JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898

ENVIRONMENTAL IMPACT ON LEARNING OUTCOMES IN SCIENCE EDUCATION IN SLOVENIAN PRIMARY SCHOOLS THROUGH THE ANALYSIS OF MATERIAL WORK CONDITIONS

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Abstract. *The study deals with material support for practical work in science classes in Slovenian primary schools (grades 1-5). It answers the question of why there are differences in national tests in terms of socio-economic development of the environment, despite the fact that schools are equally well equipped. There are two groups of teachers: in less-developed regions (N=337) and in more-developed regions (N=160) – the criterion is the "the development risk index." Material research equipment in Slovenian schools is poor. Socioeconomic development does not affect the perception of problems such as: the lack of materials and equipment, oversized groups, poor spatial conditions, and the absence of an assistant. Equipment is provided by schools, while material is brought by the pupils themselves. Comparison has shown that students in more developed environments bring their own material more frequently, which enables more research activities. It was concluded that despite the fact that the material conditions in all Slovenian schools are similar, there are differences in the development level of inquiry skills. In more-developed regions, students compensate the lack of material by providing aids from their home environment.*

Key words: *environmental impact, material conditions, practical work, primary school, science teacher*

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Introduction

Teaching science emphasizes the active role of the learner. The teaching and learning process focuses on gaining science knowledge independently and doing experimental work independently, which has an extremely motivating role. In most curricula, science education focuses on developing and broadening basic science and technical knowledge, skills, and points of view (Dow, 2006). Teaching a class enables students to use their scientific and technical knowledge and skills to understand, interpret, and solve different situations and issues in the field of science and technology.

Numerous international authors highlight the high importance of practical work in research-based learning (e.g., Monk & Osborne, 2000; Peters & Stout, 2002; Bennett, 2003; Murphy & Beggs, 2005; Duschl & Schwingruber & Shouse, 2007; Taber, 2007; Duschl & Schwingruber & Shouse, 2007; Osborne & Dillon, 2010), emphasizing that students with practical work implement a number of areas: socialization, acquisition of scientific language, as well as the use of scientific methods and aids.

Studies (e.g., Pell & Jarvis, 2001; Bennett, 2003; Bilgin, 2006) in the area of pupils' attitude towards science classes (Gibson, 2009) have shown a strong correlation between a positive attitude and the satisfaction with natural sciences and technology as a whole as well as practical work. So far, we have not had any cases where pupils could choose between different learning resources depending on their learning style (Hill & Smith, 2005), including the material for practical work.

Teacher support materials consist of three categories: (1) textbooks, workbooks, (2) teachers' book and other resources, and (3) material in the sense of the following two concepts: matter and object (Chatoney, 2006). Teacher's books should also serve as a collection of ideas for research activities (Appleton, 2002). Many international researchers (e.g., Kelly & Brown & Crawford, 2000; Palmer, 2006; Taber, 2009;) stress that the available teaching material should support research-based teaching and learning strategies only for those teachers who are generally highly qualified for the course, and vice versa (Hipkins & Barker, 2005).

Additional studies (Kruger & Summers, 2000; Appleton, 2002; Hunt & Appleton, 2003) highlight the need for professional training following changes of curricula and the introduction of new teacher's books, textbooks, and aids. Several studies (e.g., Appleton, 2002; Appleton & Asoko, 1996; Paecock & Gates, 2000; Newton, LD & Newton, DP & Blake & Brown, 2002) mention the teacher's autonomy in choosing the material for teaching science in lower grades. The importance of preparing future teachers for the research approach (Bencze, 2010) is stressed, whereby the importance of practical work and research-oriented students' environment is emphasized (Taber, 2007; Dilon & Osborne, 2010). In their study, Duschl, Schwingruber, and Shouse (2007) emphasize the teacher's role and importance in the organization of research, especially in the experimental part. It is the teacher who selects the research problems, materials, and aids. They are also responsible for the course. The authors emphasize the teacher's accountability and autonomy in relation to the organization of research.

The concept of material in the context of teaching science has a broad meaning. Chatoney (2006) uses three components to explain the concept: (1) books (2) teacher's books and resources, (3) alternative literature for children. Teacher's resources (teacher's books, teaching aids, resources, and other equipment) may differ according to their extent and type. It could be a collection of various materials in a broad sense (books, aids, resources). Research has shown (Watters & Ginns, 1997) that sets are less useful for new teachers, and much more for teachers with some experience. The usefulness of resources increases significantly if the teacher completed the appropriate additional training and courses (Appleton, 2002).

