars of the galaxy and other galaxies; the seasons and how they are related to the land gradient, the time of day at different times of the year, the various hemispheres, the light years as a unit of astronomical distance [19].

At the next stage, ie between 14 and 16, key stage 4, students need to look for evidence of the formation and evolution of the Earth's atmosphere since its formation, to investigate the anthropogenic causes of climate change and the potential effects of elevated levels of carbon dioxide and methane on the global climate and to look for ways to mitigate them, to study the common earth pollutants such as sulfur dioxide, nitrogen oxides, microparticles and their sources. They should also be taught about water reserves and ways to make it drinkable [20] but also the main features of the solar system.

**CONCLUSIONS-PROSPECTS**

Natural Sciences has always been a basic subject of study in education. Besides, Dewey states that Science represents human’s sailing board for its natural inclination towards destruction. What is observed is that the teaching methods proposed by the great educators in teaching Natural Sciences have been slightly differentiated in the educational programs in the last centuries, the teaching and the study objects are the same and the knowledge that is
communicated is addressed to a limited number of students, which some [21] attribute this fact to political expediency. The communities of teachers who teach Natural Sciences were isolated and seldom paid attention to issues outside their field and their attention was extremely narrow on the pedagogical and didactic issues of Physical Sciences [22].

From Rousseau's Emile to the present day, the educator is called upon to raise awareness and to make observation a basic learning tool, because learning through experience is easier to recall [3]. Rousseau, often addressing educators, used the expression "watch nature, observe your student carefully before telling him the first word" [9] and firmly believes that the child must feel Nature in order to understand it and his teacher should be the helper in this effort without revealing all the truth but perceiving it through observation. Reif, [23] argues that basic knowledge of Natural Sciences must be acquired through processes that the educator must explain with complete clarity and form the vague ideas that students have about the science of Nature.

The notion «come back to the field and observe» is imperative because a child «reads» better the «book of nature», his judgment is superior to his memory and that helps him decide more correctly; the teacher should make the student observe the phenomena of nature, and in doing so will make him curious, also he should not teach him science but make him discover it [3].

The above method, though widely accepted for its effectiveness, does not apply to school classes; Duschl in [24] argues that in the current programs very little time is devoted to examining and analyzing the problem being studied, teaching is exhausted in performance with the problematic being absent, thus eliminating the building of knowledge that would help to develop a high level of reasoning and combining thinking and calls on the educational community to radically change the existing situation. Lijnse in [24] also agrees that there is a gap between theory and practice in the field of Physical Science education, due, among other things, to the ignorance of the teachers and research findings, but also to the physicists of pedagogical methodologies and educational psychology.

In recent years, however, many countries in the world are looking for ways to teach Natural Sciences so that they become interesting and comprehensible throughout the class, as the resignation of children and adolescents from the Natural Sciences is a fact and subject of many research studies ([25], [26], [27], [28]). Indeed, this is an active reformation of Physics as a scientific discipline as a subject of teaching and as a public image to the public. This perspective can be achieved if different disciplines, such as Physics, Pedagogy, Psychology and Digital Media Sciences, meet and collaborate and designate new interdisciplinary sites
and produce theories and methodological tools for studying teaching of Science in order to improve education. By choosing a specific content from Natural Sciences (concepts, theories, models, phenomena, etc.) and placing it in the wider context of humanity, history and culture, Natural Sciences can be demystified; teaching can be meaningful and interesting inside the class, detracting from the positivist image of the specialization that prevailed in the past [21].

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REFERENCES


