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Meaningful Reading Skills for Improvement of Biological Literacy in Primary School

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Abstract: Biology is one of the school subjects that is the most saturated with different terms and notions. The young person finds it rather difficult to orient in the diverse offer of information in today's age of information abundance because he has to "read" and assess critically to be able to learn with understanding. The reading literacy of Latvia's 15-year-old students is low; therefore, the aim of the present study is to find out how the improvement of meaningful reading skills applying different reading strategies affects students' biological literacy. In order to explore the mutual relationship a pedagogical experiment was carried out in Riga X gymnasium in 2017. The opinion of 58 students and their teacher of biology about the assessment of students' reading skills was examined by using different reading strategies aimed at improving students' reading skills in the experimental group and checking their level of reading by using PISA tests. Data were processed using the SPPS 23 statistic data processing program. The study findings show that students' level of reading after the application of reading strategies increases and their biological literacy improves.

Keywords: reading skills, scientific literacy, biological literacy, PISA tests, 15-years old students, school education.

Introduction

Mastery of key subjects is essential to student success. Science is one of the included key subjects for the development of 21st century skills (Partnership for 21st..., 2015). The European Commission has identified 8 key competences that are fundamental for each individual in a knowledge-based society (Borrell-Fontelles, Enestam, 2006). These skills, among others, mention communicating in the mother tongue: the ability to express and interpret concepts, thoughts, feelings, facts and opinions both orally and in writing, as well as mathematical, scientific and technological competence: sound mastery of numeracy, understanding of the natural world and the ability to apply knowledge and technology to perceived human needs. It means that the young person must be science and reading-writing literate.

The young person finds it rather difficult to orient in the diverse offer of information in today's age of information abundance because he has to "read" and assess critically to be able to learn with understanding. M. Fullan, M. Langworthy and M. Barber (2014, 7) indicate that learners have to strive to achieve "deep learning as creating and using new knowledge in the world, to re-structure the learning process towards knowledge creation and purposeful use". Being the Y generation, they are informative literate and "connect learning to the world by using the power of digital tools" (ibid., 10).

Biology as a subject, as noted J.H. Wandersee (1988, 99), is especially prone to terminology overload. Terminology is a vital part of biology, however, biology education and even scientists experience difficulty keeping up with the terms in their field. There are many terms and many synonyms; most terms are long, polysyllabic words of Greek or Latin origin, which makes them more difficult to read or say. If such terms are to be learned meaningfully, they must be connected to what the learner already knows. Biology acquisition faces such difficulties as language and terminology, mathematical content, points of biological content and time allowance" (Bahar, Johnstone, Hansell, 1999, 84) as well as "overstuffed" biology curriculum (Koba, Tweed, 2009), "overloaded biology curricula, the abstract and interdisciplinary nature of biological concepts, and difficulties with the textbooks (Cimer, 2012, 61). R. Lazarowitz and S. Penso (1992), too, maintain that low-achieving students in high schools identify learning difficulties regarding the biology concepts.

In order to acquire biology successfully, students need to comprehend the basic concepts. Teacher's precise explanation of the basic concepts facilitates the corresponding development of student's knowledge and comprehension. The understanding of the basic concept develops gradually (Kreile, Krumina, 2009, 330). It means that if the teacher uses biology texts for students' independent reading she has to take into consideration that, first, it is important for the student to recognize this concept, then to understand it and this is the only way for interconnections (contiguity between the basic concepts) to develop. The awareness of the former secondary students – now the first-year students of the biology bachelor's programme - of what learning is corresponds to the classical European didactic approach, namely, acquisition of knowledge and skills to apply it, viewing knowledge as the key component of learner's experience as well as emphasizing the cognitive process of learning (Birzina, 2011, 50).

Thus, guiding students' learning with understanding makes it possible to sustain students' interest in the natural world, help students explore new areas of interest, improve their explanations of biological concepts, help them understand and use inquiry and technology, and help them make informed personal and social decisions. Students should learn and understand how to use biological information in their daily lives (Uno, 1999, 3).

