Evaluation of geographical component of students' scientific literacy using the principle of regionalization

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Abstract. The article discusses new approaches and methods, particularly the solution of situation problems aimed at generating and achieving high results of students in forming functional literacy. The use of the regional geographical material by the example of the Krasnoyarsk Territory is most effective in developing training problems that have a pronounced practice-oriented nature. Implementation of the regionalization principle in training involves the students’ perception of the processes of regional reality. Situation problems are proposed, the solution of which allows evaluating the maturity of scientific literacy of the students.

1. Introduction

Amid the integration into the world educational space, a discipline with the target being competence-oriented training has been formed in the pedagogical science of the recent decade. The knowledge, skills and abilities received by schoolchildren during the training characterize the degree of functional literacy of a person. Functional literacy usually means a person’s ability to interact with the environment, to adapt as quickly as possible and function in it, to solve the widest possible range of life problems in various spheres of human activity, communication and social relations in society. The knowledge and skills of schoolchildren aged 15 years are evaluated within the framework of the international study of education quality of the Programme for International Student Assessment conducted under the aegis of the Organization for Economic Cooperation and Development (OECD).

One of the most important types of functional literacy is scientific literacy, which includes the basics of academic disciplines: geography, biology, chemistry, physics, and astronomy. According to the international PISA study, students are tested for their ability to use scientific knowledge to ask questions, master new knowledge, explain scientific phenomena and draw conclusions based on scientific evidence of scientific problems; to understand the basic features of science as a form of human knowledge; to demonstrate awareness of the impact of science and technology on the material, intellectual and cultural spheres of the society; to stand for active citizenship on the issues related to natural science [1, 2]. There are various approaches to the development and evaluation of functional literacy of schoolchildren, the most productive of which, according to the author, are the development, solution and evaluation of fulfillment of situation problems developed on the basis of the regional geographical material.

The purpose of the study is to determine the possibility of using the principle of regionalization to evaluate the scientific literacy of students by the example of geography of the Krasnoyarsk Territory.
Geography is an integral part of the scientific literacy checked by PISA. Moreover, it is a worldview science that forms the spatial perception of students.

2. Research problem setting and results

The analysis of the international research results for Russian schoolchildren in the recent years [3] shows a low level of maturity of scientific literacy. Moreover, there is no progress in the results throughout the entire cycle of the PISA study since 2000, as opposed to reading and mathematic literacy [1, 4].

It is necessary to use new approaches and methods [5], in particular, the solution of situation problems, for the students to form and achieve high results in scientific literacy. Since one of the important directions in the Russian scientific school education is the regional specificity of academic subjects, it is reasonable to use regional material for more demonstrative and accessible understanding of geographic regularities [6].

A geographical situation problem is a description of a situation that needs to be solved by answering questions that are problematic or by performing tasks that demonstrate practical knowledge. Such problems may represent a project, memo, instruction or other presented practical result of the problem. For situation problems, titles are usually selected that reflect either the basic content of the situation or the problem the situation is aimed at [7, 8].

The processes of regional reality, establishing their relationship, reference to theoretical knowledge, as well as educational and scientific research of these objects and phenomena. Training with the use of the regionalization principle enables students to form a complete geographical picture of the world. The use of the regional geographical material of the Krasnoyarsk Territory appears to be the most effective for the development of training problems, which are clearly practice-oriented and require specific subject knowledge. These problems should be formulated as situation problems with their proximity to the real life.

When modeling a situation problem, its main components should be taken into account [9]:

- The name reflecting the content of the formulated problem;
- The situation that needs to be solved, that attracts attention and arouses students' interest;
- The informative question reflecting the actual problem and being of personal importance;
- The input information in the form of a text, figures, tables, charts, graphs, and statistics;
- The problem containing questions and forms for working with the problem.

The article presents situation problems based on the material of regional geography of the Krasnoyarsk Territory to assess the formation of scientific literacy of students.

Problem 1. On May 29, a reservoir burst open at the area of the power plant of the Norilsk-Taimyr Energy Company owned by Nornickel because of subsidence of supports. Twenty-one thousand tons of diesel fuel leaked out. Fifteen thousand tons flew into the Daldykan and Ambarnaya Rivers, and another 6 thousand tons - into the soil. The Ambarnaya River flows into the huge Lake Pyasino, from which the Pyasina River flows into the Kara Sea. To prevent further spread in the rivers, floating booms were installed.

Environmentalists call it the largest environmental disaster in the Arctic as the restoration of the ecosystem in the area of the accident will take at least 10 years. In similar situations in other regions the nature itself usually copes if not all oil products can be collected. For example, if a spill had occurred in the midland, the oil would have decomposed within 3-4 years. In the Arctic, the nature will not cope with this. Microbes have a major decomposing effect on oil products, and in the Arctic their activity is negligible. Fuel that cannot be collected during the spill liquidation is not decomposed in permafrost, so the spills remain much longer (figure 1) [10].
Problem 1.1. Identify the environmental components that have been affected in the Arctic. The codifier for the problem 1.1. is given in table 1.

**Table 1. Codifier for the problem 1.1.**

| Indicator       | Characteristic                                      |
|-----------------|-----------------------------------------------------|
| Competence      | Scientific explanation of phenomena                 |
| Type of knowledge| Substantial knowledge: components of nature          |
| Context         | Hazards and risks                                   |
| Cognitive level | Low                                                 |
| Question format | With an open answer                                 |

Problem 1.2. Is it possible to remove the top soil layer contaminated with oil products in order to eliminate oil pollution? Justify the answer. The codifier for the problem 1.2. is given in table 2.

