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Transdiciplinarity- a creative teaching method in biology

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Abstract— Nowadays, a child has to learn about sciences: mathematics, physics, chemistry, biology, but it is more interesting to study and understand how all of these may interact. All theoretical concepts are more valuable when they become practice. The aim of this paper is to prove that biology, which is a multidiciplinary field, including biology and biological processes of living beings, biochemistry and biophysiscs, can be teached, using integrative universal principles of natural science, by transdisciplinarity. This is sustained by the STEAM education, which will help our students to learn concepts, to think creatively and use innovation in solving their problems. STEAM education is important for our students because it removes limitations and stimulates their creativity, innovation, leadership, self-confidence, wonder and critical thinking. Having the multidisciplinary field status, biology as a key part of STEAM education, teaches students to integrate individual components in complex systems, to test theories and principles, to have an overview on different tasks and evaluate and implement their results. All of these skills are transferable into their life actions.

Index Terms—*transdisciplinarity, biological process, critical thinking, STEAM education*

I. INTRODUCTION

When a child is in school, he gets information and practice about all disciplines, thus gaining his general culture and planning his future. School has to support him in developing the eight-key competences required by the middle-school graduate educational training program and needed in all his life. These key-competences include knowledge, skills and attitudes required for his personal development, in the social field, employability and active citizenship.

In this process, changing biology program into more interactive one, based on the advantage of multidisciplinarity, inter and transdiciplinarity is a main priority in our educational system.

By multidisciplinarity, a subject from a specific field is analysed using information from different disciplines, without interfering with the main field [7]. For example, the bone system, can be evaluated by a biolog like an anatomic system, by a physician like a system of levers, by a chemist like a complex of organic and inorganic system, by a mathematician like different proportions of longer, shorter, thicker or wider bones.

By interdisciplinarity, the borders from different fields are crossed one by one and the common topics are underlined, using transversal competences, meaning solving problems, and decision- making. As such, the bone system can be evaluated like passive part of the locomotion system, and all information can be used to define an integrated system.

Transdisciplinarity is a higher form of interdisciplinarity, which in the scientific context, underlines new concepts, methodologies that become universal. The main issue is to answear some important questions, from everyday life. According to previous example, the bone system is trandisciplinary evaluated after the system theory, modelling theory or laws of motion. This method is based on

interactions among, across and beyond disciplines and has the purpose to create a better understanding on the contemporary environmental, including the social issues [3]. In teaching biology, all these aspects can be used, starting to multidisciplinarity and ending with transdisciplinarity, which is the most complex method to integrate theoretical concepts in a real life context.

The literature shows that there are a few case studies on the transdisciplinarity approach in biology field. A practical study [1] was made using a control group, that got classic teaching and an experimental group, that got the information by transdisciplinary approach. The experimental group manifested a positive attitude in using the transdisciplinary approach in their biology class. As a result, it improved their academic performance in biology and developed positive perceptions on the subject [1]. Another practical study about mutual integration of physiscs in teaching biology, having the subject the eye and refraction was published in 2022 [8].

In addition to this global new manner of teaching, STEAM education is an integrative learning model based on providing a comprehensive education instead of underlining the importance of individual subjects. The acronim places together the fields that are involved: Science, Technology, Engineering, Arts and Mathematics.

STEAM education is important for our students because it removes limitations and stimulates their creativity, innovation, leadership, self-confidence, wonder and critical thinking. Having the multidisciplinary field status, biology as a key part of STEAM education, teaches students to integrate individual components in complex systems, to test theories and principles, to have an overview on different tasks and evaluate and implement their results. All of these skills are transferable into their life actions.

The aim of this paper is to prove that biology, which is a multidiciplinary field, including biology and biological processes of living beings, biochemistry and biophysiscs, can be teached, using integrative universal principles of natural science, by transdisciplinarity. This is sustained by the STEAM education, which will help our students to learn concepts, to think creatively and use innovation in solving their problems.

II. MATERIALS AND METHODS

In this paper is presented one hour Biology lesson, from 9th form, in order to prove the integrative particularities of natural sciences teaching.

