THE CHEMISTRY COMPONENT OF NATURAL SCIENCE EDUCATION IN PRIMARY AND BASIC SCHOOL: SOME MAJOR ISSUES[1)]

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Abstract. Many researches of last years specify necessity of perfection of natural science education at all levels of an education system and especially at a level of a primary and basic school. The main accent of process of natural science education in a primary school should become a different sort of researches and experiments. The weak interest of the youth to natural sciences, and especially – to chemistry, is one of the most acute problems of the present education. There are many reasons for this unflavored situation is amongst these is the insufficient attention to a component of chemistry in the content of a primary education. For the period of primary school pupils does not receive the basic initial knowledge in chemistry and research skills. On the other hand, teachers of primary classes are not prepared at a sufficient level in sphere of modern natural science education. At the basic school fastening knowledge and skills in the chemistry, received in a primary school proceeds. It is very important, that before studying chemistry as an independent subject, students have received adequate representation about the basic phenomena of the nature. The integrated course of natural science subjects should promote it. In this article results of research in which students of the fourth and eight/ninth forms have taken part are presented. Students should explain such phenomena as diffusion, dissolution, condensation, evaporation, burning and others. The assumption is done that students have propaedeutic knowledge and are capable to give the explanation, as they understand the given phenomena. On the other hand, in the program of a primary school some themes in chemistry are stipulated. In this aspect the given research shows natural science literacy of students of a primary school. Research puts forward a thorny question – how to guarantee development of knowledge and skills in chemistry at the basic school.

Keywords: primary school, basic school, chemistry education, chemical phenomena

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Introduction

Teaching chemistry faces problems in the majority of countries. The investigations reveal that chemistry is one of the most complex and boring subjects in comprehensive school (Donelly et al., 1988; Gedrovics et al., 2006; Seetso & Taiwo, 2005; Takeuchi, 2002; Ковалева, 1993; Ламанаускас & Гедровицс, 2004). For example, some researchers agree that primary and secondary school science education in Japan, which once had a reputation that was recognized worldwide, has lost its past excellence due primarily to continual reductions in teaching material content and school hours (Takeuchi, 2002). The author addresses a key question – *How to Reactivate Primary and Secondary Natural Science Education in Japan?* The situation is determined by different reasons. The international ROSE research disclosed that the youth was not engaged in natural sciences and found them boring. This study highlighted the trans-cultural differences in terms of the position on natural sciences. It can be maintained that an attitude towards learning chemistry at school is formed by various factors. The problems cannot be addressed only to the process of teaching chemistry. An evaluation of what propaedeutic knowledge of chemistry the schoolchildren obtain in primary school should be made. The component of chemistry formed at school is considered to be a complex question. One of the subject matter versions is inclusion of the most principal topics integrating them into the whole natural science education content of primary school (Ламанаускас, 2005). Foreign countries have also increased their interest in the above introduced and discussed issues, for example, the Pilot Project: Chemistry for Primary Schools is running in Finland.[2)] The purpose of the R&D –pilot project is to find out how the primary school pupils explain some concepts of chemistry Special manual on teaching chemistry in primary school has been recently published (Rees & Osborne, 2000). This book consists of three main parts: A) Grouping and Classifying Materials; B) Changing Materials; C) Separating Mixtures of Materials. Firstly the book introduces research and scientific activity as well as presents chemistry as a branch of natural sciences. Such publications are supposed to be highly important to both – a learner, and a teacher. The primary school teachers frequently show lack of competence in the field of natural science education. Suitable training aids and resources for learning as well as teacher training in the field of natural science education are the crucial factors in order to reach yet in primary school the learners could be familiar with the most common substances and would be able to understand changes and numerous natural phenomena. This pilot research focuses on how primary school-leavers (10–11 years old) understand such everyday phenomena as the influence of temperature on the movement of particles (diffusion), evaporation and condensation, material melting, combustion, air expansion and reduction caused by the change in temperature conditions. The propaedeutic knowledge is just the ground for successful studying natural sciences in basic school.

