SCIENTIFIC, PHILOSOPHICAL AND USEFUL KNOWLEDGE: PROSPECTS FOR DEVELOPMENT OF EDUCATION

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The article analyzes the formation of science education - key determinant of a "knowledge society". The authors emphasize that science, in the context of natural and humanitarian notions development, is considered to be a set of views, ideas, notions aimed at the explanation, interpretation and understanding of knowledge and cognition. Science builds upon the methods of inquiry, which are essential for the formation of science education. The development and spread of scientific knowledge gives rise to the establishment of community of professional scientists and inventors. Authors state that unlike philosophy, science focuses on "useful" knowledge, based on which engineering and technologies – the drivers of socio-economic and cultural advancement – are developed. The purpose of science education is to substantiate useful (positive) knowledge, which assumes ever greater importance in the information age. The efficiency of science education includes both, learning of empirical facts and theory, and efforts toward understanding of fundamental ideas of modern times. Taken together, these components provide insight into events and phenomena that are of practical importance to the lives of students now and in the future. Important task of science education is the transformation of lessons into researches, which engage students in creative exploratory activities. Effective science education ensures communication, discussion, and emotional development that is essential to cognition and learning. It is advisable to build science education practices on inquiry- and interest-based methodology.

Key words: science, philosophy, knowledge, science education, method, humanities, useful, thinking.

Introduction

The timeliness of science education study is based on the task of its implementation with the aim to ensure more efficient acquisition of scientific knowledge, which increases steadily in the information age. Analysis of science in terms of epistemology, metaphysics, axiology, and ethics remains the most important matter of socio-philosophical and philosophical and educational research. In fact, contemporary science generates numerous problems that pose new challenges to humanity requiring their study and comprehension. This can be achieved through the system of education and training. At the same time, the essence of scientific knowledge is not a mere study of program tasks and lessons; it even differs from the essence of history, philosophy, art. The purpose of the article is to investigate and substantiate science education, which has a long history of development as a factor of modernity. To determine its essence, it is necessary to analyze science in conjunction with philosophy and humanitarian knowledge, trace the relationships between the scientific and "useful" knowledge - a criterion of social and technological advancement, which makes it possible to identify the basic parameters, goals and perspectives of science education.

Main material statement

The basic meaning of the notion "to teach" (educate) is to show a sample and identify and establish the rules how to act and think according to such sample. The other meaning is related to the development of existing potential. Education "provides" a person with "sample", "model", according to which a person organizes its "activity" and "inactivity". The existing "sample" defines the "path", comprehensively substantiates the perspective from which the person's problems are solved. However, this may be achieved with scientific knowledge and justification only. Under the constant progress in science observed now, the extent of knowledge continuously increases and necessitates changes of the educational system, including update of curricula. Therefore, the humanity needs knowledge that provides substantiated responses to real-life demands. The only knowledge that may satisfy this requirement is scientific one, which, in turn, can be provided by science-oriented education. An appropriate system of science-oriented training, i.e. science education, is required for comprehension and understanding results of scientific cognition (knowledge).

Development of science education is driven by the progress of science, which was once philosophy. Over time, first natural sciences, and later humanities, split away from philosophy as a "science of sciences" and achieved self-sufficiency. This was due to the fact that science needed good quality, i.e. clear, solid and reliable knowledge. The task of philosophy is to build a rational and universal science, which bases on sound grounds and summarizes all aspects of truth about the world around us.

For this, it is important to proceed from the multivalued nature of life goals: temporal, eternal, modern, for the improvement of subsequent generations. In this regard, science is the bearer of "eternal" truths, each of which, from the moment of its discovery, belongs to the treasury of all the humanity. Each progress in science, as a general achievement of humanity, determines the practical content of the idea of education, wisdom, knowledge and worldview.