Reading literacy

According to the latest PISA report, on average 17% of European 15-year-olds (13% of 15-year-old girls and 27% of 15-year-old boys) have poor reading skills and are not able to understand their own school textbooks well (OECD, 2013a). Reading literacy means "understanding, using and reflecting on written texts, in order to achieve one's goals, to develop one's knowledge and potential and to participate in society." (Kirsch et al., 2002, 25). Thus, the reading competence does not only mean the ability to comprehend the surface meaning of the text but also includes the ability to understand and express one's opinion about the text. It includes cognitive and metacognitive skills: to use different adequate strategies in work with the text (Geske et al., 2013).

The use of the reading strategy helps students acquire the understanding of the text by analysing and interpreting it. Students have to acquire the use of a reading strategy as any other new skill. It would be best mastered using the scaffolding method, which includes modelling of the strategy offering students to try out this strategy themselves in practice and then to use it independently. A learner can apply any reading strategy in many different ways: before reading, during reading and/or after reading. There are also many kinds of reading strategies that are used for developing the reading competence. For example, N.K. Duke and P.D. Pearson (2008) offer six strategies: prediction and prior knowledge activation, think-aloud, text structuring, visual representations of the text, summarization and questioning. Undeniably, a teacher plays an important role in developing student's reading skill because only the teacher is able to help students acquire different reading strategies.

Students' achievement in reading is defined by giving points and connecting the number of points with the competence level. Taking into consideration the cognitive content of separate tasks and the scale of points, the reading competence is assessed on seven levels – the highest is level six, the lowest – 1 b level (Table 1). The average achievement of Latvia's students in reading is 488 points – it is a bit lower than the Organisation for Economic Cooperation and Development (OECD) average level (493 points). Latvia's peculiarity is the great number of students who have the lowest levels of the reading competence. This relation during the period of OECD studies from 2003 – 2009 has not changed significantly and is lower than OECD average. The number of students, who have the highest levels of reading, in its turn, has increased a bit but is still lower than OECD average (Geske et al., 2013; OECD, 2016). This means that it is still very topical to improve students' reading competence and to achieve that students read with understanding or meaningfully.

Scientific literacy and biological literacy

Nowadays the aim of science education is the formation of scientific literacy. It would be necessary to form a common scientific literacy in all science subjects at school so that students could see interconnections and were able to apply their complex, interdisciplinary knowledge and skills that have been acquired in biology, geography, physics and other school subjects in real life situations. Educators use the phrase "scientific literacy" to express the major goal of contemporary science education, an aim recognized for all students (Uno, 1999, 39). Students' scientific literacy is also one of the indicators of the quality of education. International comparative studies in science (Geske, 2000; Kangro, Geske, 2001) show comparatively low achievement of Latvia's students in science and mathematics.

Undeniably, as M. Rocard and other co-authors (Rocard et al., 2007, 7) have noted scientific literacy is important for understanding environmental, medical, economic and other issues that modern societies face, which rely heavily on technological and scientific advances of the increasing complexity. However, one should take into account that deep understanding in science goes well beyond memorization of isolated facts and concepts. Deep scientific understanding includes a coherent system of facts, concepts, scientific inquiry, and strong problem-solving ability (Staver, 2007, 11).

The concept of scientific literacy appeared in Latvia after regaining the independence in 1991 (Lamanauskas, Gedrovics, 2005). Such concepts as biological literacy and chemical literacy (Cedere, Mozeika, 2008) are also used in science education. There is a close connection between scientific literacy and biological literacy. As recognized by G.E. Uno and R.W. Bybee (1994), biological literacy is a subset of scientific literacy, and not a final state to be achieved within a single biological discipline but a continuum over which the individual's biological understanding develops throughout his or her lifetime. G. Uno, in his turn, divides biological literacy into four levels (Table 1). The levels of biology literacy suggested by him, to a certain extent, are similar to SOLO (Structure of the Observed Learning Outcome) taxonomy (Biggs, 1995) and provide a systematic way of describing how learner's performance grows in complexity while forming the biological literacy.