The focal point is that the succession of natural science education in basic school must be ensured. Natural science education in Lithuanian primary school yet does not agree neither with the requirements for the educational standards nor with the international trends. Therefore, we must intensify the efforts to make natural science education in basic school more effective. Due to the huge amount of specific information natural sciences are very hard to be mastered. Chemistry is one of the most difficult subjects for comprehensive school learners. Thus, while learning chemistry, first, definitions and the meanings of symbols and second, formulae and equations need to be learned. Finally, on the basis of the studied material, the tasks must be accomplished. However, learning concepts is boring as frequently they need to be drilled to keep them clear in mind. In this case, one of the crucial issues is to ensure that the concepts of physics/chemistry should be firmly mastered and correctly interpreted. In 2002, a thesis entitled Complementary Chemistry Teaching in Comprehensive School as Pedagogical Phenomenon (Kurienė, 2002) was presented. This study puts emphasis on complementary, attractive forms of teaching/learning chemistry to increase the learners' interest in the subject. The thesis compares the test results achieved by the pupils, participants of chemistry competition and those who did not attend any contests. The findings indicate that complementary teaching of chemistry which is less academic but more compatible with the students' interests determines better learners' abilities to conduct different mental operations (conclusion, comparison, systematization). On the other hand, although natural science education in forms 5 and 6 of Lithuanian comprehensive school is integrated (a course *Human and Nature*), the pupils' knowledge obtained in primary school most frequently is not properly broadened in basic school.

Geography is started to be taught in form 6, physics as a single subject – in form 7, chemistry – in form 8. In 2003, national research on the fourth and eight-formers' achievements was carried out in Lithuania.[3]) Depending on the sex of the surveyed participants, the investigation revealed rather significant deviations – the girls and boys' learning conditions were not exactly equal. According to testing results, the boys and girls achievements on natural sciences are similar. Nevertheless, the average boys' term evaluations of chemistry, physics and biology are marked 1 point lower.

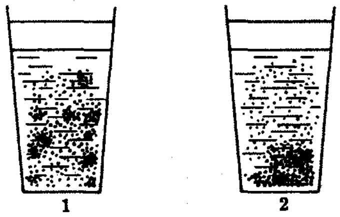
For more than the last two decades, Western countries have tried to advance teaching techniques of natural sciences and suggest using a constructive system[4]) instead of didactical one (Zoller et al., 1997). However, in general, there is little research on the secondary school learners' achievements, motivation for learning chemistry and the peculiarities of concept and phenomenon perception. The object of the present study is the fourth, eighth and ninth-formers' ability to perceive physical/chemical phenomena. The purpose of research is to find out how the primary and basic school learners understand and interpret such phenomena as: diffusion, water evaporation and condensation, air expansion and reduction, combustion and melting.

Research Methodology

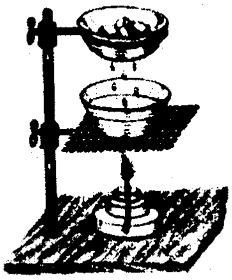
Research was carried out in April-May, 2006. The fourth-formers of Љiauliai comprehensive schools participated in the survey. Concerning the format of the pilot research, the survey sample was limited. 110 learners representing 4 schools of Љiauliai were involved in research. In September, additional research using the same methodology was conducted in four schools in Љiauliai and involved the eighth and ninth-formers. One of the schools was gymnasium the students in which were the ninth-formers from various schools of the city. Thus, the sample was more representative. Hypothetically, knowledge of the learners of all three age groups should differ. The eighth-formers started studying physics in form 7, geography – in form 6. In forms 5 and 6, they were taught an integrated course *Human and Nature*. Apart from the above mentioned subjects, the ninth-formers had been learning chemistry for one year. 224 pupils – 108 eighth-formers (50 girls and 58 boys) and 114 ninth-formers (66 girls and 48 boys) were involved in the survey. Such sample complies with capacity requirements for the pilot research.

