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STEM Engaging Teaching and Learning for the Heart in Bioscience Education

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Abstract

The aim of this this research and educational path was to involve high school students and science teachers in STEM integrated teaching and learning in the anatomy and physiology of the cardiovascular system with engaging, collaborative and innovative methodology to overcome a mnemonic-notional learning. This STEM innovative project connects tradition and modernity in a balanced way, guiding teachers and students in using in an integrated way different digital tools and international scientific sites. Many questions about the heart were proposed in the classes to create a "Digital Heart Debate" between the students and the group of teachers in interdisciplinary methodology approaches using also chemical mathematical equation to interpret the excitability of cardiac cells. A view of didactic work with contaminations between different disciplines and methodological strategies to promote the development of skills in integrating, comparing, identifying relationship between basic principles of the chemical, physical and biological sciences with reasoned historical elements. Considering that at different levels of educational system the learning of the anatomy and the physiology fascinate greatly, it proved very effective to create and to realize an interactive and multidisciplinary learning by doing and coworking itinerary to promote an innovative and dynamic vision of the human body in which the heart can be studied in the structural and functional complexity and in the interrelationships with other systems, to activate also original orientation teaching in Health Education. Innovative STEM and IBSE itinerary also with the historical dimension of science which is fundamental to know the steps with which science proceeds, revisiting the important discoveries useful to understand the physiology of the heart. One important objective in this future research about educational activity for students and teachers will be to promote the awareness that the life cannot be explained only at the molecular and genetic level, but that's the biological systems should be studied as complex systems that derive from dynamic interactions that operate in a coordinated manner.

Keywords: *Didactic Innovation; Heart Debate; STEM Digital Teaching; Systems Biology; Orientation Teaching*

Introduction

This STEM project started after presenting to the high school classes the study of chemical equilibrium, the acid-base and electrochemical theories, treating both theoretically and experimentally the Volta' battery and the Daniell' battery, the electrolysis process, therefore the concepts of electromotive force, spontaneity or non-spontaneity of a chemical process. Different ideas were proposed to the teachers with some questions: How can we lead students to understand that basic principles of chemical-physics are the basis of the understanding of some fundamental functions of living things, also identifying relationships between different sciences that are too often presented in a fragmented and clearly separated way? It is not a question of «closing» the chemistry programming to «open» that of biology, but of studying a system such as the cardiovascular one, and the electrical conductivity of the heart, starting from the historical research carried out on the electric current in living and non-living animals in the past. The educational-scientific objective was to "get the scientists to talk" thanks to numerous attempts and heated comparisons, for example between the followers of Galen of Pergamum and those of William Harvey, led to understanding the anatomical structure and the physiology of the heart.

Materials and Methods

The analysis of historical experiments has made students and teachers aware of scientific conquests realized in continuous comparisons, in real case with real diatribes, experimental remodulations: alternation of success and defeats that should encourage people to get back into the game with new projects. The different activities in the IBSE methodology started analyzing from Luigi Galvani's intuitions on soul electricity by reading the descriptions of the historical experiments with frog and the lively narrations of the initial contrasts between Luigi Galvani and Alessandro Volta. In conclusion was realized discussion about how science comes to conclude that each cell behaves as a microscopic pile. The students took into consideration and retraced phases of the experimental work of the two scientists in the laboratory, also building with poor material, the historical Volta' pile. The students "actors" then identified themselves with ideas of Galvani or Volta and were protagonists and interpreters of an active dialectical confrontation between the two scientists. Identify themselves in the scientists' ideas, identify their strengths and weakness, to present them in dialectical comparison: a real scientific debate between students protagonists. Starting from the scientific readings carried out in the classes with the guide of science teachers, the students chose to interpret Galvani or Volta, favoring specific insights relating above all to the different experiments carried out by two scientists. Another phase of STEM itinerary was a brief analysis of their respective biographic and principal publications of the two scientists. Subsequently were defined Galvani-Volta working pairs: students who must support the ideas of the chosen scientist with strength of communicative conviction, proposing criticisms to the antagonist who must respond in an argumentative manner. It was a sort of simple "scientific theater" in which all the students, even those who normally display expressive uncertainties, enthusiastically explained the work they had done. To guide the reworking the researcher suggested to the students a series of questions including, for example: In what historical context and with what premises do Galvani's experiments fit in?
What objections does Volta to Galvani's conclusions?
What experimental modifications are implemented by Galvani and Volta to demonstrate the validity of their theories?
The students also discussed the answers to these stimulus questions:
How is it possible to reinterpret the principles of Galvani and Volta today, based on the current scientific knowledge?
Is there a real contrast between the ideas of the two scientists?
Galvani and Volta definitively managed to demonstrate their conclusions through significant experiments, thanks to which today it is known that both were right. Volta built the first pile: a pile of copper and zinc disks separated by cardboard disks soaked in salt water. If the column was tall enough, it was shaken: it had demonstrated the need for heterogeneous metals and wet conductors for the production of electricity.
In realtion of modern scientific knowledge, scientists believe that there is no gap between the opinions of Volta and Galvani and that their experiments are complementary.
Both scientists made mistakes because Volta did not realize that what he was observing were chemical oxidation-reduction reactions and Galvani believed that there was something completely different about biological energy. Galvani, however, understood what years later scientists somehow confirmed: every cell in our organism functions like a Volta battery. The salt-soaked discs are similar to membranes, zinc and copper to ions inside or outside the membrane (charge separation). The contraction is, therefore, due to an electric current flowing through the nervous system and not to an ethereal life force. A reflection was realized together the students on the quote by William Harvey: «All we know is infinitely less than what we have left to know» opened the reading work to the classes of the chapter "The mysteries of the heart" of the book *The ten most beautiful* by George Johnson.
In the third part of this cultural itinerary were very important the reflections on the functions of the cardiocirculatory system in controlling the thermal and chemical homeostatic balance of our organism, underlining above all the fact that the cardiovascular system serves to connect various organs and systems located throughout the body, thus assuming a systemic function. An important reference was to the fact that the blood maintains a constant pH value thanks to buffer systems; blood that is too acidic would cause the denaturation of proteins which would no longer be able to carry out their function. The heart was thus presented as a fundamental "component" of the body system, a real "machine" that produces a constant beat until the individual's death. The heart is an involuntary muscle which, with its contractions, converts chemical energy into the mechanical energy necessary to carry out its main function: pumping blood to all regions of the body. A chemical equation was so useful to interpret together with students the excitability of cardiac cells is the equation that all students studied in the electrochemistry program; the Nernst equation was explicitly used to interpret a biological phenomenon: the excitability of heart cells.