During its development, striving to get a scientific connotation, philosophy managed to give rise to independent sciences only. In fact, with accumulation of knowledge, the sciences "got through" the process of naturalization: first, the sciences of nature and later - the sciences of consciousness have become positive. Bertrand Russell put a high value on the increasing role of science in relation to philosophy. As a mathematician and logician, he questioned the fundamental role of philosophical reflection and did not fully believe in it. According to Russel, social progress requires precision tools of mathematical logic that would clearly and accurately separate truth from error [Russel, 1998]. At the same time it should be remembered that, when engaged in science, the person gets involved in a certain philosophical cognition of the world. Since, everything that is called a "common sense" in fact is a combination of general, unspoken assumptions about the nature of things. The fundamental achievement of critical philosophy is the focus on this fact. It must be remembered however that the purpose of scientific theories is to assert certain truths about the world, irrespective of "beneficial" or "disadvantageous" effects it may have. As a social, cultural being, human is interested not only in explaining everything about own world, but also in acting in it. Science can "show" a human the best ways to achieve certain, first and foremost, "positive" results. While philosophy can "advise" what result "must be achieved with own brains and will" [Russel, 1998: 464-465].

In Russell's opinion, the essence of both science and philosophy is determined by mathematics and logic. However, there exists a "substantial tension" between philosophy and science (Thomas Kuhn), which manifests in the scientific research in-between "convergent" and "divergent" thinking. There may be various types of science-philosophy relationship. One of them is as follows: suppose science "broke up" with philosophy (science "does not think"). The "pure" philosophy remains on its own. It may ignore science or regard it as a subject for consideration among other subjects. Another type: science "rejected" metaphysical ideas, retaining however its philosophical impulse (science "thinks"). The desire for truth may be a common feature here. The difference is that science works to "conquer" (gain) new knowledge, while philosophy retrospectively examines how science does it (philosophy accompanies science as methodology and history). In this case, philosophy and science complement each other. One more type: theoretical discourses, cognitive analyzes, "prospective thinking" "inside" science are "attempts of theoretical analysis" [Fago-Larzho, 2010: 131].

In this situation, one should take into account the peculiarity of science, which existence and development is impossible without the convention and agreement, the adoption of certain fundamental principles by the majority, irrespective of whether it is Isaac Newton's or Albert Einstein's physics, quantum mechanics and genetics, or cybernetics and synergetics. These are complex scientific theories requiring in-depth study.

However, such learning process needs an organized educational system that is based on the principles of scientifically grounded methodology of teaching. Science education approach is characterized by a complex relationship between form and content, which is determined by the specificity of activity. In particular, this means transforming the method of scientific cognition, which originates from certain currently developed knowledge patterns of the individual, into research practice, and engaging the mental content of the individual, new knowledge and new skills of its internal and external activity through social and professional content. In such a way, new gains in the cognitive structures of the individual are formed, linking knowledge, past and present experiences.

It is reasonable to consider the conditional distinction between "pure" science, which explains natural and social phenomena, and applied one that is focused on the creation of new products, manufacturing processes and technologies. A community of professional scientists and inventors has evolved in the process of their interaction and development. The significance of scientific cognition methods consisted in the fact that they allowed rapid accumulation of knowledge, and at the same time created opportunities for professional knowledge transfer to those who needed them. The number of such people increased continuously, and this contributed to the expansion of the system of educational institutions, which taught open, attained and science-based knowledge.

Beyond that, when determining the methods and ways of teaching, the educational institution should take into account that the process of knowledge acquisition has its own specificity and is not similar in nature to other types of activities. The desire to understand the nature and get recognition of the success of these efforts by scientists goes beyond purely material motivation. Interest and pursuit of knowledge are the driving forces behind the accumulation of such offered knowledge throughout the whole history of society. Over time, however, the "concern" (interest) gives way to concreteness. According to Joel Mokyr, one of the hallmarks of the modern age is that "the relative importance of abstract knowledge has decreased compared to the knowledge, which may be used to improve technologies" [Mokyr, 2012: 368].

