Original Contribution

SCIENCE LITERACY OF BULGARIAN STUDENTS THROUGH TEACHERS' VIEW

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ABSTRACT

The article presents results and analysis of data from a national survey conducted among teachers, regarding the science literacy of Bulgarian students. The conducted international studies PISSA and TIMSS show that the results of Bulgarian students are below the average for the study. In the field of natural sciences, the most significant decrease was observed, with the average score of Bulgarian students according to PISSA data falling by 22 points in the study conducted in 2018, compared to 2015. The research presented in this article was conducted through an online questionnaire with 15 questions of different types. 105 teachers participated in the study. The results show that teachers use different methods to build science literacy in students. Teachers share that they are partially or not familiar with the results of the PISSA and TIMSS international studies conducted in our country, in the years 2015 and 2019. They need additional methodical help and literature for acquiring further knowledge and skills for improving science literacy among students.

Key words: education, PISSA, TIMSS, results, methods

INTRODUCTION

Literacy has been talked about and will be talked about a lot. And if in the past a literate person was expected to be able to read and write, today we consider this basic literacy (PISA level 1) and distinguish between: reading, mathematical, and natural sciences.

The Committee of Permanent Representatives to the Council of the EU, November 2012, defines that Literacy covers the reading and writing skills that serve to understand, use and critically evaluate different forms of information, including texts and images in written, printed and electronic form, and includes basic, functional and multifaceted literacy. (1)

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Achieving the three main types of literacy - reading, math and by natural sciences - is an extremely necessary and key skill for the 21st century.

Despite numerous attempts to define the concept of “science literacy”, after more than 60 years since its appearance in 1958 until today, there is still no single accepted definition (2, 3). For PISA, natural science literacy is much more than being able to read and write, i.e. it is functional literacy: Knowledge of natural sciences and its use to define a problem, acquiring new knowledge, explaining scientific phenomena and processes and drawing reasoned conclusions; understanding the characteristic features of natural sciences as part of knowledge about the world; understanding how the natural sciences form their knowledge and the methods they use to do so. (4)
Science literacy is measured by some of the most authoritative international assessments such as PISA and TIMSS. TIMSS has been conducted every four years since 1995 in more than 60 countries, examining the math and science skills of 4th-grade and 8th-grade students. The research is standardized and reports on trends in student achievement and examines differences between national education systems to help improve teaching and learning around the world. Bulgaria participated in the research with 8th-grade students in 1995, 1999, 2003 and 2007, and in 2015 and 2019 with 4th-grade students. In TIMSS, each student works on one test booklet containing two parts – math and science. The tasks are in two different formats - a close-ended (with four possible answers, of which only one is correct) and an open-ended one. Answers to the open-ended tasks are evaluated according to specially developed evaluation criteria by trained evaluators. Scores are presented on a scale of 0 to 1000 points, with the mean of the distribution centered at 500 points with a standard deviation of 100 points. TIMSS defines 4 comparative levels of ability in mathematics and science. The advanced level (625 points) is achieved by students who apply natural science knowledge in the study of phenomena and processes and argue through the application of facts and evidence. These are competencies that are covered poorly or not at all by the educational standards up to and for the respective grade, and a small proportion of students are expected to reach them. We want most students to achieve a high level (550 points) by applying scientific knowledge to explain visible and abstract phenomena. The average level (475 points) is achieved by students who understand basic natural science laws and apply them in elementary practical situations. The low level (400 points) that all students must have reached shows that they know some basic concepts and regularities of the natural sciences. The achievements of Bulgarian fourth-graders in natural sciences in 2019 ranged between 326 and 666, or a difference of 340 points (compared to 316 points in 2015), with the average score being 521 points (15 points less than the previous study). The analysis of the results of the research conducted in 2019 shows "that 15% of the Bulgarian fourth graders have reached the advanced level of natural science abilities, 44% - high, 71% - medium and 87% - low." (5) The data show, that the achievements of weak students, although not statistically significant, are even lower compared to the previous cycle of the study - 13% of our fourth graders (compared to 10% in 2015) do not have the minimum knowledge and skills to cover educational standards in natural sciences, and 10% (compared to 8% in 2015) – in mathematics. (5)

The Program for International Student Assessment (PISA) of the Organization for Economic Cooperation and Development (OECD) aims to examine the quality of education in individual countries by assessing the achievements of 15-year-old students. The survey has been conducted since 2000 every three years in countries around the world. PISA assesses the extent to which students at the end of compulsory education have acquired knowledge and skills identified as key to their full participation in public life. The program measures whether they can develop what they have learned and apply their knowledge in both school and out-of-school settings in three core cognitive areas – reading literacy, mathematics and natural science. Each assessment focuses on one of the three areas, while the other two are presented more generally. - PISA 2000 and 2009 and 2018 - reading, PISA 2003 and 2012, 2022 - mathematics (Bulgaria did not participate in PISA 2003). PISA 2006 and 2015 - natural sciences. (6)

