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The Level of Scientific Literacy Among Primary School Pupils: Preliminary Results

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Abstract

Scientific literacy is a term which is often mentioned in the context of contemporary problems and in the current society in general. Scientific literacy is a term used since the 1950s to describe the scientific knowledge of broad public; although almost 75 years have passed, its definition is still not unanimous; the term lacks a single universal definition. The main aim of the research was to determine the level of scientific literacy among primary school pupils and also to determine differences in the level of scientific literacy with regard to the relevant grade and gender. The total of 112 pupils from 3 primary schools selected from the schools available participated in the research. The research tool was designed from published TIMSS 2019 tasks aimed at the scientific literacy with 4-grade pupils. The test tool consisted of 12 questions diversified according to their difficulty to 2 – 5, similarly as in the TIMSS test. I used 3 tasks in every category of difficulty. In order to fulfil the research aims, the inductive statistical methods were used, specifically the Student's t-test for independent selections. If we focus on the results of the scientific literacy test from the age perspective (or the relevant grade), we concluded that 9-grade pupils achieved statistically much better results in all test areas and there were no statistically significant differences in the success rates of boys and girls.

Keywords: *primary school pupils; quantitative approach; scientific literacy; test*

1 Introduction

Scientific literacy is a term which is often mentioned in the context of contemporary problems and in the current society in general. Scientific literacy, similarly as many other kinds of literacy, is a phenomenon in modern school systems, not only in the Czech Republic but worldwide. School systems all over Europe, but not only there, compete in the development of this skill and strive to achieve the best possible results. A whole set of test tools was developed to compare them; I will mention one of them – the most well-known, the infamous international PISA (Programme for International Student Assessment) examination; OECD countries participate in it every 3 years; its aim is to measure and compare the level of this skill with 9-grade pupils in member countries. The test tool used to measure scientific literacy is the TIMSS (Trends in International Mathematics and Science Study) assessment; it focuses, among other things, on primary-school pupils, specifically on 4-grade pupils. It was used the published TIMSS tasks for 4-grade pupils as a test tool in this study – to find out the level of scientific literacy with 8-grade and 9-grade primary school pupils. The aim was to find out whether a test tool, which was primarily aimed at testing 4-grade primary school pupils, would also work with 8-grade and 9-grade pupils on the second level of primary schools.

1.1 Definitions of basic concepts

Scientific literacy is a term used since the 1950s to describe the scientific knowledge of broad public [1]; although almost 75 years have passed, its definition is still not unanimous; the term lacks a single universal definition. Scientific literacy encompasses a broad understanding of scientific concepts and processes, which enable individuals to make informed decisions, participate in social and cultural events and contribute to economic productivity [2]. Fives et al. [3] emphasized the changing and specific situation dependent nature of scientific literacy, including the ability to co-operate and communicate with others in the course of scientific work. Moreover, scientific literacy is not focused solely on individual's knowledge and skills, but also includes social and cultural aspects of science. It includes understanding of the nature of science, mutual relations between science and society and the ethical aspects of scientific work [4]. It encompasses the ability to critically assess scientific

information, participate in scientific discourse and apply scientific know-how in the real world [5]. Scientific literacy can be considered a social fundament enabling citizens to participate in social and economic development, cultivate innovative talents and better face complex global challenges [6]. The concept of scientific literacy has developed over time as a result of scientific, technological, social and political changes in contemporary societies [7]. In general, we can say that scientific literacy is a constantly changing and evolving understanding of science, which starts by learning natural sciences in both formal and informal educational environments and continues lifelong [8].
TIMSS (Trends in International Mathematics and Science Study) is a comparative testing carried out by the International Association for the Evaluation of Educational Achievement (IEA), which measures pupils' achievements in math and natural sciences in various countries [9]. The aim of TIMSS is to provide insights into educational systems of participating countries and assess the knowledge and skills of pupils in math and natural sciences [10].