Topic: Similarities and differences between prokaryotic and eukaryotic cells

Educational goals of the lesson:

- to identify particularities of a cell
- to find similarities between prokaryotic and eukaryotic cells, according to biological, chemical and physical approaches
- to find differences between prokaryotic and eukaryotic cells according to biological, chemical and physical approaches
- to explain how this two cell types can maintain a balance for optimum health

Methods

a) Peer-learning is a new method that helps students to improve their knowledge by teaching each other. Unlike traditional learning, where teacher is the only one that provides information, peer- learning allows all partners to learn from each other, meaning that everyone, including teacher, can be listener. This method has a major advantage because it allows learners to get different perspectives on the same issue and also it encourages active implication and will help build relationships between students.

b) Team-working is a peer-working method or group-working method

c) SINELG method is an interactive method that encourages critical thinking. It consists in noticing the information that students know about the subject, it is not important if there are right or wrong. After reading and writing on the table, there is a discussion and students note what they knew, the new information they got and what they misunderstood. In this way, students feel free to express their knowledge and teacher can give a new approach to his speech [6].

d) Demonstration with pictures, drawings, models, presentations [5].

e) Debate

III. RESULTS

A modern lesson has to upgrade a scenario also the term is more from dramaturgy or cinematography. In our field, a scenario represents the anticipation of teaching activity, in order to accomplish the main goals of the lesson. It is a process that requires creativity and imagination, capacity for reflection and critical thinking for the teacher. In the modern teaching, there has to be a succession of teaching- learning-evaluation processes and learning process places the student in the center of it. We present the moments of lesson after Gagne [2].

a)**Getting attention** is the first moment of the lesson, when teacher starts his speech about cell structure and suggests that cell is a biological, chemical and physical system. This moment has to guide students towards the main central goal of the lesson.

b) **Informing about the theme of the lesson** and the main goals in order to raise the efficiency of working progress using the common interest [4].

c) **Repeating the anterior knowledge** has a great importance in learning new information, it has to connect what students know with what they get.

d) **Teaching and exploring** are the most important moments in lesson, when students and teacher are working together. Now, teacher provides basic information about the cell structure organizes the working groups and sets out their work tasks. Peer- learning is

a good way for students to strive each other to have a better understanding. Students are divided into three working groups, one working-team compare and contrast the two types of cells in a biological view, the second group in a chemical view and the third group observes prokaryotes and eukaryotes like physical systems. Students are observed by their teacher and elaborate their conclusions. After finishing their researchers, students coordinated by their teacher analyze and integrate all information about the two cell types. Both of them have a plasma membrane, cytoplasm and ribosomes, but the eukaryotic cell is more complex than the prokaryotic cell and has a true nucleus, meaning a DNA molecule surrounded by a membrane and other membrane organelles that allow integration of vital functions. Membrane is composed of proteins and lipids, mostly phospholipids, that occurres two layers.

First question is: What kind of susbstances are integrated in prokaryotic and eukaryotic cells?

In both cell types, organical (proteins, lipids, glucides, hormones and vitamins) and inorganical (water and minerals) susbstances are distributed. The number and proportion depend on age, physiological status or functional role. Water is in proportion of 60-95%, depending on the age, type and cell activity.

Glucides, the sourse of energy, are distributed in prokaryotes: glycogen, starch and in eukaryotes: glycogen, starch, celulosis, chitins. They are the cell fuels, used in mithocondria (the energy converter of the cell) to produce energy and to storage it in ATP molecules. For all aerobic organisms (meaning prokaryotes and eukaryotes) the aerobic respiration is an oxidative process and has the same global reaction.

$C_6H_{12}O_6$ (s) + 6 O_2 (g) → 6 CO_2 (g) + 6 H_2O (l) + energy

This energy is used in all vital processes of cell: for growth, nutrition, cell division, locomotion or nervous activity.

Lipids are important in both cell types, because they have a plastic role, being integrated in all plasma membranes and and function like energy storehouses for cells. Simple lipids are present in prokaryotic cell, mainly polyesters or phosholipids and phospholipids, glycolipids or sterols in eukaryotes.

Proteins are aminoacids chains with plastic role in any cell membrane, form cytoskeleton and also synthetise hormones, enzymes or vitamins.

Second question is: Have the cell components similar functional roles in both cell types?

All living cells have also a cytoplasm, a semiliquid substance, in which the cellular organelles are floating. Membranes are organized by the fluid mosaic model and their role is to isolate cell from the external environment.

Genetic material (DNA molecules) is in nucleus at eukayotes or spread in cytoplasm in prokaryotes. The functional role is the same, to control all biological processes that are taking place in the cell. Is like a cell brain and it is vital for the cell division.

Ribosomes (initially named Palade granules, after romanian biologist that identified) are macromolecular machines that synthetise proteins from aminoacids, due to RNAm information, that copies DNA information, so every synthetised protein has some specific aminoacids that ribosome unity converted from genetic code of every cell. They are common organelles to prokaryotes and eukaryotes cells.