In Slovenia, kits which can be used in addition to textbooks, workbooks, and materials, are not in use. Schools and teachers themselves provide material for experimental work. Several studies (e.g., Kruger & Summers, 2000; Appleton, 2003, Hunt & Appleton, 2003) emphasize that the result of the use of teacher resources depends heavily on the level of professional training.

Numerous foreign publishers provide science kits that include material, as outlined in the teacher's guide. Material such as Science for Children (National Science Resources Center, 2002) also brings a number of didactic and methodical ideas for teachers and other sources of knowledge (Kimble, 2006).

In their study, Machin and McNally (2011) show that a number of previous studies highlighted the modest impact of physical equipment on educational achievements. Another study (Gibbons & McNally & Viarengo, 2011) reports that there is a strong influence of the material equipment on the students' achievements. The report The Evaluation of Education Policies (2011), presents the connection between schools that devote more resources to physical teaching aids and learning achievements. This study emphasizes that the availability level of equipment is very important for the group of students, which has no appropriate incentives in the home environment, and such gaps can thus be replaced at school.

Problem of Research

Science is taught in Slovenian primary schools (grades 1-5) for two consecutive school years (ages 9 to 11). It serves as the follow-up to the course Environmental Education from the first educational period (ages 5 to 8). Science classes continue with the Technical Sciences and Technology course in grades 6, 7, and 8, Natural Sciences in grades 6 and 7, as well as Biology, Chemistry and Physics in grades 8 and 9.

The true modernization of teaching science at the primary level in Slovenia did not begin until the 1990's with the "Early Science Education" Tempus project. The last major reform of the Slovenian education system with the introduction of the nine-year school program (1999-2009) generated new curricula. The introduction of new curricula in the context of the introduction of the nine-year primary school should lead to more procedural knowledge, investigative approach of students, and (practical) experimental work.

Science activities are based on: (1) experimental work, (2) project work (laboratory, field research), (3) working with models, and (4) the use of information resources. Practical experience shows that the professional development of teachers was not sufficiently emphasized. Similar to any other post-socialist countries (Kask & Rannikmäe, 2006), there is a deficit in teacher education in Slovenia. In science, for example, there is the prevailing opinion that teachers can achieve the same results by merely demonstrating experiments or providing photographs of practical work.

Differences in the equipment availability in Slovenian primary schools (about 450) are almost absent because of the financing of all schools by the government. For this reason, it is considered that that all students in Slovenia have equal conditions for learning. Differences between urban and rural schools are also not detected. Sinclair & Naizer & Ledbetter, 2011, report that in the U. S. there are large differences in equipment availability between urban and rural and between large and small schools due to the local funding system. Slovenian schools are generally ill-equipped; lots of tools are useless and storage facilities are inadequate.

The curriculum change (1999–2009) should prioritize research-oriented learning in science classes. There are no thorough analyses of the change in the curriculum. However, national tests are being carried out that show large differences in performance between the more developed Western Cohesive Regions and less developed Eastern Cohesive Region. The development risk index in Eastern Slovenia is higher (127.00) than in Western Slovenia (73.00) (Operative program for strengthening regional development potential for 2007-2013).

No research about the reasons for the differences in learning outcomes in science classes has been done. We are therefore interested in discovering why there are differences in knowledge considering that the rate of practical work in all Slovenian schools is similar, taking into account the scope of material support.

Methodology of Research

General Background of Research

A survey was carried out. This is the most common form of pedagogical research for obtaining information from a large group of people about their opinion, characteristics, and attitudes. Moreover, it allows the determination of existing situations or their features (Fraenkel and Wallen, 2005).

In the empirical part, answers to the question of why there are differences in national examination results in the field of science between developed and less-developed parts of the country despite the same equipment availability in schools were provided. Science teachers (N = 497) were asked the following questions:

– What are some problems in practical (hands-on) work in teaching science?
– How is material support for practical work in lower grades provided?
– Who is responsible for the material?
– Where are the material and tools for experimental work most commonly kept?

In this study, a number of other factors for the practical work, obstacles, and team approach are examined. The results serve as a starting point for the systematic provision of material support, while professional training.