1.2 Current stage of knowledge

Widyasari and Hermanto [11] carried out a study on the influence of cognitive abilities in problem-based learning on the ability – scientific literacy of 4-grade primary school pupils. The research discovered a significant positive influence of cognitive abilities on the ability – scientific literacy. This indicates that pupils' cognitive abilities play a crucial role in the development of their scientific literacy.
Akilli and Kutur [12] examined the correlation between the belief in own efficiency in relation to teaching natural sciences and the level of scientific literacy with primary school teachers. The research used structural equation modelling and found a significant positive correlation between the belief in own efficiency and the scientific literacy, similarly as Öztürk [13].
Several studies examined the relationship between gender and scientific literacy. Osborne et al. [14] carried out a summarizing study on attitudes to natural sciences and found out that gender plays a crucial role in forming attitudes to natural sciences. This finding is confirmed by Nurramadhani's [15] study, in which boys achieved better results than girls. The study by Akpinar et al. [16] came to the same conclusion. On the other hand, we can find studies which discovered no significant differences between girls and boys, which is confirmed, for example, in the work by Jia et al. [17].
Mullis et al. [18] reffered about not statistically significant difference between 4-grade boys and girls in 33 countries; in 18 instances girls achieved statistically more significant difference in the level of scientific literacy, in 7 instances (including the Czech Republic), boys were better than girls. With 8-grade pupils, girls achieved a statistically more important difference compared to boys in 15 instances; in 18 instances there was no statistically important difference between boys and girls; in 6 instances, boys achieved a statistically more important difference in the test of scientific literacy compared to girls.
The research aims were:
- to determine differences in the level of scientific literacy with regard to the relevant grade;
- to determine differences in the level of scientific literacy with regard to gender.

2 Methodology

2.1 Research sample

The total of 112 pupils from 3 primary schools selected from the schools available participated in the research. The pupils in the schools are educated without the use of alternative teaching methods; the learning is not focused in one particular direction. The questionnaire was completed by 53 (47.32 %) 8-grade pupils and 59 (52.68 %) 9-grade pupils. From the gender perspective, the research sample can be divided into 52 (46.43 %) girls and 60 (53.57 %) boys. The average age of respondents was 14.34 years.

2.2 Research tool

The research tool was designed from published TIMSS 2019 tasks aimed at the scientific literacy with 4-grade pupils [19]. The test tool consisted of 12 questions diversified according to their difficulty to 2 – 5, similarly as in the TIMSS test. I used 3 tasks in every category of difficulty. From the perspective of tested abilities, tasks in the research tool were divided as follows: 3 reasoning tasks, 4 knowledge demonstration tasks and 5 knowledge application tasks. The research tool intentionally used the tasks in which 4-grade Czech pupils were the least successful; the tool adhered to the rule that every category of difficulty used the same number of questions. The test tool consisted of both open and closed questions. In the evaluation of results, similarly as in the TIMSS test, correct answers received 1 point and incorrect or incomplete answers received 0 points. The test was distributed among pupils by the researchers and teachers. The pupils were assured about anonymity an it took nearly all teaching lesson.

2.3 Data Analysis

After the tests were acquired, the data were entered into MS Excel. In order to fulfil the secondary aims, the inductive statistical methods were used, specifically the Student's t-test for independent selections due to the fact that each variable included only two groups. This procedure was possible to find out in other studies like Capinding [20].

To determine internal consistency, the Cronbach's alpha (α) coefficient was used; its value was 0.71, which documents the overall internal consistency of the test in scientific literacy with regard to the number of items and the number of respondents. Reliability values were also determined for individual groups (with regard to exploratory factor analysis) as well as for groups of questions divided according to the examined ability. The reliability values are in Table 1. The values enable us to state that every dimension showed reliability, even if it achieved the limit according to the alpha value.

Table 1: Cronbach's alfa values for individual dimensions

Dimensions	Values of Cronbach's alpha
Dimension according to items difficulty	
Difficulty I	0.51
Difficulty II	0.53
Difficulty III	0.51
Difficulty IV	0.52
Dimension according to abilities	
Applying	0.53
Reasoning	0.51
Knowing	0.59