Table 1

Comparing levels and descriptions of reading literacy, scientific literacy and biological literacy

<table>
<tr><th>Reading literacy
(OECD, 2013b)</th><th>Scientific literacy
(OECD, 2000)</th><th>Biological literacy
(Uno, Bybee, 1994; Uno, 1999)</th></tr>
<tr><td>1a (355 points)
Locate a single piece of explicitly stated information
1b (262 points)
Locate one or more independent pieces of explicitly stated information</td><td>1
Limited scientific knowledge</td><td>Nominal
Can identify terms and questions as biological in nature, but possess misconceptions, and provide naive explanations of biological concepts</td></tr>
<tr><td>2 (407 points)
Locate one or more pieces of information, which may need to be inferred and may need to meet several conditions</td><td>2
Adequate scientific knowledge to provide possible explanations in familiar contexts</td><td>Functional
Use biological vocabulary, define terms correctly, but memorize responses</td></tr>
<tr><td>3 (480 points)
Locate, and in some cases recognise the relationship between several pieces of information that must meet multiple conditions</td><td>3
Can clearly describe scientific issues in a range of contexts</td><td>Structural
Understand the conceptual scheme of biology, possess procedural knowledge and skills, and can explain biological concepts in their own words</td></tr>
<tr><td>4 (553 points)
Locate and organise several pieces of embedded information</td><td>4
Can make inference, can integrate explanation</td><td rowspan="3">Multidimensional
Understand the place of biology among other disciplines, know the history and nature of biology, and understand the interactions between biology and society</td></tr>
<tr><td>5 (626 points)
Locate and organise several pieces of deeply embedded information</td><td>5
Can apply scientific concepts and knowledge about science</td></tr>
<tr><td>6 (698 points)
Make multiple inferences, comparisons and contrasts that are both detailed and precise</td><td>6
Can consistently identify, explain and apply scientific knowledge and knowledge about science in a variety of complex life situations</td></tr>
</table>

As the study reflected in the article is connected with the exploration of reading skills and biological literacy, the study also uses PISA tests (PISA, 2015), then Table 1 (adapted from (Garthwaite, France, Ward, 2014)) presents the mutual connection between reading literacy, scientific literacy and biological literacy.

The aim of the study is to explore the impact of meaningful reading literacy skills on biological literacy by using different reading strategies in the process of learning biology.

The study question was identified: how the use of various reading strategies in the process of teaching biology improves students' reading skills and biology literacy?

Methodology

A pedagogical experiment was carried out to clarify how the use of various reading strategies in the biology teaching process has improved students' reading and biology literacy in 2017. The study took place in five successive stages (Figure 1): the situation analysis, OECD test 1 (PISA, 2015), elaboration of biological assignment, approbation of the developed assignment and OECD test 2 (PISA, 2015). The study was conducted using the method of convenience (Geske, Grinfelds, 2006). The sampling consisted of two convenient groups – 15-years old students of one of Riga X gymnasium: the control group 30 and experimental group 28, who were accessible in the given circumstances, overall 58 students. The number of respondents in some stages of the study had insignificant differences and it did not influence the course of the study. The study was performed from February to April 2017.

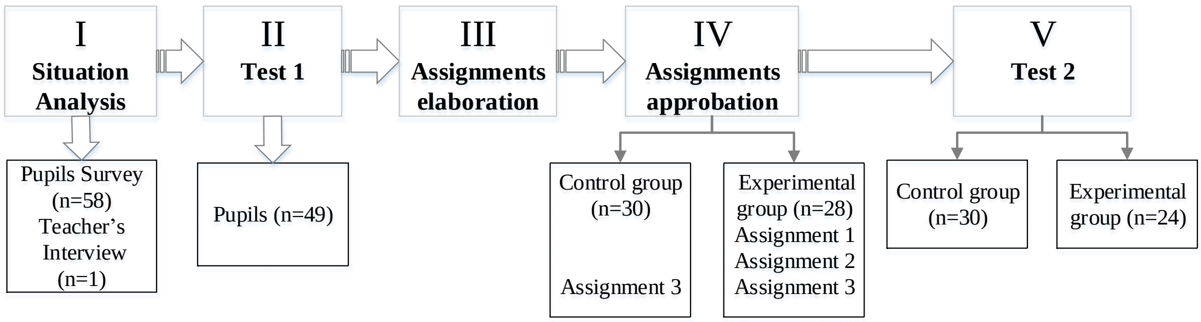


Figure 1. Scheme of the stages of the study.