At the same time, increasing the role and importance of an educated, intellectual environment in a society with market-based economic institutions remains a motivated scientific consideration, an interest in discovering the truth during cognitive activity. Although the economic interests are likely to prevail, scientific (epistemological) interest has been and continues to be an important impetus. To understand the essence of science education it is necessary to proceed from the fact that, since the 19th century, scientific research and science as a whole have been focused on "useful" (necessary) knowledge. This has led to reforming higher educational institutions in Europe. At the beginning of the Second Industrial Revolution (19th century), this trend became more intense. There appeared four channels of "useful" knowledge building. The first was the ability of society to accumulate new offerings of such knowledge. In particular, for many generations, the Jewish sages have dedicated their lives to the interpretation of sacred books (the Old Testament, the Talmud), which contributed to improved level of education and development of logics, jurisprudence, law. Such education, however, mostly failed to give people useful (necessary) knowledge. The second channel was the dissemination of invented and studied "offered" knowledge and thoroughness of such knowledge. It is necessary to know to whom and to how many people such knowledge is available, how it is tested, i.e. how it is obtained through consensus and recognition by the society. The third channel was the use of offered knowledge and its "translation" into technologies. The fourth channel - the distribution of innovations: even in case the knowledge was "transferred" into technologies, or an invention was made − how far will it be mastered? The success of western engineering and technological achievements with their existence, development and practical implementation illustrate the answer to these questions [Mokyr, 2012: 372-373].

The history of science development shows the social and physical connections between those who studied natural phenomena and those who applied such technologies in practice and sought to achieve their effectiveness, i.e. "performance efficiency". Knowledge must be passed on from those who know and understand the phenomena of the world to those who produce things for this world and, ultimately, for themselves. Such dissemination of knowledge can take many forms - from lectures, conferences, philosophical societies, encyclopedias, research laboratories to modern universities, colleges, lyceums, and Internet. At the same time, there should operate institutions that facilitate this process. Establishment of such institutions is rather a complex task. Similar to new life forms, building of useful knowledge occurs for the most part independently. This process cannot be explained by the demand or combination of various production factors. In most cases, "useful" (needed) knowledge appears prior to understanding of its use. Overall, such knowledge appears sequentially - either as a "logical step that stems from a previous discovery, or as a combination of previously acquired knowledge. Later on, the mechanisms of selecting necessary and less necessary knowledge comes into effect" [Mokyr, 2012: 376].

It should be considered that the natural and social sciences have practical extensions - methods of transformation of objects that are perceived and studied. In the humanities, this extension failed to find its proper place and purpose in the system of scientific knowledge. The humanities are believed to know a lot, but generate little ideas able to determine the development of physics, mathematics, economics, technology, industry etc. The authority and strength of humanitarian knowledge remains however a significant factor in the development of the world in its natural and social dimensions. In this situation, it is necessary to elaborate the concept of "humanitarian technologies", which will serve to produce "useful", scientific knowledge, because there should be a circulation between science and technologies: knowledge passes into a system of actions that transform its subject and bring new knowledge. As a result of their specific focus on the subject of cognition, i.e. person, the humanities are, in fact, even more constructive, practice-oriented compared to the natural and social sciences. This means that humanities, primarily philosophy, are “doomed” to construct and transform their subjects. Due to their “innate” and inevitable constructiveness, the humanities later than natural and socio-economic ones come to an understanding of their institutional and methodological capabilities. Although explaining nature, natural sciences are not part of it, while the humanities form an important part of the culture of thought, which, according to Mikhail Epstein, “reflects upon itself and transforms itself” through them. [Epstein, 2016: 21-22]

This ability of the humanities is manifested to the greatest extent in education, in particular − philosophy of education. Its task is not only to understand the peculiarities and specifics of the pedagogical and educational process, but also to determine the directions of development of education in general. Moreover, based on the growing needs of a society in the era of digital technologies and ”artificial intelligence”, it focuses education on “useful”, scientific knowledge. Currently, such knowledge stems from educational and pedagogical activity.