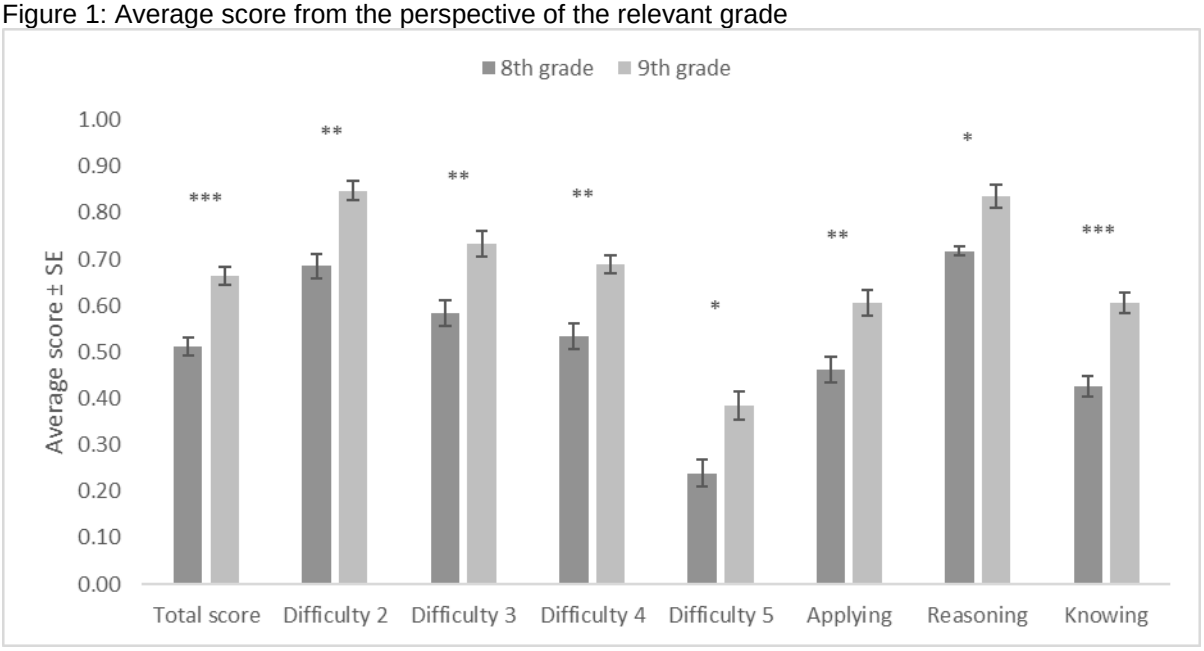
3 Results

The level of scientifici literacy was on moderate level (x = 0.59), when we focused on categories according difficulty and abilities, it was possible to observe some differences. The worst score was achieved in the most difficult category of the tasks and and also categories of tasks focused on applying and knowing were problematic for all pupils.

If we focused on the results of the scientific literacy test from the age perspective (or the relevant grade), we concluded that 9-grade pupils achieved statistically much better results in all test areas. Figure 2 makes it clear that the most important difference $p < 0.001$ in the favour of 9-grade pupils can be seen in the overall score of the scientific literacy test, where 9-grade pupils achieved 66 % success (51 % success with 8-grade pupils) and also in knowledge demonstration tasks, where 9-grade pupils achieved 61 % success whereas 8-grade pupils achieved 43 % success. As far as the average score with regard to the difficulty of individual tasks is concerned, 9-grade pupils also achieved a statistically more significant success in all instances. In the categories of difficulty 2 – 4 the value was $p < 0.01$. This section of the chart also makes it clear that both categories of pupils achieved the best results in the least difficult tasks; on the contrary, both groups were the least successful in the most difficult tasks.

From the perspective of tested abilities, pupils in both groups (8-grade and 9-grade) achieved the best results in reasoning tasks (based on TIMSS 2019). The success rate of 9-grade pupils in these tasks was 84 %, the success rate of 8-grade pupils was 72 %, $p < 0.05$. In knowledge application tasks and knowledge demonstration tasks, 9-grade pupils shoved the same success rate of 61 %. In the category of knowledge application questions, the statistically significant difference was $p < 0.01$, also in favour of 9-grade pupils. In the knowledge demonstration category of questions, the difference was statistically the most significant, $p < 0.001$ (figure 1).

