

**Dimova D.M.**  
**Towards the Problem of “Scientific Literacy”**  
**(results from a study)**

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**Abstract.** The concept of “scientific literacy” was acknowledged in the 50s of the 20th century. It denotes the desired objectives and the desired results from learning natural sciences and is in response to the registered shortfalls in this field. It also provides answer to the question: “How does scientific knowledge function in the society of non-specialists?” This Article presents a survey conducted among school students, which is part of a wider experimental research. The questions were open-ended and were processed by content analysis. The purpose was to establish the attitude of the students towards the role of natural sciences and the related environmental health and social problems in people’s lives and in society as a whole. The results are encouraging, yet they mainly show that the formation of scientific literacy is a process requiring a fundamental change in the pedagogical approach, diverse methods and organization, and closely binding formal, informal and non-formal education.

**Keywords:** *scientific literacy, student mindsets, man and science*

**Foreword**

In this research we shall use the concept of science in its historically established meaning of natural, nature’s sciences. One of the most dynamic fields of the Science concerning education is Science Education (Theory and methodology of teaching and learning natural sciences and mathematics). The reasons for the fast development of this independent science are diverse, and among them is the dramatic drop in the interest of the younger generations in natural sciences, which is seen as a real threat to the future economic and scientific progress of humanity. [4] This further requires deeper interpretation of the basic pedagogical phenomena and analysis of the priorities of the education in natural science, and expansion and rethinking of the integrative interactions. The scientific issues are the object of many debates. We find ourselves in a much more questionable relationship with scientific achievements than ever, since they directly affect our lives and activities. Scientific literacy provides the necessary background and context needed to understand and assess the processes in the natural and social world. Since several decades ago scientific literacy became an internationally recognized educational slogan and a current educational objective.

**A short overview of the publications on the topic**

In this study we rely on a general concept about the objectives and the content of education in natural science known as “natural scientific literacy” (scientific literacy). The understanding of this notion undergoes several stages, which include initial introduction, interpretation, gradual development and establishment as a generally accepted concept, nowadays meaning almost everything related to teaching in natural sciences. Numerous attempts at its defining and interpretation were identified. Some of these interpretations were based on research, others were based on personal perceptions about the characteristics of a scientifically literate individual and what such an individual should be able to do. For example - Scientific literacy “stands for what the general public ought to know about science” and “commonly implies an appreciation of the nature, aims, and general limitations of science, coupled with some understanding of the more important scientific ideas” [6, p. 71], and also “possession of the kind of scientific knowledge that can be used to help solve practical problems [6, p. 77],

”scientific literacy was to enable citizens to become sufficiently aware of science and science-related public issues in order for the average citizen to become involved in the decision making process related to such issues as, for example, health, energy, natural resources, food, the environment, and so forth.”[6, p. 77]

Here are two somewhat more emotional definitions of the role of scientific literacy – “a few pieces of essential scientific information can mean the difference between health and disease, life and death”. ” [6, p. 77] „Scientific literacy, quite simply, is a mix of concepts, history, and philosophy that help you understand the scientific issues of our time .Scientific literacy means a broad understanding of basic concepts.

- Scientific literacy is not the specialized, jargon-filled esoteric lingo of the experts. You don’t have to be able to synthesize new drugs to appreciate the importance of medical advances, nor do you need to be able to calculate the orbit of the space station to understand its role in space exploration.

- Scientific literacy is rooted in the most general scientific principles and broad knowledge of science; the scientifically literate citizen possesses facts and vocabulary sufficient to comprehend the context of the daily news.

- If you can understand scientific issues in magazines and newspapers (if you can tackle articles about genetic engineering or the ozone hole with the same ease that you would sports, politics, or the arts) then you are scientifically literate.” [5]

Even this short overview shows that the phenomenon “scientific literacy” may be defined rather by listing, through a blend of its characteristics, than by using the form of definition. From the existing beliefs one may derive some generally accepted manifestations of ‘scientific literacy’ – to be capable of explaining facts, processes and phenomena scientifically; use of scientific data and evidence; being aware of scientific facts and axioms; rationalize leading scientific ideas; understand the role of science for socio-economic development; evaluate the significance of scientific achievements; understand scientific concepts, principles and processes, apply this knowledge to real-life situations.