OECD and associated countries decided to postpone the PISA 2021 assessment to 2022 and the PISA 2024 assessment to 2025 due to post-Covid difficulties. PISA 2022, held from March 21 to April 22, focuses on mathematics with an additional test on creative thinking. (7). The scale by which PISA summarizes students' knowledge and skills is divided into six levels, of which the lowest is the first and the highest is the sixth. For each level, the knowledge and skills necessary to solve the tasks relevant to the level are described. The share of Bulgarian students with the highest achievements is very small, and remains almost unchanged in various studies and compared to the share of students in OECD countries. The percentage of Bulgarian students below the critical achievement threshold is alarmingly high in all stages after 2006. It is almost twice the
corresponding share of students from OECD countries. (8)

In the study conducted in 2018, the average score of Bulgarian students in natural sciences was 424 points and is significantly below the average score of the OECD countries, which is 489 points. The most significant decrease was observed in the field of natural sciences, with the average result of Bulgarian students decreasing by 22 points compared to 2015 (446 points). (9)

Bulgaria, as a member of the European Union, complying with the requirements of the European Commission for Education, made a number of changes in education that put the student at the center of the educational process. Despite the reforms made, there is a continuous decrease in students’ interest in learning, and especially in studying natural sciences, their results in various assessments are disturbingly low. This necessitates conducting research to discover the causes of this condition, discovering work methods leading to increasing the interest, knowledge and skills of students in natural sciences.

**AIM AND METHODS**

The present study aims to investigate the awareness of teachers about the results of Bulgarian students from the conducted international studies PISSA and TIMS, their opinion about the nature and methods of building science literacy among students, the need for changes in the curricula and the teachers' need for additional methodological help or literature, to acquire knowledge and skills to build science literacy among students.

The survey was conducted in the period from 06.02.2022 to 09.05.2022 and was self-funded. The survey method is web-based and created using GoogleForms. The survey was posted in several teacher social media groups, a copy is available at: https://docs.google.com/forms/d/1ujKkxgb7xTP5tJNzx9xDCS28c_d8k3fijmDPN-XEE/edit. This specialized product enables fast statistical processing and visualization of aggregated information. The survey is partially standardized and consists of 15 questions of different types, with some of the questions having the opportunity to express one's own opinions and comments (10, 11). 105 teachers participated in the study.

**RESULTS AND ANALYSIS**

The first five, along with the last one, are identification questions (10, 11) and they aim to collect data for the studied sample. Table 1 presents the composition of the sample according to the place of residence and the type of educational institution where the respondents work. 105 teachers working in different settlements and at different stages of secondary education participated in the study - elementary, junior high, and high school, which shows that the problem of science literacy of Bulgarian students is equally important for all. The fact that the survey was completed by people working in the education system who are not teachers shows an increased interest in scientific literacy.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Area of residence</th>
<th>Type of educational institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of respondents</td>
<td>51</td>
<td>34</td>
</tr>
</tbody>
</table>

1City - with a population of over 50 000 inhabitants
Town - with a population of 10 000 to 50 000 inhabitants
Small town/Village - with a population of up to 10 000 inhabitants

1SS - Secondary School (1 - 12 grade)
PS - Primary School (1 - 7 grade)
D – high school (8 - 12 grade)
PrS - Professional School
US - United School (1 - 10 grade)
The professional characteristics of the surveyed teachers are represented by their age, teaching experience, their professional-qualification degree (PQD) (Table 2), and the taught subject. Teachers with the longest teaching experience and aged 35-55 have the largest share among the respondents. These results are in line with the analysis of the European Commission, the results of the study confirm that in Europe the majority of teachers are over 40 years old. Almost half of the teachers are over 50 years old in Austria, Bulgaria etc., (12)

Table 2. Composition of the sample surveyed by age, pedagogical experience and professional qualification degree (PQD)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Age, years¹</th>
<th>Pedagogical internship, years</th>
<th>PQD²</th>
<th>do not have</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>below 35</td>
<td>35-55</td>
<td>above 55</td>
<td>below 5</td>
</tr>
<tr>
<td>Number of respondents</td>
<td>3</td>
<td>71</td>
<td>27</td>
<td>7</td>
</tr>
</tbody>
</table>

¹Four respondents did not answer the question.
²One of the respondents did not answer this question.