The first stage was devoted to finding out students' self-assessment of their reading literacy. The questionnaires were developed using the Lickert scale with four possible versions of answers (skills: 1 – very poor; 2 – poor; 3 – good; 4 – very good). A structured interview was conducted with their teacher of biology.

During the second stage, using tasks of different difficulty levels from OECD PISA (PISA, 2015; Geske et al., 2013) Test 1, students' level of reading was assessed. Students of Grade 9a and Grade 9b did the tasks. The experimental and control groups were chosen. The class with the lowest achievement in the tasks of the highest level and in the test in general became the experimental group.

Three tasks in the biology theme "Nervous system" were developed in **the third stage**. This is one of the relatively difficult themes for students because they have to master many abstract biological concepts (Bahar, Johnstone, Hansell, 1999; Cimer, 2012). The tasks included not only issues that had to be mastered theoretically but also instructions how to use the intended reading strategy for the text comprehension. A self-assessment table for student's reflection on the used reading strategy supplemented each task.

The fourth stage was devoted to the pedagogical experiment for the approbation of the developed tasks. Students of the experimental group in the first two tasks along doing the task also acquired and assessed reading strategies. They had to use text visualisation and structuring based on their prior knowledge in the reading strategy in the first task. In the second task, they had to find the most important information in the text, to write it in their own words, to retell the text and to put down the most important from what the classmate was telling. Both groups did the third task using such reading strategies as prediction, prior knowledge activation, questioning and text structuring, summarization and learning through think-aloud. The qualitative content analysis of students' summaries of both groups was also performed in this stage.

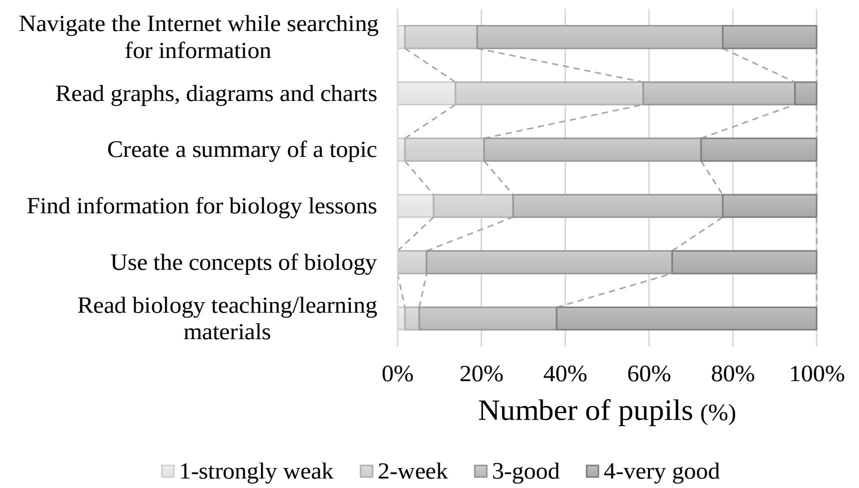
Test 2 (PISA, 2015; Geske et al., 2013) to identify students' level of reading literacy and biological literacy was carried out in the **fifth stage**. The tasks were done by 30 students from the experimental group and 24 – from the control group. Data were processed using the SPPS 23 statistic data processing program.

Results and Discussion

In order to find out how the use of different reading strategies in the teaching/learning process of biology improves students' reading literacy and biological literacy, students' and teacher's opinions about the reading literacy were compared, the use of reading strategies in the acquisition of biology was found and the results of Test 1 and Test 2 were analysed.

Students' and teacher's opinion about reading skills

Summarising the results of students' survey, it was learnt that students of both classes considered their skill to express themselves, using the biology terms, as the poorest (M=2.33). However, students considered their skill to orient in the internet searching for the necessary information for biology lessons as very well or well developed (M=3.55) (Figure 2).



