PUBLIC SCIENCE EDUCATION: SOME MORE ROLES AND CONTRIBUTIONS

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In previous editorial (Lakhvich, 2021) we have discussed three comprehensive roles of Science Education, determining its contribution to our life: if briefly, (1) Science Education gives the methodology to digest facts via the experiment, reasoning, and discussion; (2) Science Education gives rise to the development of logics, problem-solving skills, complements the command of language, social communication and etc.; (3) Science Education develops specific person's thinking skills involved in inquiry, experimentation, evidence evaluation, speculation argumentation, and finally, inference. In this issue we pursue the topic discussing two more roles the Science Education contributes to our life:

4. Every Science discipline (the same with Humanities and arts) has its own epistemology, language, concept structure and specific modelling techniques. This means that by skipping the systematic study of one or more scientific disciplines, a person loses the opportunity to use specific ways of thinking that are characteristic of this area of knowledge.

5. Nowadays tendency to democracy and sustainable development requires that people were able to make personal and collective decisions based on reliable facts and/or expert assessment; the approach being typical for scientific method.

4. At the turn of the millennium, the approach focused on interest context was very popular (Holbrook, 2014; Bennett & Holman, 2002). In a few words, it was proposed to fill the curricula mostly with the facts and skills which will be useful and applicable for average graduate (non-scientist) in everyday activity. Thus, for example, in organic chemistry the topic "carboxylic acids" might be proposed to limit with acetic and few other naturally occurred acids which are used in everyday activity. Some educators proposed additionally to provide all school experiment exclusively with the products that can be purchased at a grocery or hardware store. I agree with the notion that interest context increases the motivation to study science (Önen & Ulusoy, (2014). But curricula and educational ideology based exclusively on interest context corrupt the science and all the system of science education. The first, it leads to unsystematic courses; unsystematic knowledge and skills tending to be forgotten and neglected in future. The second, science is losing its cognitive potential that arises from a specific scientific method. And finally, when saying about the utility, nobody will recognize in grocery shop the acetic acid in its solution: consumer chooses vinegar! To understand the nature of vinegar is important for motivation to study science, but the applicable object has no cognitive and systematizing potential to construct science curriculum.

Another approach formally is content focused and is targeted to give students basic knowledge within the framework of a definite science discipline. But up to date most curricula are oriented on teaching facts but not the acquiring of the scientific method. It's very typical for biology where students starting from secondary/high school and undergraduate levels should memorize a lot of terms, in particular Latin. In most countries students

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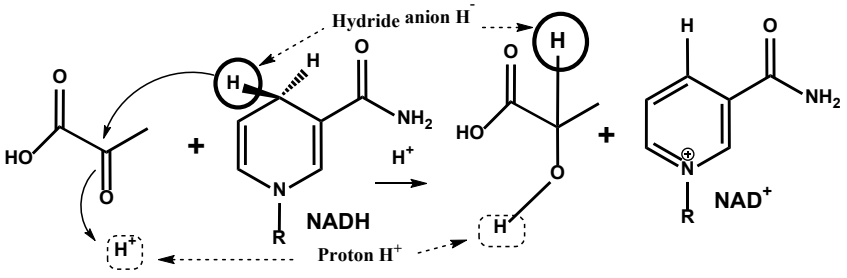
start their acquaintance with the biology in context of classical botany/zoology/anatomy paradigm including all this termism of Latin. Chemistry and Physics are less dependent on medieval traditions, but in real most of school teachers prefer the algorithmic ways of problem solving during the initial stage of learning process. And we know the result for most graduates from high school who have chosen non-science fields of activity: a few years after graduation they have neither scientific knowledge nor scientific method, they need to understand adequately natural and social processes.