The data shows that the respondents are experienced teachers improving their qualifications. Almost 90% of the respondents have a PQD. The survey was completed mostly by teachers of biology and health education 59 (57.3%) and of chemistry and environmental protection 15 (14.6%). There are 9 (8.7%) teachers in junior school. Among the respondents, there are teachers of mathematics - 5, Bulgarian language and literature and physics and astronomy - 3, technology and entrepreneurship - 2, informatics and information technologies, foreign language and history and civilizations 1, other - 4 and two respondents who did not answer (three respondents do not work in a school). The reason that the survey was completed by most biology and health education and chemistry and environmental protection teachers is probably the expectation of some teachers that natural science literacy is formed only in science education. The relatively small share of teachers in the initial stage of education shows that the formation of science literacy is thought of mostly in the junior high school stage of education when the subjects are differentiated. According to the teachers participating in the study, the curricula provide good opportunities for building natural science literacy (37 indicate "3" and 33 indicate "4"). Only two participants believe that it gives almost no opportunity, and 15 to a very large extent.

To build science literacy among students, teachers use a variety of methods (13-14), both traditional and modern (interactive) (Table 3). According to the respondents, the most frequently used methods are conversation and narration. 55 respondents indicated that they have conversation every period, and 23 use the method at least once a week. 44 respondents indicated that they use narration every period and 24 use the method at least once a week. Other frequently used methods according to respondents (indicated as being used every period or at least once a week by more than 20 respondents) are discussion, ICT-based methods. Working on a project is a method applied by almost half of the respondents at least once a month (42 respondents) or less than once a month (25 respondents). Some teachers shared that they do not use some of the methods mentioned, such as the interactive methods of mind maps and brainstorming. Mind maps were listed as an unused method by 23 respondents. Interactive role-playing games are not used by 19 of the respondents. The present study does not take into account the reasons for applying, or not, a certain method for building natural science literacy.
among students. This could be the subject of further research. The results show that for the formation of natural science literacy in students, teachers most often apply traditional teaching methods, such as conversation and narration. Of the interactive methods, the ICT-based ones are applied the most.

Table 3. Variety of methods used by teachers to build science literacy among students.

<table>
<thead>
<tr>
<th>Indicator Method</th>
<th>Every period</th>
<th>At least once a:</th>
<th>Less than once a month</th>
<th>I don't use</th>
<th>No answer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>week</td>
<td>month</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Narrative</td>
<td>44</td>
<td>24</td>
<td>8</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Conversation</td>
<td>55</td>
<td>23</td>
<td>12</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>WWB</td>
<td>16</td>
<td>18</td>
<td>19</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>Observation</td>
<td>22</td>
<td>29</td>
<td>22</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Demonstration</td>
<td>11</td>
<td>33</td>
<td>25</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Experiment</td>
<td>0</td>
<td>19</td>
<td>29</td>
<td>27</td>
<td>11</td>
</tr>
<tr>
<td>Self-work</td>
<td>18</td>
<td>30</td>
<td>36</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Group discussion</td>
<td>14</td>
<td>31</td>
<td>19</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Brainstorming</td>
<td>13</td>
<td>24</td>
<td>21</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>Discussion</td>
<td>24</td>
<td>39</td>
<td>24</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Case studies</td>
<td>8</td>
<td>25</td>
<td>22</td>
<td>22</td>
<td>6</td>
</tr>
<tr>
<td>Mind maps</td>
<td>3</td>
<td>22</td>
<td>17</td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td>Projects</td>
<td>3</td>
<td>16</td>
<td>42</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Roleplay</td>
<td>2</td>
<td>17</td>
<td>23</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>ICT</td>
<td>24</td>
<td>33</td>
<td>18</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>11</td>
</tr>
</tbody>
</table>

1 Working with a book
2 Information and Communication Technologies

Reasons for less frequent or non-application of interactive methods are probably related to a weak familiarity and teachers' need for additional methodical assistance, as well as various difficulties in their application, such as laboriousness in organization and implementation, difficult, time-delayed reporting of the results. What was found in the present study is in line with what was found by D. Neikova, that "the concept of "interactive methods" is known to teachers and these methods are part of the planned activities in the lessons.", but "this toolkit is not yet widely represented in the daily work of the teacher." She also reports a 'never' response stated by 1.54% of respondents regarding role-playing (15).

The respondents indicate that to build natural science literacy among students they also use other methods such as: modeling, "Natural sciences workshops" where students demonstrate their knowledge in front of an audience, educational trips, "theatrical plays on scientific topics with student written scripts", competitive lessons, work with popular scientific literature. This shows that some teachers use different methods to build science literacy in students.