**Table 2. Codifier for the problem 1.2.**

| Indicator       | Characteristic                                      |
|-----------------|-----------------------------------------------------|
| Competence      | Scientific explanation of phenomena                 |
| Type of knowledge| Substantial knowledge: components of nature          |
| Context         | Hazards and risks                                   |
| Cognitive level | Medium                                              |
| Question format | With an open answer                                 |

Problem 1.3. Specify the reasons for long-term restoration of the oil-contaminated Arctic ecosystem. The codifier for the problem 1.3. is given in table 3.

**Table 3. Codifier for the problem 1.3.**

| Indicator       | Characteristic                                      |
|-----------------|-----------------------------------------------------|
| Competence      | Scientific explanation of phenomena                 |
| Type of knowledge| Substantial knowledge: components of nature          |
| Context         | Hazards and risks                                   |
| Cognitive level | Medium                                              |
| Question format | With an open answer                                 |
Problem 1.4. Specify several environmental safety requirements that are particularly relevant for the Arctic. The codifier for the problem 1.4. is given in table 4.

| Indicator     | Characteristic                        |
|---------------|---------------------------------------|
| Competence    | Scientific explanation of phenomena   |
| Type of knowledge | Substantial knowledge: components of nature |
| Context       | Hazards and risks                     |
| Cognitive level | High                                  |
| Question format | With an open answer                    |

Problem 2. Every year in August the City of Minusinsk hosts the Tomato Festival. During the holiday gardeners present different fruits grown on fertile black earth soils within their allotments: apples, pears, apricots, cherries, and watermelons. The climate of Minusinsk allows growing other fruit and berry crops as well. The City of Minusinsk is located in the south of the Krasnoyarsk Territory within the Minusinsk Basin. This basin is limited by the Eastern Sayan mountains in the east, the Kuznetsky Alatau in the west, and the Western Sayan in the south. In the north, the basin is closed by the Arga Ridge. The elevation above the sea level is 200-700 m. Before the Revolution, the Minusinsk Basin was often called "Siberian Italy". In 1829, the Decembrist S.G. Krasnokutsky, who lived in exile in Minusinsk, was the first to start growing cherries. This was the beginning of the Siberian horticulture. Warm climate and abundant sunlight allow not only successful cultivation of cereals in the Minusinsk Basin, but also doing gardening and melon growing. The average temperature in January is minus 18°C, and in July it reaches plus 21.1°C. In winter, frosts up to minus 40°C are possible. The summer temperature in July may exceed plus 45°C. The vegetation period is about 160 days; the precipitation in the central part of the basin is about 300 mm (figure 2).

Figure 2. Orographic map of the Minusinsk Basin.

Problem 2.1. While characterizing the climate, the scientists identify a number of other factors affecting the formation of vegetation in this region. Which of the factors listed below plays a leading role in vegetation formation in this region?

A. Winds forming in this region;
B. Topography of this area;
C. Geographic latitude;
D. Proximity of seas and oceans.

The codifier for the problem 2.1. is presented in table 5.
Table 5. Codifier for the problem 2.1.

| Indicator       | Characteristic                          |
|-----------------|----------------------------------------|
| Competence      | Scientific explanation of phenomena    |
| Type of knowledge| Substantial knowledge: components of nature |
| Context         | Environment                             |
| Cognitive level | Low                                    |
| Question format | With an open answer                     |

Problem 2.2. The vegetation period (from Lat. vegetatio - revival, growth) is a period of the year, during which growth and development (vegetation) of plants is possible. The vegetation period is conditionally determined by the time between the transition of the average daily temperature in spring and autumn across +5°C.

Please calculate the vegetation period for Krasnoyarsk, if the dates of transition of the air temperature across plus 5 °C are May 10 and September 23.

Please calculate the vegetation period for Minusinsk, if the dates of transition of the air temperature across plus 5°C are May April 21 and September 30.

Please determine which plants can grow in these cities by using the data presented in table 6.

Table 6. Types of plants and duration of their vegetation period.

| Plant        | Vegetation period, days |
|--------------|-------------------------|
| Pineapple    | 242                     |
| Watermelon   | 70                      |
| Tomato       | 60                      |
| Cabbage      | 120                     |
| Banana       | 280                     |
| Grapes       | 145                     |
| Orange       | 220                     |
| Sugar beet   | 140                     |
| Spring wheat | 90                      |

The codifier for the problem 2.2. is presented in table 7.

Table 7. Codifier for the problem 2.2.

| Indicator       | Characteristic                          |
|-----------------|----------------------------------------|
| Competence      | Scientific explanation of phenomena    |
| Type of knowledge| Substantial knowledge: components of nature |
| Context         | Environment                             |
| Cognitive level | Medium                                 |
| Question format | With an open answer                     |

Problem 2.3. What climatic indicators, except for the vegetation period, should be taken into account when growing plants? Please explain why. The codifier for the problem 2.3. is presented in table 8.

Table 8. Codifier for the problem 2.3.

| Indicator       | Characteristic                          |
|-----------------|----------------------------------------|
| Competence      | Scientific explanation of phenomena    |
| Type of knowledge| Substantial knowledge: components of nature |
| Context         | Environment                             |
| Cognitive level | High                                   |
| Question format | With an open answer                     |
3. Conclusions
The capacities of situation problems as an effective methodical resource consist in developing the skills of self-organization of educational activity, forming the skills of students to explain the phenomena of reality, mastering the ability to navigate in the world of values, increasing the level of functional literacy, the ability to navigate in key problems of modern life.

The specifics of the geographical situation problems developed taking into account the regional geographic data is that they are clearly practice-oriented.

The solution of problems associated with the analysis of specific situations that have occurred in the Krasnoyarsk Territory, where the students live, will allow them to improve the level of formation of scientific literacy.

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