Modelling is a very important technique in the modern world that helps people to study, to understand, to predict some meanings which are untouchable and / or unperceivable (constantly or this definite moment) through simplification, substitution duplication. People apply models because they are relevant and convenient stand-ins. When applying them, one can achieve the aim in the only possible or the shortest/more convenient/ more effective way (Belohvostov & Arshansky, 2009). When you buy a new device, you read a guideline to manage its work in a proper way. Cooking recipe plays the same role. The ability to recognize, to construct, and to improve models gives you an advantage in many walks of life. Models are useful in everyday life because success in any activity (both professional and non-professional) requires the manipulation with meaning which are available in the moment. It can either predict of something one will reach in the future (e.g., the assessment of risks on the stock exchange), or the presentation of something absent in real at the moment of your activity (e.g., buying goods on the internet requires virtual trading platform that includes a lot of models like size charts, catalogs and searching machines, payment instruments, etc.). In both cases, reliable modelling gives you a good chance to gain a success.

Nowadays, the adequate modeling is a key technique in Science and education. The initial period of Science was almost completely empirical. Science itself and Science Education were based on the experiment. But then Science gained the new paradigm which was rather formal by nature and fundamental in methodological meaning. Still the tool for interconversion between the empiric and theoretical moieties seems to be the core point of the consideration and can be associated with the problem of modelling, which is one of the most important in modern Science. When studying Science, students explore the technique of modelling that is (and will be!) useful and applicable in their every-day activity.

Partisans of compulsory Science discipline integration in secondary School propose the application of modelling within the framework of integrated discipline (scientific methodology seems to be evidently universal). I want to argue such approach is not fully suitable even for non-professional educational lines. For sure, we need integration into the curricula of students (STEM, STEMM, STEAM and etc.) because it will improve science and technology literacy and provide new tools and perspectives for artistic and humanistic scholarship and practice ((National Academies of Sciences, Engineering, and Medicine, 2018). For primary Education the integrated Sciences are highly approved because young children and pupils mostly explore the world via the real experiment. But unconfined integrated approach in Science Education in secondary school would lead to the loss of the cognitive potential of the definite discipline. Every discipline has its own epistemology system, as well as the language and modelling we are here. Working with medical and pharmacy students I meet different models applied in different Science disciplines (Kırkıç, K. A.,2021).

One of many examples deals with the modelling in redox process in vivo. The chemical approach is based on the transfer of atomic particles – Hydride-anion and Proton, in Physiology and biophysics the electron transfer is discussed. In Chemical model the enzyme LDA reduces of pyruvate to lactate *via* transferring of Hydride anion (H^-) from NADH coenzyme molecule and a proton (H^+) from the protein. In the reverse process NAD^+ oxidizes pyruvate into lactate.



Whereas the chemical model discusses the transfer of atoms; biophysics models the process as the flow of the electrons in a protic environment:

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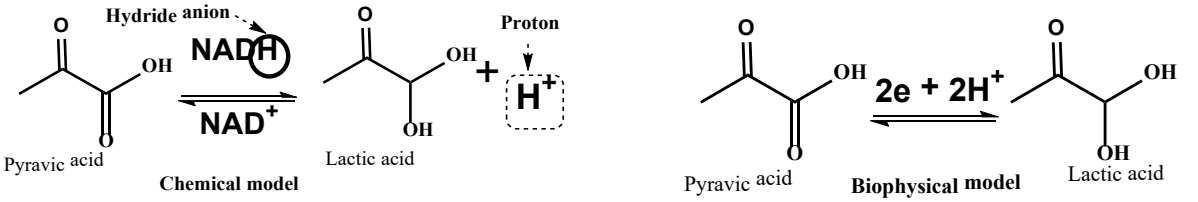

Hierarchically the higher physical level of modelling brings together two concepts (the highest relevancy of both models!). But as we can see the study within the framework of both disciplines develops the broader range of skills for everyday modelling. The chemical approach develops the more imaginary modelling based in picturing, the physical mostly being based on abstract meaning of electron flow.

5. Science is an integral part of Education and should be compulsory for all students. We live in the changing world where Technology and Science are among the forces defining the development of any country. People face global natural and societal challenges, and they need to understand their implications on their lives and the development of the society. Education gives people skills and knowledge, which make Technology and Science the tools to gain progress and success. The time Science created crisis seems to go away and just now the same science may resolve the most exciting challenges of our life. Democratic society has a good chance to overcome all current challenges because its potential affords people to participate actively in science-based decision making. That is why Science is a compulsory educational platform fostering broad-minded and responsible in their decision-making citizens.