To the question asking respondents to indicate the characteristics of natural science literacy according to PISA 9 (9.5%) of respondents indicated all characteristics. 33 of the respondents indicate only one of the characteristics, 35 indicate two of the characteristics, 21 respondents indicate three of the characteristics, 4 respondents indicate four of the characteristics, and 3 of the respondents do not indicate an answer. The largest share of the respondents 72 (70.6%) indicate "understanding the characteristic features of natural sciences as part of the knowledge of the world" and 65 (63.7%) "explaining scientific phenomena and processes and drawing reasoned conclusions". These are basic characteristics of science literacy, therefore
teachers are partially familiar with this concept. An interesting fact is that only 20 (19.6%) of the respondents indicate "acquiring new knowledge" as a characteristic of natural science literacy, and this is reaching on an independent path of learning something new, and is the basis of science literacy. Probably considering that the acquisition of knowledge is a priority of basic literacy, some of the surveyed teachers do not consider it an element of the higher, functional level of natural science literacy. The analysis of the data shows that teachers partially know the main characteristics of natural science literacy and need additional qualifications regarding its essence.

The research shows that a small part of the teachers (10%) share that they are familiar with the results of the international PISA study conducted with Bulgarian students, they are partly familiar (60%) or they are not familiar (20%). 10% of respondents did not answer the question. Therefore, it is good for all teachers to become familiar with the results of the research. It would also be good to promote the results to the public.

To build science literacy in students, almost half of the teachers say that they more often take tasks from the international studies TIMSS/PISA, and less often prepare tasks of this format themselves. 12 of the respondents indicate that they use ready-made tasks at least once a month, 23 less than once a month, 17 when preparing for a competition and 47 do not use tasks of the TIMSS or PISA format for building natural science literacy among students. 25 of the respondents indicate that they prepare tasks themselves - 3 every period, 6 when preparing for a competition, 7 once a month, and 9 less than once a month. 55 do not use such a task format, and 25 do not answer. The large percentage of non-answers to the question and teachers indicating that they do not use this task format is probably due to the low awareness of teachers about the ongoing international studies TIMSS and PISA and indicates the need for better promotion of the research framework.

To increase students' science literacy, teachers suggest increasing exercises (80.8%), increasing experimental activities (72.1%), increasing integration between subjects (56.7%), more clearly linking learning content with expected results (53.8%), reduction in the volume of learning content (52.9%), and reduction in factuality in learning content (46.2%). Increasing exercise and experimental activities are an integral part of natural science literacy. Carrying out an experiment, the student plans it, implements it, analyzes the data, and so he walks the path of scientific knowledge. But in the curricula of man and nature for 3 grade and 4 grade, there are no classes with practical activities (16, 17). The desire of teachers to increase the "share of experimental work" has also been established in previous studies. (18, 19)

To the question: "Do you need additional methodical help or literature, to acquire knowledge and skills to build science literacy among students?" the data clearly shows the teachers' need for methodical literature and help. 90.3% of teachers say that they need methodical literature/ready-made tasks, and aids and 58.8% of teachers say that they need methodical help/qualification courses.

FINDINGS AND CONCLUSION
- The construction of science literacy is considered a priority task of education in the lower secondary and high school stages of education, the role of the initial stage of education in building science literacy among students is underestimated;
- The essence of the science literacy concept of literacy is partially known, but the characteristic "acquisition of new knowledge" is underestimated;
- In the formation of science literacy among students, teachers continue to use primarily the emphasized narrative and conversation methods, the role of interactive methods, except ICT-based methods, is significantly underestimated.

Better promotion of the framework of the international studies TIMSS and PISA and the established results is needed to reach all teachers, not only those whose students participated in the studies.

Teachers know the main characteristics of natural science literacy. According to them, the curricula provide good opportunities for building science literacy among students and propose an increase
in exercises, experimental activities, and integration between educational subjects, a clearer connection of educational content with expected results, and a reduction of the volume and facts in the educational content. To build science literacy among students, teachers most often use traditional methods, and less often interactive ones. The teachers are adamant that they need methodical help and literature to build natural science literacy among students.

To prepare for the needs of teachers a handbook with tasks in the form of the international study formats TIMSS and PISA can be created.

In a possible subsequent study, teachers’ motives for using specific approaches and methods for building science literacy among students could be explored.

**GRATITUDE**

Thanks to everyone who filled out the survey! Thank you for your time, effort, and shared experience. Without your activity, this study would not have been possible.

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