The respondents were given five tasks to be carried out:

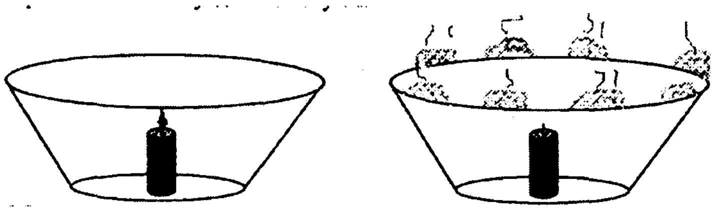
Task 1. *Two glasses of a similar size are filled with an equal amount of water. One of the glasses contain warm, the other one – cold water. A portion of a paint substance is added to both glasses. Look at the picture and find out the glass with cold water.*



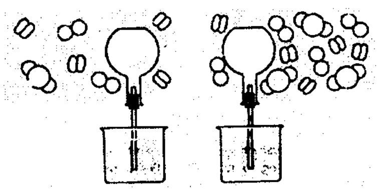
Task 2. *The stand takes two containers. The underneath container is filled with liquid water and is heated from the below (a light-bulb is used). The topside one is a plate with the ice cubes. What processes are taking place?*



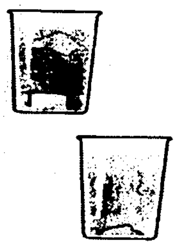
Task 3. *A candle was lighted and placed into the large open container (picture on the left). The candle was brightly burning. Thereafter, a cotton-wool ring was placed around the edge of the container (picture on the right). The cotton-wool was fired and in a few seconds the candle went out. Explain the reasons for the burning out process.*



Task 4. *A flask with a tube is fixed inside the glass filled with water (picture on the left). What process is taking place? The flask is warmed up using palms. What process is taking place? Why do the bubbles 'escape' through the glass tube? Later, a piece of cold wet cloth is placed on the flask (picture on the right). The water starts rising in the tube. Explain all occurring phenomena?*



Task 5. *A sugar cube is placed inside the glass filled with water. For a moment, the sugar cube can be clearly seen but later disappears. Explain the process. Name the phenomenon.*



When dealing with Task 1, the learners should explain that in this case, a spontaneous blend of the elements of the paint substance occurs. The substance elements move faster in warm water rather than in cold one.

When discussing Task 2, the participants should understand that water evaporates when heating and water vapour rises. When the cold bottom of the topside plate is reached, vapour condensates, the drops of water form and fall down. The pupils should also draw an analogy between a real cycle of water circulation and the above introduced experiment imitating similar cycle.

When interpreting Task 3, the students should realise that the air oxygen is a necessary component of burning. The latter process is failed if oxygen is omitted. The candle placed in container 2 goes out because the burning cotton-wool produces carbon dioxide which is heavier than the air, and therefore sinks and replaces oxygen. Although such interpretation is correct, it should be complicated for the fourth-formers. The task could help with coming across the exceptionally bright children.

When looking over Task 4, the respondents should grasp the main qualities of the air. First, when the flask is immersed in the liquid, water does not flood due to the air interference. If the flask is warmed in the palms, the air expands (distance between the elements forming the air increases), and thus the air bubbles can be noticed in water. Having iced the flask again, water rises through the tube. The pupils have to guess the main point illustrating that the air is a mixture of different components.

Comments on Task 5 should help the learners to understand and explain the phenomenon of melting. The placed sugar cube falls into the micro elements that become invisible (sugar melts). The pupils perceive that substances are made of micro elements.

The research data has been quantitatively and qualitatively analyzed. The authors of the survey do not see any main difference between the components of chemistry and physics in the content of primary school. The course on nature taken in primary school is closely integrated.

The tasks have been evaluated applying the proportion scale (no comments made – 0 points, a wrong option is chosen – 0.25 points, the phenomenon is perceived but failed to be fully explained – 0.5 points, the task is almost correctly completed – 0.75 points, the task is successfully accomplished – 1 point). Three experts have individually evaluated the tasks by general agreement.

Research is of a local character and the reached conclusions are not applied for the whole population.

Results

Primary school respondents

The findings of quantity-based analysis

The examination and evaluation of the respondents' results disclosed that the tasks were rather complicated and the surveyed participants' knowledge was insufficient to explain the introduced phenomena.