An important task of the humanities, primarily philosophy, is substantiation of science education. In particular, appreciating the demand for “useful” knowledge, we should preserve the intellectual environment created at universities. The humanities traditionally occupy a prominent place in university curricula, despite universities’ focus on specialization. In this situation, “useful” knowledge may turn into truly useful when its preparation and teaching will engage not only “exact” sciences, essential for modern technologies, but also the humanities. University, as a place where knowledge is studied and applied, and an intellectual and psychological, cultural environment, in which the material learnt in classrooms is consolidated in practice, is both a condition and a product of science and educational process. The main result of higher education as a science education is the university itself, which emerges as a system of self-disclosure of individual’s creative capabilities, his/her ability to produce reasonable ideas, his/her attitude to oneself and others: “Education is one of the most “mysterious” and intrinsic components of life, a real “existential experience”. In education, the secret of creative self-fulfillment of a person occurs primarily directly and spontaneously - as the self-creation of person “here and now”, through dialogue with other people. When studying mathematics, physics or economics, we do not apply this knowledge of nature and society directly to ourselves, while in the humanities, the subject and object coincide, thus education acts here directly as a transformation of the person being educated (learner)” [Epstein, 2016: 37]. Actually, this fact should be taken into account by the system of education, educational practice, focused on the development of modern science.

Intensiveness and reflexivity of the knowledge acquisition process creates external “instrumental” capabilities of an individual, and its special “internal” acquirement, forming “integrated” structures of knowledge in mind, including declarative and procedural aspects thereof. These, in turn, expand the psychosocial sphere of an individual in the process of his/her development, covering both the world of ideas and professions. This dichotomy makes possible to create relevant social reality projects by the members of scientific and educational community, as well as the educational process, and at the same time, forms a conscious, thinking individual, coherent with the existing technological reality of life.

Knowledge is an objectified result of "earlier" thinking. The main task of activities related to science education is the research: systematic, persistent study and exploration in any area of the world learning. It must be borne in mind, that science begins where knowledge ends and a problem arises, and is mastered only through creative exploration and its comprehension. In this situation, it is necessary to identify the main issues of science education, as well as to identify those tasks arising in the current educational process, especially in schools. As experience shows, students often express dissatisfaction with the remote nature of school education, which makes the learning process uninteresting. They obviously lack the understanding of the links between their scientific activities and the world around them. They "see no point" in exploring things that appear to them as a series of unrelated facts to be learned. That is why science education gains importance. However, its implementation needs appropriate reforms.

Each reform depends on the past. Recently, the study of natural sciences was optional for senior school students. In secondary school, natural sciences were considered primarily for those, who would pursue a specialization in science, not for all students. Although science education is now recognized as essential for all individuals throughout mandatory school education, it is difficult to get rid of the traditional stereotype. Now the modern schools, both domestic and European, don't inform many students of the development of general ideas of science. However, they could certainly help students to understand the world around them, allow them to participate in decision-making, as informed citizens in a society where science and technology are increasingly gaining importance [European Commission, 2007].

An important aspect of solving these problems is the understanding of the purpose of science education, which consists not so much in the knowledge of facts and theories as in the pursuit of key ideas of modern time. Their unification makes it possible to understand events and phenomena that relate to the lives of students now and will be important for them after graduation. They need to be perceived as "great ideas" in science to comprehend the various aspects of the world around us. However, not only natural science studies can be improved by incorporating facts and figures into the topics covered. In particular, historians call for "intertwining" specific events in stories; there are also good reasons for combining ideas in the study of different phenomena in geography. The same may be said about numerous fields of knowledge that exist as domains due to the availability of a core of knowledge, skills and competences. In order to justify the grounds and conditions for the introduction of relevant topics and types of studies in the school curriculum, it is necessary to put into practice the above mentioned in terms of the development of "great ideas" [European Commission, 2015].

The material presented is evaluated through assessment, in contrast to what is of value for stimulating increased understanding key ideas and developing scientific knowledge. As a result, it is not satisfactory for both teachers and students. Contemporary actions aimed to overcome the students' lack of interest and enjoyment of science have focused on justifying new approaches to studies. In particular, the research-based natural science studies approach is widely promoted and implemented in many countries around the world. Professionally conducted study results in the understanding of the material and provides a regular reflection on how new ideas evolve from previous ones. Students' work becomes similar to the work of scientists, as in its course they gain understanding of the method of collecting and using evidences to test ways of explaining the phenomena under study. The evidences of such positive effect on the attitude to science are ever increasing. However, changes in pedagogy may be triggered by changes in program or curriculum content. Research-based teaching can improve understanding the material, but as it takes more time, its "volume" should consequently be reduced. Thus, the discovery of "great ideas" in science is a natural and even essential assisting component for the advancement of research-based natural sciences education [European Commission, 2007].