In this context we may point out that scientific literacy is the meeting point between scientific consciousness and daily consciousness. It is a specific conglomerate of

knowledge, beliefs, assessments, set of values for rationalizing the role of science in the way people think, feel and act on a daily basis. This conviction is our contribution to the debate about the place, role and significance of scientific literacy in our lives. Our understanding approaches more the concept used in the United Kingdom – public understanding of science.

Using scientific knowledge and not the making of science is the basis of scientific literacy. With such implication this concept is considered a milestone when adopting reforms in scientific education, in determining the expected results, their assessment, and the selection of various training activities. There is a consensus that the objectives of scientific literacy unify both formal and informal education. The more radical interpretations include also radio, television, printed media, botanical gardens, zoos and generally all sources of penetration of science into the social environment.

Often scientific literacy and functional literacy are juxtaposed. According to us these concepts are not identical. In order to successfully apply the knowledge in practical situations it is necessary first to dispose with an adequate database (facts, concepts, patterns, laws, theoretical standpoints), and second, an important component of scientific literacy is the values attributed to scientific knowledge, scientific methods and the scientific style of thinking and problem solving. Then and only then may knowledge in and about science be applied in a meaningful and personally significant context, i.e. thus they acquire the characteristic of functionality.

Since decades ago various studies differing in scope were carried out in the field of “scientific literacy”. [1, 2, 3, 7] This is one of the most complex aspects of the practical application of the overall concept.

### **Purpose**

In this article we are presenting a small part of experimental training we conducted and the analysis of the results from it. This study includes 45 students of the 10th and 11th class in the same school studied over a two-year period. We would like to emphasize that the trained students took part in the study in two different ways. Part of them participated actively in club project activities related to issues in environmental health and social issues by working in the so-called dynamic groups whose membership continuously changed. The rest of the students were participants in all of the numerous actions to promote the results from the work on the projects. We are intentionally not making a distinction between the two groups of students; instead, we are combining them into one group of surveyed persons. The ones studied actively, while the others participated in training events designed to provide “learning from others” or “peers training peers”. This enables us to encompass both effects at the same time and to make the relevant conclusions on the improvement of the organization and the training methods.

The purpose of the survey is to establish the presence of some of the features of “scientific literacy”, mainly in the area of student’s mindsets, the value attributed to scientific knowledge, the understanding of its role in the socio-cultural aspect.

### **Materials and methods**

One of the instruments, the results of which we are examining here, is the survey questionnaire. All survey questions were open-ended, i.e. the answers were constructed by the students themselves. While realizing the difficulties with processing the data, still we chose this type of questions in order to approximate as close as possible the manner in which the students themselves rationalize such kinds of issues. This joins our research to the big and widely discussed group of qualifying pedagogical researches. It approximates most of the basic characteristics of this type of research – approaching as close as possible the surveyed object, rejection of the complicated statistical processing, and instead penetrating into the personal opinions and mindsets, analysis and interpretation of the data from the point of view of defined known conceptual grounds.

The freely chosen answers from the conducted survey were processed through the content analysis method.

We searched for the categories of the analysis in the presence of words and phrases expressing the opinions and views of the students about the place, role, and significance of scientific knowledge in the life of the individual and in the life of society as a whole.

### **Results and their discussion**

The conducted survey had as a goal to establish the attitude of students to the significance of natural scientific knowledge in their daily lives. Each of the survey questions required each one of them to express an opinion and standpoint on the posed issue in a few sentences.