Sample of Research

The survey was conducted among 497 4th and 5th grade primary school science teachers, which represents 24% of all primary school science teachers in Slovenia. According to the Statistical Office of the Republic of Slovenia there was a total of 2074 4th and 5th grade class units in the 2009/10 school year, which represents the total number of science teachers. The study included two groups of teachers. The first group consists of teachers from the more developed regions (N = 160). The second group (N = 337) consists of teachers from the less developed part of the country. In order to indicate the economic and social development of the environment, objective regional development risk indicators of the two cohesive regions (Eastern Slovenia, Western Slovenia) were used (The Classification of Territorial Units for Statistics, NUTS 2, 2007). Eastern Slovenia's regional development risk index was higher (127.00) than in Western Slovenia (73.00). The regional development risk index is comprised of the following: gross domestic product per resident, gross added value per employee, gross income tax basis per resident and the number of work places per number of active population, population aging index, registered unemployment level and employment level, average number of years of education, development of communal infrastructure, area share, and inhabitation indicator.

The average age of teachers is 41. On average, their length of service is 19 years as primary school teachers.

Instruments and Procedures

Data were collected through a questionnaire handed out in 2010. The questionnaire for teachers included closed questions. The teachers´ responses concerning the intensity of problems in the implementation of experimental work in science were based on a 4-point scale: low level = 1, medium level = 2, high level = 3, the highest level = 4. Teachers´ responses concerning the frequency of offering material and equipment for experimental work in science were based on a 4-point scale: never = 1, sometimes = 2, often = 3; always = 4. The questionnaire was created in accordance with the following measurement characteristics:

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Validity is based on the rational assessment of the test questionnaire made by experts for content-and-format related properties (Institute of Education and Faculty of Education). The next test survey was carried out on the sample of 46 teachers from the Savinjska region.

Reliability – When drawing up the questionnaire the reliability was provided with precise and unambiguous instructions, single-meaning specific questions.

Objectivity – objectivity at the implementation phase was ensured with unified, unambiguous instructions that the teachers followed individually, while filling out the questionnaire. Objectivity at the surveying phase was ensured by using scaled answers that exclude the possibility that subjective judgment would change information.

Data Analysis

The data were processed at the level of descriptive statistics: number (N) and percentage (%), Mean ($\bar{x}$), standard deviation (SD), the Mann-Whitney test for verifying differences between the individual points of view of teachers in relation to economic and social development of the environment (cohesive region) and a t-test for independent samples for verifying differences between the means of differences between teachers in the overall result of the measurement of obstacles, according to the development of the region.

Results of Research

As a starting point, the results of the most common problems in teaching science are dealt with. (Table 1)

Table 1. The means ($\bar{x}$) of teachers concerning the intensity of problems in the implementation of the experimental work in science.

Problem	Average rating of the intensity of problems (a low level = 1, a medium level = 2, a high level = 3, the highest level = 4) $\bar{x}$	Standard deviation (SD)
Lack of material	3.304	0.843
Lack of accessories and equipment	3.295	0.956
Maintenance of accessories and materials (collecting, sorting, refurbishing, cleaning...)	3.292	1.053
Providing facilities	2.962	1.166
Oversize groups of pupils	2.953	1.056
Working conditions for the storage of equipment	2.923	0.909
Total	3.122	1.091

Lack of material ($\bar{x}$ = 3.304, SD = 0.843) is the most notable of all the problems. It is followed by the lack of aids and equipment ($\bar{x}$ = 3.295, SD = 0.956), and maintenance of the material and teaching aids (collecting, sorting, cleaning, refurbishing ...) ($\bar{x}$ = 3.292, SD = 1.053). Three difficulties, which are represented somewhat equally, are the following; poor spatial conditions in the classroom ($\bar{x}$ = 2.962, SD = 1.166), oversized groups of pupils ($\bar{x}$ = 2.953, SD = 1.056) and poor spatial conditions for storing material and aids ($\bar{x}$ = 2.923, SD = 0.909).

Table 2. Results of t-test of differences between teachers in the overall result of the measurement of obstacles (lack of material, lack of aids and equipment), according to the development of the region.

Region	N	Mean $\bar{x}$	Standard deviation SD	Test of homogeneity of variances		Test of differences between Means	
				F	p	t	p
More developed	160	6.456	1.718	4.681	0.067	1.164	0.281
Less developed	337	6.563	1.424				

The assumption of homogeneity of variances is justified (F = 4.681, p = 0.067), so we refer to the usual t-test (F = 1.164, p = 0.281). It can be said that, among the teachers, there are no statistically significant differences in the intensity of experiencing the problems (lack of material, lack of aids and equipment) in relation to the development of the environment. In schools, teachers are experiencing similar obstacles, regardless of the economic and cultural development of environment.