It's common that people meet science examples everywhere. But as it was stated in a lot of research studies, "most citizens are not equipped to personally assess the facts, nor often even to separate the facts from opinion or political spin, science from non-science. They therefore are likely to be predominantly influenced on these issues by the prevailing perception in their communities" (Marincola, 2006).

In many cases, this is due to the memorization of scientific facts across classical teaching of Science disciplines. Such approach fosters the strategy of decision making that is based on beliefs and traditions. Democracy and sustainable development require reasoning processes in decision making (Aristotle defined the Science as "reasoning facts"). And it's much more important to show the students the technique Science applies to gain the result. It teaches to use scientific thought, method, and inquiry to come to a responsible decision. This does not necessarily concern Science; people need to resolve issues in everyday life. Sustainable development of the democratic society from epistemological point of view should be based mostly on scientific reasoning than a dogmatic testimony. The latter is very typical to autocratic societies, but a lot of research studies show the influence of such dogmatic decision-making strategy in all the countries.

The last year has been marked by Covid-19. The medical and healthcare problem influenced crucially the society. I suppose that from medical and social point of view Tuberculosis touched much more drastically people and society before the invention of antibiotics and other antibacterial drugs. And no doubt, nowadays people have been much more equipped to struggle with the new plaque. To my mind, such a destructive and pervasive influence of COVID Pandemic on society is partially connected with the lack of reasoning thinking. A lot of people rely more on beliefs (they believe relatives, newspapers, internet sites, neighbors etc.) neglecting the basic principles of scientific method. For sure, nobody can carry out empirical study to find the answer to all the questions. But when a scientist needs to find some reliable information (in many cases in the fields far from his/her basic education), he/she searches results from experts in the field, followed by their comparison and analysis. The lack of such approach and belief to some "great guru" seriously complicated the initial phase of the response to the epidemic, and today it is favoring the growth of opponents of vaccination. (Germani, 2021) Anti-vaxxers regard pandemic as the chance to influence the public opinion for the growth of hesitancy for all vaccines. Most of them strongly believe the conspiracy theory and obscurantist versions. Anti-vaxxers invent different arguments: the droplets by which the coronavirus travels are spread by 5G waves; the Covid pandemic is a cover for the effects of 5G exposure, and finally, the top-idiotic theory according to which, during vaccination, a chip might be implanted into people through which human behavior will be controlled via 5G. While none of the theories is true, some celebrities and public opinion makers pursue to spread them. There are a lot of research studies revealing different reasons of vaccine hesitancy, objecting to find effective strategies to dismantle the rhetoric of anti-vaccination supporters. There is a strong dependence between the level and scientific constituent of educational background of anti- and pro-vaccination supporters. (Al-Jayyousi, 2021.) Science education increases confidence in vaccine importance and effectiveness: the lack of science education fos-

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ters anti-vaxxers' behavior associated with a general belief in conspiracy theories and feelings. This fact supports the idea that compulsory Science Education teaches all students the scientific method. This corresponds to tendency of democracy and sustainable development that requires from people being able to make personal and collective decisions based on reliable facts and/or expert assessment.

Plato was the first who defined the education being the way to comprehend the whole of life, and a preparation for another in which education begins again. It coincides with the scientific paradigm in which the research method affords to study the facts, to confirm the results of previous findings, to solve different problems and to develop a theory. Science education nowadays is mostly inquiry-based both on contents and methods. Equipped with scientific knowledge, people are able to apply evidence-based knowledge across a broad range of issues. Evidently, it refers to understanding of natural phenomena that affords to resolve effectively the environmental and technological issues. But additionally, teaching by a scientific method within the framework of definite Sciences develops skills which are used in social and public activity. That is why the contribution of Science in education coincides with the tendency for sustainable development and a tolerant democratic society. We hope contributors to Journal will provide new evidence about the important role of different Sciences in Education, as well as find the proper place of definite disciplines in educational syllabi and curricula.

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