1. What meaning do you assign, what do you understand by the notion “civic scientific literacy”?

**The first question** was related to the concept of “civic scientific literacy” and more precisely the meaning the student implied in it. According to them all citizens must possess at least minimal scientific literacy, or more precisely, knowledge about the way in which they themselves affect the environment and the methods to reduce the damage they cause, they must be informed, committed and responsible with respect to the scientific achievements, the terminology in science, the problems of the world, in which they live. These problems are doubtlessly related to ecology, which presupposes knowledge in the field of environmental protection and people’s health, higher degree of general knowledge and education. Phrases like the following repeat themselves: “general knowledge”, “being informed”, “awareness of specific scientific terminology, achievements, problems”, “relationship of the person with the knowledge”, “to know how to deal with a certain problem”, “to understand the processes in nature and to know to what causes them”, “knowledge from school, books, the media”, “to know the consequences from his/ her actions and to correct his/ her actions”.

2. What meaning do you imply in the concept of “educated citizen”?

**The second question** once again requires a definition, an expression of personal understanding and to a degree aims at once again verifying the results from the first question where in this case the emphasis is on the concept of “educated citizen”. We see that there is an accord within the opinions under the first question. 76% of the respondents chose the more general cultural meaning of the con-

cept. The rest pointed out specific, most often ecological, problems. An educated citizen is considered everyone who is aware of the political and economical and of the ecological problems at the same time, who knows the rules and his/ her responsibilities, observes the order, is of a sane and reasonable mind, is informed, responsible, is not indifferent. The identical answers may be summarized shortly as: "has extensive general knowledge", "looks after the status of the planet", "educated on current general topics", "understands and is conscious about the essence of the problems and their solutions", "is aware of facts, laws, problems through studying the sciences", "thinks not just of herself/ himself, but also of what surrounds them", "takes interest in the world around him/ her". We may report a significant degree of uniformity of the opinions with respect to the interconnection between the natural and social environment and the relationship man-society as a whole. It is of great importance to highlight a favorable trend – most answers demonstrate the emphasis of the knowledge, awareness, being informed, on concrete actions. Key words are - being active and participating, taking a citizen's stance, "apply what we know", "everyone to show literacy by actions", "everyone to give everything they can for improving the status".

We examine the ability of our students to narrow down their more general convictions by means of **question 3** - "Point out 5 important pieces of knowledge from natural science (facts, concepts, laws, patterns, ideas), which according to you the educated citizen must have". This question gave us the opportunity to establish what part exactly of the taught educational content and activities performed by them was most lastingly imprinted in their minds. Here the categories of the analysis encompass two groups of answers – the first one is the specific scientific facts remembered, while the second includes more general ideas about nature, science and the man. The first group shared scientific facts of the type – "Most families throw away about 45 kg plastic a year, while for one plastic bottle it takes 100-1000 years to disintegrate", "Each recycled ton of paper is equal to 17 trees and 35 000 liters of water", etc. In the second group two subgroups were distinguished. The one group formulated the problems that had impressed them more generally, while the others took a more philosophic approach attempting to generalize leading ideas about the relationship man-science. Examples of the first subgroup are the statements – "Carbon dioxide is the reason for the greenhouse effect", "Saving on non-renewable sources", "The trees purify the air and enrich it with oxygen", "It is necessary to develop alternative sources of energy for a cleaner world", "We must be careful what we eat", "The water resources on Earth are depleting", etc. The examples of statements for the second group show a well-defined difference – "Preserving nature is equivalent to preserving the health and life of people", "We must be familiar with the structure of the world", "We must exert common efforts to preserve our common home", "The importance of the norms of behavior and the moral values", "Achieving harmony with nature", "Being engaged with the problems of humanity, "The illiteracy of people is commensurate with the scope of damages", etc. We did not make any appraising observations of the individual groups of answers. Each one of them contributes to achieving the objectives of the research. It is important to achieve lasting

retention of the knowledge and assurance in its importance and usefulness. Their transformation into individual philosophy is related to shifting towards the higher taxonomic levels and requires systematic, complex, and focused pedagogical impact.