Mean	Moda	SD
3.55	4	0.654
3.28	3	0.586
2.86	3	0.868
3.05	3	0.736
2.33	2	0.781
3.02	3	0.688

Figure 2. Students' point of view on reading literacy.

The teacher of biology, too, considers that students have a very well-developed skill of orienting in the internet searching for the necessary information in relation to biology and materials when preparing for biology lessons. Yet, she points out that students are able to find information in the internet but usually it does not come from research articles, therefore she considers that students need to learn to read popular scientific publications and research articles in biology lessons. However, despite the fact whether the information is found in the internet or read in the printed text students have to improve their skill of selecting the information.

Students' and teacher's opinion coincides as regards students' skills to read the biology textbook materials and to read information from graphs, schemes and diagrams. These skills are well developed and usually do not cause problems for students in the learning process. However, the teacher considers that students perceive the information from biology materials better if all biology concepts are understandable. She assesses students' skill to make a summary about a particular theme as good, which partly coincides with students' assessment (50% admit that this skill is well developed). However, students themselves are aware and the teacher indicates that students lack the skill of using biology terms. This is also proved by indicators of descriptive statistics (M=2.33) with the most frequently used choice "poor" (Mode=2).

Analysis of using reading strategies in the acquisition of biology

In order to find out how the use of reading strategies affected the acquisition of biology, students' performance in doing tasks and their self-assessment were compared. As seen in Table 2, students of the experimental group admit that reading strategies have facilitated the understanding of biology terms. The use of text visualization and structuring has led to the increase of students' comprehension from M=1.94 to M=3.29; in the second strategy (to find the most important information in the text, to write it in one's own words, to retell the text and to make notes from what the classmate has told) – from M=2.52 to M=3.56.

Table 2

Comparison of students' self-assessment after the use of two reading strategies

Description of the item	The first reading strategy			The second reading strategy		
	Mean	Mode	SD	Mean	Mode	SD
I understood the text after the first reading	3.47	3	0.514	3.44	3	0.583
I knew all the terms	1.94	2	0.659	2.52	3	1.005
After completing the task, I comprehended the topic	3.29	4	0.772	3.56	4	0.583
	N=17			N=25		

The same regularity is observed in the use of the third strategy (prediction and prior knowledge activation, questioning and text structuring, summarization and think-aloud). The comprehension of biology terms increases from M=2.04 to M=2.48 for the students of the experimental group and from M=2.17 to M=2.30 in the control group (Table 3).

Table 3

Comparison of students' self-assessment after using of the common reading strategy

Description of the item	Experimental group			Control group		
	Mean	Mode	SD	Mean	Mode	SD
I understood the text after the first reading	3.19	3	0.622	3.03	3	0.615
I knew all the terms	2.04	2	0.808	2.17	2	0.834
After completing the task, I have no difficulties to create a summary	2.48	2	0.935	2.30	2	0.877
	N=27			N=30		

Students' performance and the level of their biological literacy is reflected in Table 4. The comparison of answers given by students of the experimental and control groups allows stating that there are no statistically significant differences; however, the results of the experimental group are a bit better.

Table 4

Results of tasks performed by students and the level of biological literacy

Issue	Experimental group			Control group
	Assignment 1	Assignment 2	Assignment 3	Assignment 3
Average level of performance	51%	75%	71%	68%
Difficulty level of tasks	0.51	0.75	0.71	0.68
Level of biological literacy	Structural	Structural	Structural	Structural

In order to find out the acquisition of biology terms, the qualitative content analysis of students' summaries of both groups was performed. Twelve biology terms were mentioned in students' summaries: embryonic period; neural cell; neuron; synapses; central nervous system; perceptive memory; short-term memory; working memory; long-term memory; hippocampus; nervous system; irritation. Students of the control group have mentioned 3.37 terms on average, students of the experimental group, in their turn, have mentioned on average by two terms more, i.e., 5.56 terms from the 12 given. The most frequently mentioned terms are "neural cell", "neuron", "short-term memory" and "long-term memory". Students of both the experimental and the control groups fell within the structural level of the biological literacy: they were able to understand the conceptual scheme of biology; they possessed procedural knowledge and skills and were able to explain biological concepts in their own words.