Results

Interesting results of this project was obtained also in proposing to groups of students these questions and in comparative analysis of the different answers: Why does the heart have such a complex structure? Why does it work like a pump and not like a simpler reel, a device that requires less energy consumption? The heart has a complex structure: is it a pump or a whirlpool? What does it mean that the heart is autorhythmic?
Due to personal or family health needs, students increasingly carry out a diagnostic test such as an electrocardiogram in their early years, also to be able to carry out sporting activities. They are therefore intrigued to know the physiological findings of this test correlated with the systole and diastole phases of the cardiac cycle for the health of the cardiovascular system: reasoned research. At the end of the class project path was decided to make students aware of the causes of some pathologies of the cardiovascular system by involving them in a reasoned analysis of scientific sources that led to the writing of an abstract. Students in little groups therefore worked reading of scientific articles (in Italian and English), their interpretation in light of the different topics covered in class and the writing of a text. All students were given the text of the article realizing also an analysis of cardiovascular risks at global health: science issues in which the main health risk factors are also represented graphically with a digital descriptive aerogram: behaviors and metabolic alterations especially in relation to the most important chronic diseases, including heart disease. In this case, writing an abstract required the transition from numerical data, a form of synthetic communication, to analytical and reasoned argumentation. Science teachers assigned the students to search online the article *Sugar restriction: the evidence for a drug-free to reduce cardiovascular diseases, by S. Thornley, R. Taylor, K. Sikaris published in 2012 in the International Medicine Journal.* The students with better English skills read the article in its entirety, preparing a short summary to present to the class; the other students in pairs chose to read, analyze and summarize one or two sections of the article to integrate with information from the Health World Organization, preparing a written digital interactive summary of two pages.

Discussion

In the terminal part of the teaching and learning itinerary the proposed text of scientific article some authors' questions are used for a discussion in the classes about the dietary behaviors to adopt to reduce the risk of cardiovascular diseases, especially in relation to sugar consumption. A section of the article focuses on diabetes was very interesting for the students; diabetes is a pathology that has spread like a sort of epidemic wave initially in Anglo-Saxon countries, mainly the United States.
The sections of the article entitled *Physiology of fructose* and *Epidemiological association between fructose and risk factors for cardiovascular disease* were analyzed to understand a positive correlation between the intake of sugary foods and genesis of cardiovascular diseases. All biologist - teachers proceed with students to in-depth analysis of the data presented in the *Sources of fructose* in the diet section , comparing the average quantities consumed in different age groups in the countries of the Anglo-Saxon world, starting from a high consumption, especially of sweetened drinks.
The students, very motivated regarding this topic, carry out in-depth research on sugar consumption, consulting at least three scientific reliable sources, presented the results of the work carried out on the problem of sugar addiction to others classes in a digital computerized way. The classes thus become integrated communities of shared scientific learning, at the end of the different presentations all the students realized a short written report about the different and significant results presented in the "Digital Heart Debate".

Conclusion

Despite decades of research on the functioning of the cardiovascular system and the causes of its pathological degeneration, we still find ourselves today with several obscure points in understanding the physiology and pathology of the heart and the circulatory apparatus.
There is, for example, an enormous intellectual and material investment in experimentation on the use of stem cells to make infarcted heart tissue active again. In fact, at the site of the "fracture" a fibrous tissue forms which does not conduct electrical potential. Being able to make the infarcted areas of the ventricle excitable again could prevent new traumas and expensive and demanding operations such as transplants. From a prevention point of view, there is still enormous work to be done in terms of nutritional and behavioral education.

The food we ingest practically accounts for 70 percent of our quality of life in terms of health. It is therefore necessary to inform the communities both regarding correct nutrition and correct physical exercise.
Scientific research in these two fields has developed greatly in recent years and the trend is to increase efforts in this direction. A population that eats well and is in good physical shape, as well as having a better living condition, has an enormous economic return with significant savings in healthcare costs. From this perspective, researchers are increasingly convinced that it is essential to activate innovative paths in cultural educational planning that educate people to understand that life cannot be explained only at the molecular and genetic level, that biological systems must be studied as complex systems that derive from dynamic interactions at different levels of components operating in a coordinated manner.

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