Table 3. Number and percentage of the group of teachers as a whole in the way of ensuring the material and equipment for experimental work in science.

The way of providing material and equipment for experimental work			Always = 4	Often = 3	Sometimes = 2	Never = 1	$\bar{x}$
Material	Provided by students themselves	N	40	221	188	48	2.5091
		%	8.00	45.5	37.8	9.7	
	Obtained at school	N	12	43	215	191	2.1903
		%	2.4	8.7	43,3	38.4	
Tools	Obtained at school	N	60	206	219	12	2.6318
		%	12.1	41.4	44.1	2.4	
	Brought by students themselves	N	2	16	202	263	1.4969
		%	0.4	3.3	41.8	54.5	

About half of the teachers (53.5%) said that they largely (always, often) receive aid for experimental work in school ($\bar{x}$ = 2.6318). The percentage of those (44.1%) who only occasionally receive aid in school is also similar. As illustrated by shunting type, students quite often (45.5%) bring material for experimenting by themselves ($\bar{x}$ = 2.5091). For example, they bring a balloon, a straw, a rubber band, a plastic bottle, string, etc. There is also a large percentage of teachers (37.8%) who stated that students occasionally or sometimes provide the material.

Only 40 or 8.0 % of respondents responded that students always bring material for experimenting themselves. The experience that the material for experimentation is rarely available at school ($\bar{x}$ = 2.1903) dominated among teachers who filled out the questionnaire. 38.4% of the teachers chose to answer "never" to the question "How often do you get the material for experimentation at school?" 43.4% chose the answer "sometimes." Students sometimes (41.8%) or never (54.5%) bring aids for experimenting.

In summary, the results of our research show that about half of the schools always provide aids for experimental work, but the material is largely brought by the pupils themselves.

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Table 4. The results of the Mann-Whitney (M-W) test of the differences between teachers answering the question of how often they get material for experimentation at school, according to the development level of the environment.

Region	N	$\overline{R}$	The M-W test result	
			$\lvert Z \rvert$	p
More developed	160	228.22	-2.392	0.017
Less developed	337	256.74		
Total	497			

The results of the applied non-parametric test show that there is a statistically significant difference between the teachers of each region depending on how often the material for the experiments is received at school (Z = -2.392, p = 0.017). In less developed regions, material for experimentation is often obtained at school. Students from developed regions often bring material for experimenting themselves. Therefore, it may be concluded that the development of the environment affects the amount of practical work in science classes. Students in the more developed part experiment more and develop their knowledge through research. Such knowledge is of better quality.

Table 5. Number and percentage of teachers' response to the question of where the material and tools for experimental work are most commonly kept.

Room for storage of materials and equipment for experimental work	N	%
Registration classroom	305	61.4
Office for grades 1-5	113	22.7
Office or specialized classroom for grades 6-9	79	15.9
Total	497	100

More than half of class teachers (61.4%) keep material and tools for experimentation in science in their classrooms, 22.7% of the teachers who filled out the questionnaire mentioned the office for grades 1-5, and a minimum of those questioned (15.9%) reported that they keep material and tools for experimental work in specialized labs for grades 6-9 or in the office of Chemistry, Biology and Physics.

This information would be encouraging if the school had sufficient materials and tools in order for each classroom for grades 1-5 to be equipped with several types of scales, magnifying glasses, microscopes, stopwatches, cookers, electric circuits, magnets, etc. This raises the question of rationalization in the provision of aids and materials. Considering that each teacher keeps tools and materials in the classroom, there is a small possibility of borrowing. A team approach would enable a more effective organization of material support. In this case, all tools and material would be kept together in one room. Finally, by sharing aids, it is easier to ensure the quality of material support (collection, preparation, recovery, sorting, cleaning, etc.) which is a great relief for the teacher. Having such organization reduces the costs of the school. Aids and materials are in fact frequently used and require a fewer number of items. This shows the great practical importance of the office for teaching science in grades 1-5, and of course of the need for teamwork.

Table 6. Number and percentage of teachers' response to the question of who is largely responsible for the material and aids for experimental work at school.