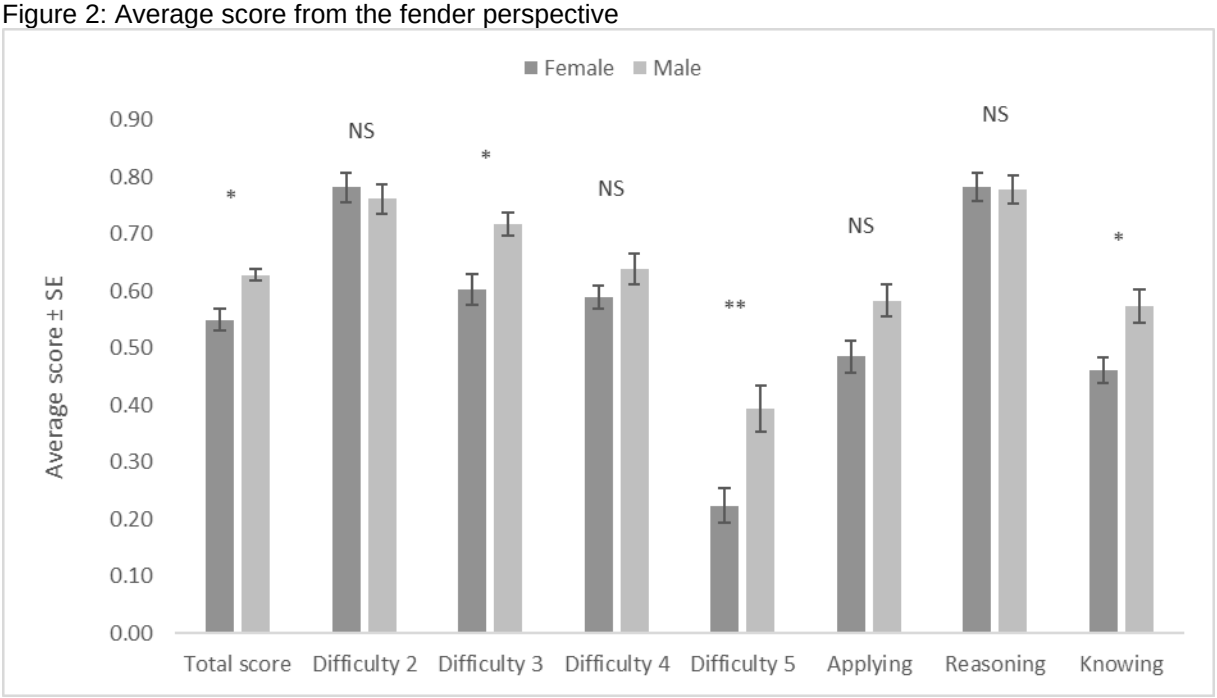
Figure 1: Average score from the perspective of the relevant grade



* p < 0.05, ** p < 0.01, *** p < 0.001

If we focus on all characteristic monitored in the test, which we mentioned above with regard to gender (figure 2), we come to the conclusion that in 4 instances there were no statistically significant differences in the success rates of boys and girls, specifically in questions in difficulty categories 2 and 4, and also in reasoning questions and knowledge application questions. On the contrary, the biggest statistically significant difference p < 0.01 was in favour of boys in the most difficult questions. The boys' success rate in these questions was 39 % compared to 22 % with girls. From the perspective of the overall score, again the statistically significant difference p < 0.05 was in favour of boys, also in questions in the difficulty category 3 and knowledge demonstration questions.

Figure 2: Average score from the fender perspective



NS – non-significant difference, * p < 0.05, ** p < 0.01

4 Discussion

The level of scientific literacy achieved moderate level, it could be caused by the relatively lower level of scientific lessons in the primary schools. Also it could be caused by the teaching style of teachers

on first and second level of primary schools. The memorization style of teaching is predominant in many schools, so it could be reason, why the tasks focused on the applying and also knowing are problematic for the pupils. Pupils are probably not able to solve tasks, where they should connect knowledge from various topics and also from different subjects. In this place it is important to say, that concept of gamification has got a significant effect on the level of scientific literacy. As authors quoted the using of computers and games could increase the level of scientific literacy among pupils of all age [18, 19]. As [18] wrote, the pupils were able to understand also abstract topics as nanotechnology are, by the using of games. On the basis of these facts, it is possible to say, that the level of scientific literacy is possible to improve by the using of tools, methods, forms or techniques, which could increase the level of understanding and motivation toward any of scientific subjects. The scientific literacy, as it was mentioned in many studies and also in this text, is an important concept for the future life and career of the pupils. The teachers and also researchers are trying to think and use different methods, forms and tools, which could be helpful for the better understanding of the scientific complex. Before the application of these activities, it is important to find out the level of scientific literacy among every age cohort of pupils.