Analysis of Test 1 and Test 2

After doing Test 1 (Table 5) it was stated that the reading competence of students of both groups differed statistically insignificantly. The observed tendency was that if the level of the reading competence increased, i.e., the difficulty level of the task increased, the number of students who were able to do this task decreased.

Results of Test 2 show that the average result of the experimental group in all separate tasks is higher by 7% than that of the control group. The results of students of the experimental group on the higher levels of the reading competence have become better than those of the control group. For example, ~ 10% more students in the experimental group have performed the tasks of the 5^{th} level than in the control group, 6^{th} level tasks about ~ 15%. Comparing the results of Test 1 and Test 2 achieved by both the groups it is possible to see that the performance of the experimental group on the 5^{th} and 6^{th} level of the reading competence has noticeably increased.

Comparing Test 1 and Test 2 results achieved by the experimental group and the control group with the average results of (PISA, 2015) OECD countries and Latvia it is seen that after the performance of tests and counting the points obtained on the respective level and expressing them in percentage the results are much higher. Probably, the fact that the study was carried out in Riga X gymnasium in which students are enrolled after the selection process could explain it. OECD (PISA, 2015) study, in its turn, is performed covering a wide network of general comprehensive schools of Latvia.

Table 5

Test results of the experimental and control group (%) and their comparison with (PISA, 2015) **levels of the reading competence in Latvia and the mean indicator of OECD countries** (OECD,2016)

Level / Issue	<1.b	1. b	1. a	2.	3.	4.	5.	6.
Test 1 (Control group)	0	0	0	12.0	16.0	32.0	28.0	12.0
Test 2 (Control group)	0	0	0	0	16.8	36.6	36.6	10.0
Test 1 (Experimental group)	0	0	0	16.7	16.7	29.2	29.2	8.2
Test 2 (Experimental group)	0	0	0	0	8.4	20.8	45.8	25
OECD (average)	1.3	5.2	13.6	23.2	27.9	20.5	7.2	1.1
Latvia (average)	0.4	3.8	13.4	27.2	32.1	18.7	4	0.3

Limitation of the study

The limitations of the study are related to the sample size, the measure used to collect the data, the access and longitudinal effects. As it was a case study, researchers in a random selection situation had to accept the chosen number of participants and the access to them. The results of the obtained data, too, show that the study could anticipate more specific questions regarding the aspects of reading literacy and biological literacy. It would have also been important to include more open questions that would help to learn the respondents' opinions in more detail. The obtained conclusions are correct for the concrete target group – Grade 9 students of the gymnasium; however, it should be taken into consideration that results of these students could be higher than in other general comprehensive schools of Latvia. This means that in order to define the improvement of reading literacy and biological literacy a more comprehensive and time-consuming research is needed.

Conclusions

Students' reading literacy in Latvia on the higher levels of the reading competence is low which hinders the attainment of one of the aims of modern science education – the formation of scientific literacy. There exists a mutual connection between levels of reading, scientific and biological literacy, thus it is possible to promote the biological literacy by improving the reading literacy.

In order to facilitate the improvement of student's biological literacy, it is, first, necessary to acquire the basic terminology of biology and then its gradual, more profound comprehension. It can be developed using meaningfully different reading strategies aimed at text comprehension: prediction and prior knowledge activation, think-aloud, text structuring, visual representations of text, summarization and questioning. This means that the diversification of the kinds of learning using the verbally linguistic kinds (reading, telling, summary in one's own words), students' individual learning (structuring, visualization, questioning) and the improvement of interpersonal skills (cooperative learning, retelling in the group and comparison of notes) leads to the development of students' reading literacy. The use of different reading strategies in the teaching/learning process of biology facilitates the improvement of meaningful reading literacy, which is proved by the increase of results on the higher levels of reading competence of the experimental group. Thus, it allows concluding that a meaningful use of reading strategies helps students make a spring from knowing to understanding and to improve their performance reaching a higher level of biological literacy.

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