Chloroplasts, internal organelles in eukaryotes cell, evolved from prokaryotes. Like mithocondria, they have their own DNA molecule, that is called extranuclear eredity. They represent the key structures in photosynthesis. The sun energy is absorbed by chlorophyl (a green pigment) and using water and carbon dioxide, chloroplasts produce oxygen and energy that is stored in organic compounds (glucose is first organic molecule that is synthetised) and used by the plant for food or converted in different forms of energy. For all photosynthetic organisms, the global reaction of photosynthesis is the same and it is the opposite reaction of aerobc respiration.

6 CO_2 (g) + 6 H_2O (l) → $C_6H_{12}O_6$ (s) + 6 O_2 (g)

The third question: How physics interferes to biological microsystems?

One of the most important feature of a cell is possibility of changing it's shape, meaning moving or dividing.

All cell transformations come from cell and environmental interactions. Plasma membrane is a key-component for all cell exchange. There are two ways of transport across a cell membrane: passive transport, when molecules are moved through the concentration gradient, without using energy from ATP. An example of passive transport is maintaning the osmotic equilibrium at aquatic cell. The other transport is active, when molecules cross the membrane against the concentration gradient, using energy (ATP). Diffusion and osmosis are two passive physical processes involved in movement of molecules in cytoplasm and cross the plasma membrane. The active transport is consuming energy and it needs an active transporter, which utilises different joint mechanisms. Both processes take place in prokaryotes and eukaryotes cells.

a)**Providing feedback** is the next moment of our lesson- and it is a practical activity. This is the part of the lesson when students prove their skills and use STEAM learning. They can work in groups. The task is to create their own transition cell, the prokaryo-eukaryo-cell, that comprises intermediate characters between the two cell types and plays a probiotic role for the oral microflora. They also have to use all information that got and to think if this cell will be similar with a friendly bacteria or would be more like a macrophage.

d)**Learning retention**- is the last moment of lesson, teacher discusses with his students about how much the main goals have been achieved. Students have now the chance to reflect on their new acquisition and to review their critical thinking for finding better solutions.

IV. DISCUSSION

By transdisciplinarity, we can present a new side of teaching for all disciplines and the new goal for us is to teach our

students that all small parts are functioning together and like in a puzzle, they integrate the system in a global system, that, in biology, is based on three general principles: decentralization (the characteristic of a biological system that allows a uniform distribution of his components), randomness (an inherent characteristic in evolution or genetic, for example gametogenesis and fertilization) and analogy (similarity of function but using structures that have different origins, for example the wings of a fly and a bird).

In our example, by transdisciplinarity, students had the possibility to create links between biology, chemistry and physics. They understood that all biological structures have a chemical composition, which is similar in many cases, that all mechanisms that require intra or extracellular movements or changing the cell form are physical and a cell is the best example to demonstrate how a microscopic structure can become a microsystem and all functions and processes of living organisms (growth, nutrition, relation, reproduction) take place no matter if we are talking about prokaryotes or eukaryotes.

Also, they recognized that even if prokaryotes and eukaryotes are different structures, they live in the same environment and influence each other. Both cell types are living in a special symbiosis in our bodies and the way that we influence the environment can influence our living.

When students got the task to create their own hybrid cell, they learned how to get solutions to new situations and not to reproduce the information they got, thus having possibility to synthetise, to compare and to create some algorithms that can help them in similar situations, in every day life.

Giving them the possibility to create a design or a project, which is the main goal of STEAM education, teacher can be very surprised of the results. If we are engaging them in ICT field, they will be even more motivated, because their everyday life is linked to social- media and gaming. The traditional boundaries between disciplines need to be set more flexible because the new approaches are coming from virtual reality, gamification and these are premises of a new interactive teaching methos, called digital learning.

Teachers can have different approaches, even contradictory hypothesis, and teaching becomes more like a talk-show [6].

At the end of the hour, students must acquire content and information but also new techiniques of being succeseful in their real life, how to be original and how to have different perspectives on the same situation, because the new target is creating a multitasking job and no more reproducing working protocols.

V. CONCLUSSION

At the end of our study, we demonstrated, by presenting a scenario for a biology lesson from a 9th form, that biology can be teached by transdisciplinary learning, using integrative modern methods. This must be sustained by the STEAM education, which will help our students to get skills and learn new concepts, to think creatively and use innovation in solving their problems in their everyday life.

Thus, the new integrative approach leads our student to understand that the environmental is a whole and our actions can affect it in many ways. Living beings are so connected to each other, in chemical, biological and physical manners and a healthy lifestyle comes from a positive and sustainable exploitation of other living resources, because all organisms are prokaryotes or eukaryotes and their equilibrium constitutes the support of life.

In conclusion, we can say that interdisciplinary and transdisciplinary approaches need to be analysed in future studies because they are the paths of a modern personality formation in our children.

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