Throughout school studies, science education programs should be systematically focused on the developing and supporting students' curiosity, enjoyment of scientific activities, and understanding of how natural phenomena can be explained. The purpose of science education is to increase students' curiosity based on their natural inclination to seek meaning and understanding of the world around them. Science should be introduced and understood by students as activities, which are carried out by people, including themselves. Their personal experience of finding and connecting new and previous expertise not only brings joy and satisfaction, but also an awareness that they can add to their knowledge through active research. In this situation, both the process and the product of scientific activity can evoke positive emotional responses that motivate further learning.

Science is understood as a multifaceted, comprehensive knowledge of the world and the processes of observation, research and thinking of data through which knowledge and theories are developed and transformed. Claiming that science, which is understood in this way, plays a key role in learning, does not deny the importance of basic literacy, particularly language, in the early years of study. According to Stanislav Dovgyi, language is "the main carrier of scientific knowledge, and sometimes even a convenient tool for scientific experiment" [Dovgyi, 2014: 5]. Language is essential for all studies, and science plays a special role in providing context and motivation for its development. Communicating and discussing ideas arising from the direct experience requires students to attempt to convey meaning to others and bring their reformulation in line with experience of other people. Thus, the development of language and ideas about the world naturally come together. Similarly, science provides a key context for the development of skills in natural sciences, including mathematical ones.

The primary target of science education should be the ability of each individual to make informed decisions and take appropriate actions that will affect both his/her personal life and society well-being, as well as the conservation of the environment. Ways of studying science that lead to understanding can also foster the development of learning skills, that is, the ability to learn which is necessary throughout life to effectively operate and work in a dynamically changing world.

Science education has many goals. However, it must first and foremost aim at understanding the set of “great ideas” in science, which include scientific ideas and ideas about science, its role in society; creative abilities to collect and use scientific evidences; the use of scientific impressions and sensations. At the same time, there must be clear progress in defining the goals of science education, highlighting the ideas that need to be realized at various points based on a careful analysis of concepts and current research, in particular in understanding how the educational process is carried out. By identifying how students draw lessons from experience, one can provide a full description of changes in thinking that indicate progress toward goals. Progress toward great ideas should be the result of studying topics that are of interest to students and, importantly, relevant to their practical lives. It is very difficult for students to learn in order to understand tasks and problems that are not of any significance to them [6].

In science education, learning experience reflects a vision of scientific knowledge and scientific curiosity that is clear and consistent with modern scientific, technological, informational and educational thinking. Science that provides knowledge for understanding the world is more likely to “involve” students, than science, which is seen as a set of mechanical procedures and established “correct answers”. Entire scientific content of the learning process is deepened by understanding the scientific ideas and, at the same time, has other possible goals, such as the cultivation of impressions, emotions, feelings and abilities. In primary school, where “great ideas” may seem to be difficult for understanding by children, teachers should assist in grasping the importance of progressing to “great ideas” based on the “minor ideas” of previous learning and teaching experiences. In this situation, the curriculum for students and the initial training and professional development of teachers should be consistent and involve the individual teaching methods necessary to achieve the objectives assigned. An important target is mental (intellectual) activity of students being the thoughtful participants in obtaining and using evidence, discussing it, and comparing it with each other [European Commission, 2007].

In science education, assessment plays a key role. An important part of this process is to assist students in recognizing the purpose of the activity and evaluation of the level of goals achievement so that they can intensify their efforts. Using assessment in this way is an ongoing process rather than one-time final evaluation of the training results. Therefore, it should be embedded in programs and manuals used by the teachers. The final assessment is used to know what the students have achieved at a given time in order to inform their relatives at the points of transition and transfer. The combination of teacher assessment and special tasks, where task is used to moderate teachers’ judgments, are more likely to provide data with the necessary combination of accuracy and reliability.