An important question in relation to the problem of "scientific literacy" examined here, is **question 8** "What does it mean to give scientific explanation to a given process or phenomenon?" This question was answered by 66% of the surveyed students. The identical answers may be summarized by the following expressions: "to discover the cause", "what triggers a given process or phenomenon", "to relate the facts exactly as they are", "to explain the essence of the problem and the way to resolve it", "by means of scientific terminology and facts to determine the cause and effect", "basing oneself on scientific terminology to give a possibly more exact explanation of a given problem", "to give a clear and exact explanation in order to transfer important information, which to convince the person", "to explain the factors and causes", "this is a scientifically justified thesis about a given problem", "when there are enough facts and evidence and when a person is sufficiently informed". These answers demonstrate that at the end of their educational process the majority of our students had managed to grasp the essence and characteristic features of scientific thinking. Part of the answers display also the belief that scientific explanations must have the characteristic of comprehensibility and relatedness to real problems, like for example – "what is the significance and impact on nature", "to know the consequences for man and the environment", "to determine the damages and benefits", "to know how it is prompted and how we can prevent it". This is in line with one of the modern trends of environmentalization and humanization of scientific knowledge as a process and result.

## **Conclusions**

The results from the survey are very encouraging with respect to the objectives of the research. They show a very high degree of expression of the more basic characteristics of "scientific literacy". It is evident that the students share a personal opinion on the posed questions, which are focused on building their civic behavior. They have not taken the answers formally, but the problems obviously were deeply considered and they have formulated their own independent opinions. Of extreme importance is their clearly expressed positive attitude to the role of science and knowledge in natural sciences in people's lives.

These results may be certainly explained with their repeated participation in the work under projects involving various environmental health and socially significant problems.

Another important conclusion is that we cannot rely only and solely on spontaneously emerged scientific literacy, mainly through the media and the channels of distribution of daily life experiences. This concept may become efficiently and practically working if the manner of teaching of knowledge in natural science changes. The results from the survey show that obviously the students had remembered what most impressed them. Here the manner of learning plays an important role. They were actively participating in long-term and diverse educational activities. This proves

one of the main theses of constructivism: that it is extremely important not just what we study, but also how we study it.

The results from this research provide us with a theme for future work both during the classes in natural science and when enhancing and expanding the content of informal education – for example examining topics and questions related to history, philosophy and methodology of science, leading ideas and patterns in the knowledge of natural science, important facts, contemporary scientific achievements, getting to know and applying the methods of scientific knowledge, building an attitude of attributing value to and trust in the explanatory possibilities of science.

Scientific literacy must be examined both as a purpose and as a result from the education in natural science. It is necessary to purposefully build an overall educational environment, a socially and personally significant context when acquiring, understanding, rationalizing and applying natural scientific knowledge. Literacy in natural science is not something achieved; it is a process of formation and development.

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#### Даниела Димова. Проблема "естественнонаучной грамотности" (Результаты исследования)

**Аннотация.** Термин "научной грамотности" известно из 50-х годов 20-го века. Это означает желаемых целей и желаемых результатов естественнонаучного образования и представляет ответ на дефицит в этой области. Это помогает ответить на вопрос: Как существуют научные знания в обществе, не являющихся специалистами? Статья представляет собой опрос среди учеников, который является частью комплексного экспериментального исследования. Вопросы требуют свободного ответа и обрабатываются с помощью контент-анализа. Цель состоит в том, чтобы установить отношение учеников к роли науки и здравоохранения, связанным с экологическими и социальными проблемами в жизни людей и общества в целом. Результаты обнадеживают, но они в основном показывают, что развитие научной грамотности является процессом, который требует полного изменения педагогического подхода, разнообразие методов и организации и тесной увязки формального и неформального образования.

**Ключевые слова:** научная грамотность, отношение студентов, наука и человек