A person responsible for the material and aids for experimental work	N	%
Science teacher	419	84.3
Primary school Physics, Chemistry, and Biology teacher	49	9.9
A team of teachers	26	5.2
A laboratory assistant	3	0.6
Total	497	100

The table shows that the majority of primary school teachers (84.3%) who teach science classes in the fourth or fifth grade are responsible for providing material and aids themselves. Only 10% of teachers responded that the material and aids are provided by primary school science teachers. 5.2% of teachers responded that a team of primary school teachers or one of the primary school teachers provides material and aids. Only 0.6% of the teachers stated that the laboratory assistant also provides material for experimentation in grades 1-5).

The data is not encouraging. It can be concluded that there is a lack of teamwork among primary school teachers in grades 1-5. Most of them make collections for experimental work themselves. So, it can be reasonably concluded that the exchange of materials and aids within individual schools is rather modest. On the other hand, the role of a laboratory assistant cannot be ignored. Although the working position of the laboratory assistant is legally systematic for the teaching of science subjects in the 6^{th}, 7^{th}, 8^{th}, and 9th grade, the school may, in its autonomy and flexibility, with internal redeployment, transfer obligations for the preparation of experimental work in grades 1-5 to the laboratory assistant. The laboratory assistant should therefore, assume certain responsibilities for grades 1-5.

Discussion

With the introduction of the nine-year primary school in Slovenia (1999-2009), the focus shifted to the research approach also in teaching science in grades 1-5. As our research shows, Slovenian teachers very strongly experience the lack in the area of material support for teaching science (8-10 years). Most of them expressed that there is a lack of materials, aids, and other equipment, which could be one reason for the limited use of research activities in the classroom (Mork, 2005). Based on this, it can be concluded that there is not much exploratory learning in science. The change of the curriculum (1999-2009) did not result in different teaching approaches. When comparing the two groups of teachers (from more developed and less developed regions), it was discovered that the teachers experience difficulties similarly, regardless of the development of environment, which is surprising. Therefore, the development of the environment does not affect the perception of problems.

It should be noted that the equipment in all Slovenian schools is similar due to government funding. On the other hand, in connection with material support and the economic and social development situation of the environment, the reasons for the large differences in learning outcomes on national tests between the less developed Western region and the more developed Eastern region was explored. It was discovered that the equipment is largely provided by schools and that the material for experimentation is mainly provided by the pupils themselves.

The results show a statistically significant difference between the two groups. Students from more developed regions often bring material for experimenting themselves. From this we can conclude that the development of the environment affects the amount of practical work in teaching science and indirect learning outcomes. Students from more developed parts of the country experiment more and develop knowledge through research. Such knowledge is of better quality. Of course, it is inappropriate for teachers to rely on students in the organization of practical work. Some students forget, while others simply do not bring material. Although the government is trying to bridge the differences in the development of the environment by providing the same physical equipment for all schools, differences remain and they are reflected in the level of knowledge.

In grades 1-5, most teachers keep the material and aids for experimentation in the classroom which is not good. For a better arrangement keeping of the material should be regulated in the Office of Science. Most science teachers provide materials and aids themselves. A team approach is the exception rather than the rule. Assignments for primary level are rarely performed by laboratory assistants.

In any case, material support for teaching science is important, particularly with regard to the selection of appropriate methods, but not critical to the achievement of quality objectives (Wilson & Harris, 2003). As the findings of most European studies show (Dow, 2006), it is necessary to change the curriculum (in Slovenia, with the introduction of a nine-year primary school), train teachers previously in all three areas: (A) Subject Matter Knowledge (SMK), (B) Pedagogical Content Knowledge (PCK), and (C) Attitude (Parkinson, 2001, Davis et al. 2002).

The introduction of changes in the teaching of science in grades 1-5 should not be oriented only towards creating scientific knowledge and skills, but also towards changing teachers' attitudes towards learning and teaching and conceptions of knowledge. It is assumed that the recent large-scale school reform in Slovenia has not brought the desired results in the field of science.

Conclusions

It can be concluded that supporting material impact learning outcomes. Poor material conditions are generally offset from the students' home environment, which is related to the economic and social development situation. There are differences in learning outcomes which are the result of exploratory learning. The government funding of schools did not bridge the differences in material support. Research findings also provide a platform for the creation of a scientific centre that would provide high-quality material support for carrying out practical work in teaching science in conjunction with professional training. The study also raises dilemmas about the impact of the environment on learning outcomes in science, which would be interesting to examine with the international study in other countries where there are differences in economic development between regions and to ask how to bridge these gaps.

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Received: *March 02, 2014* Accepted: *June 18, 2014*

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