To achieve the goals of science education, school science curricular should be developed with a focus on collaboration between teachers and the community, including involvement of scholars. All participants will benefit from curricular that provide for exchange of experience between teachers, access to the advice of scientists, as well as ideas concerning the implementation of science from industry or the scientific community.

For many people, science is a body of knowledge that explains physical and biological, terrestrial and space systems, and technologies. Science is considered therewith exclusively in the context of educational disciplines (STEM – natural science, technology, engineering and mathematics). Sometimes science is considered separately from school subjects, and out-of-school life [European Commission, 2015]. It must be presumed, that science affects all areas of our lives and decision-making processes. Alongside with language skills and artistic literacy, scientific and mathematical awareness is the basis for achieving personal success and learning the principles of responsible citizenship, social, and economic development in the context of an innovative approach.

Today, the concept of science education based on inquiry in primary school is being developed. Experience shows that pedagogical practice based on the methodology of inquiry is more effective. Inquiry Based Science Education (IBSE) has proven effective in both primary and secondary schools, as it increases interest in scientific advancements while stimulating teachers' motivation. IBSE is effective for all students, including those who make poor progress and those performing very well. In addition, the IBSE has proved positive for invoking interest and increasing participation of young people in scientific activities. After all, IBSE and traditional deductive approaches are not mutually exclusive; they should be combined in science education to accommodate different types of thinking and age groups. IBSE and problem-based education (PBE) can historically be presented as two approaches (methods) in teaching science. The first, traditionally used at school, is the "deductive approach". In this approach, a teacher presents the concepts, their logical (deductive) meaning and provides examples of application. This method is also called "top-down". It is used to help students understand abstract ideas, which complicates teaching science in primary school. The second one is called the "inductive approach" (method). Within this approach, more attention is paid to the observation, experiment, and teacher-led construction of the student's own knowledge. This approach is described as a "down-top" approach [European Commission, 2015].

Students have very good memory for experiments with their own participation, however to be effective, they need to be able to achieve their purposes through experiments initiated by them. There is nothing better, than enabling students to experiment on their own so that they are aware of the possibility of achieving practical results, especially when looking at the parameters one by one (keeping other parameters constant). All this in total would make the educational process consistent, scientifically determined and effective.

Conclusions

Thus, the analysis of science in its interaction with philosophy determines the nature of science education. From this standpoint, the prospects of education based on the methodological principles of science and scientific (rational) thinking are opened. On this framework, various forms of knowledge are produced:

philosophical, humanitarian, as well as scientific, “useful”. This is connected with the activity of consciousness at the level of feelings and at the level of rational knowledge, formation of elements of discursive and figurative, non-verbalized knowledge, and implementation of analytical and synthetic abilities of perception and thinking. It also affirms personal and universal, local and global, analogue and digital perceptions of reality. The indicated multidimensional content of complex knowledge attests to its compliance with the requirements and needs of science education.

REFERENCES:

Dovgyi, Stanislav. Science and art together. In Sharpak G. Memoirs of an exile, phisician, citizen of the world. Kyiv: Kalvariia, 2014: 5-7 [in Ukrainian].

Epshtein, Mikhail. From knowledge to creativity. How humanities can change the world. Moscow; Saint-Petersburg.: Center of humanitarian initiatives, 2016 [in Russian].

European Commission. Science Education for Responsible Citizenship. (Report to the European Commission of the Expert Group on Science Education). Brussels: European Commission, 2015.

European Commission. Science Education Now: A Renewed Pedagogy for the Future of Europe. Brussels: European Commission, 2007.

Faho-Larzho, Anna. The legend about the striptease of philosophy (modern tendencies in philosophy of science). Questions of Philosophy, 8, 2010: 125-142 [in Russian].

Mokyr, Joel. The Gifts of Athena: Historical Origins of the Knowledge Economy. Moscow: Haidar Institute Publishing House, 2012 [in Russian].

Russel, Bertrand. Wisdow of the West: a historical survey of Western philosophy in its social and political setting. Moscow: Republic, 1998 [in Russian].