From the gender perspective, boys achieved better results than girls in general, which is confirmed by the results of the TIMSS 2019 assessment - Czech boys were truly more successful than girls in the scientific literacy tests [20]; this trend is also obvious in PISA tests, however, only when compared to the results of 4-grade pupils, because 8-grade pupils did not participate in the TIMSS 2019 assessment. The PISA 2018 survey found that in scientific literacy, girls in OECD countries achieve slightly better results (by two points) on average; the results of Czech girls and boys are similar. As already mentioned above, in the international comparison of 4-grade and 8-grade pupils, boys had statistically much better results than girls in a lower number of instances [20]. In USA and other 21 educational systems, no significant differences in average results between 8-grade boys and girls in natural sciences were found in 2019. However, significant differences in results between boys and girls, most often in favour of girls, were found in 24 educational. On average, girls exceeded boys in natural sciences by two points in OECD countries and the Czech Republic; approximately in half of OECD countries, girls were better than boys. According to Tomasek et al. [21], boys were generally more successful in the knowledge demonstration category – they achieved significantly better results than girls in 13 countries. Girls were not better in either country. This finding was also confirmed in our research – boys were better than girls in this category. In the knowledge application category, the results of boys and girls are equal. Here, the results of this research also conform to this finding. Girls only achieved better results in 3 countries; on the contrary, boys were more successful in 2 countries. Furthermore, as discovered by Tomasek et al. [21], girls were more successful in reasoning tasks on general – they had statistically much better results in 9 countries; this was not confirmed in our research. When assessing scientific literacy with regard to gender, we can observe a trend where girls achieve a higher score than boys, provided that we take into account primary schools. The aforesaid results can be found in researches of the following researchers: Shazhaadi and Nasreen [23] or Yuliana et al. [24]. The reason for the differences can be found in the research tool used. Certain research tools put more focus on biology, other on chemistry or physics. This may result in differences between boys and girls.

Another variable monitored in the research was the relevant grade; although we focused on close age groups, we could observe differences in results. 9-grade pupils achieved a higher score – this could also be observed in individual dimensions. Similar results can be found in other researches as well, such as Turiman et al. [25]. We did not want to mention the studies confirming this finding, but it is generally known and confirmed that older pupils achieve better results than younger pupils. The reason for it is obvious and foreseeable – older pupils have more knowledge, experience and skills, therefore they regularly achieve higher score. Within the scope of the research, we need to stress the fact that the research only focused on the last two grades of primary schools. It is because this is a methodological study; in further research, we will take into account all grades in primary schools, so than we can identify the turning points in scientific literacy. This variable was also mentioned in other studies. For example [26] found out that digitalisation of achievement process had got a positive effect on the level of scientific reasoning, which is the inseparable part of the scientific literacy. On the basis of this, it is possible to say, that process of digitalization of learning an detaching could improve the level of scientific literacy.

5 Conclusion

The preliminary results showed the moderate level of scientific literacy among primary school pupils. The older pupils achieved higher score in comparison with younger ones, but it did not mean, that the level of their scientific literacy is sufficient. In some categories, also older pupils, achieved insufficient

level of scientific literacy, in the most difficult tasks used in the test and also tasks focused on knowing and applying were problematic as for younger even for older pupils. The similar trend is possible to observe in the gender, where in majority of categories boys achieved higher score, the problematic categories were similar as in grade variable.
On the basis of the findings is possible to suggest some implications to pedagogical practice, some of them could be focus on the application tasks, which are the most problematic for the pupils in every grade of study and also this trend was possible to find in gender variable. The pupils had got also problems with the tasks, which were more difficult- All these aspects could be caused by relatively lower interest in scientific subjects by the pupils in the all levels of education. This effect is probably caused by the predominant style of teaching, which is in many topics focused on memorizing without any aspects of applying and reasoning. This is connected also with the preparation of future teachers, where the modern aspect of teaching behaviour is not applicated in many cases. The further research will show the actual level of scientific literacy among primary school pupils, where the number of sample size will be higher and other variables, which could influence the level of scientific literacy will be take into consideration.

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