Table 1. The average evaluations of the respondents' comments on the natural phenomena

Phenomena	Sex	N	Mean	Std. Deviation	Std. Error Mean	Total (Mean, N, Std.Deviation; Correlation)
Phenomenon 1	*Girls*	52	0.3798	0.2865	0.0397	0.3449; 108; 0.2915; 0.61
	Boys	56	0.3125	0.2948	0.0394	
Phenomenon 2	*Girls*	52	0.4375	0.2469	0.0342	0.4606; 108; 0.2716; 0.65
	Boys	56	0.4821	0.2933	0.0392	

Phenomenon 3	*Girls*	52	0.2644	0.2904	0.0403	0.2685; 108; 0.2874; 0.58
	Boys	56	0.2723	0.2871	0.0384	
Phenomenon 4	*Girls*	52	0.0817	0.2084	0.0289	0.0949; 108; 0.2181; 0.59
	Boys	56	0.1071	0.2279	0.0305	
Phenomenon 5	*Girls*	52	0.4567	0.1544	0.0214	0.4491; 108; 0.1926; 0.54
	Boys	56	0.4420	0.2236	0.0299	

The applied parametrical t-test does not indicate statistically reliable deviations between the girls and boys' comments. The representatives of both sexes have made equally inadequate explanations. A general average evaluation of the accomplishment of the tasks among the girls is 0.3240 (std. deviation – 0.1270) while among the boys it makes 0.3232 (std. deviation – 0.1729). Table 1 demonstrates that a total general evaluation of the accomplishment of all tasks correlates with an individual task. The high correlation coefficients show that all the tasks are basically of a similar complexity and none of them can be singled out from the whole system of 5 tasks. The presented figure clearly depicts that principally no deviations between girls and boys have been established.

The most unfavourable comments are made interpreting nature phenomenon 4, which is the air qualities. The respondents have failed to explain why the heated air expands and the iced air – reduces. The best results are obtained describing situation 2 which is the evaporation of heated water and condensation of cooled water vapour. Moreover, the girls rather than boys are better at offering explanations, though this deviation remains statistically insignificant.

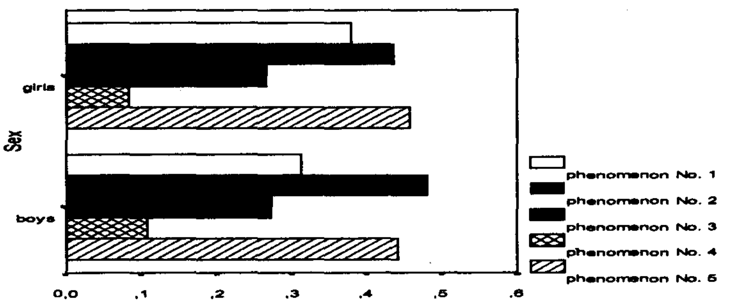


Figure 1. Distribution of task evaluation according to the sex

The findings of quality-based analysis

The assessment and summary of the pupils' findings reveal that the influence of temperature on the speed of the substance particles movement is hardly understandable to the learners of age 10 and 11. In order to interpret the phenomenon, the respondents appeal to experience unrelated to the formal educational process. Some surveyed participants remember seeing a lime precipitate after boiled water is cooled off and that most frequently the precipitate does not occur in cold water. On the basis of such experience they make a decision that warm water is in glass 2 due to a larger amount of the sinking substance at the bottom. It is also noticed that from their experience the children better understand the phenomenon of substance melting in water, and therefore a large part of the learners agree that water in glass 2 rather than that in glass 1 is warmer. They realise that glass 2 contains far less added paint substance. This precondition is proved by task 5 in which almost all the participants of the survey identify the phenomenon as melting.

The phenomenon of evaporation is described by the majority of the respondents. The assessment of the comments demonstrates that the schoolchildren perceive the phenomenon of transferring the heat (if heated, water boils and starts evaporating; if reached a container with the ice cubes, vapour becomes cold, etc.). A few respondents notice the phenomenon of condensation. A part of the learners think of the cubes of the melting ice. Considering that frequently children mix reality and vision, a precondition that the phenomenon of condensation presented in the picture without the ice cubes should be explained by a major part of the surveyed participants can be accepted. As the survey is pilot research and includes a research instrument, omission of the ice cubes placed in the topside container should be a purposeful idea for the future.

The assessment of the comments on Task 3 discloses that a larger part of the pupils know that the air is of a key importance for the burning process. However, a greater part of the learners do not distinguish between the constituent elements of the air, i.e. have no idea of why oxygen existed in the air is necessary for burning. The majority of the surveyed participants agree that the candle goes out due to lack of the air (only a few respondents point to oxygen). Also a number of children logically relate the extinction of the candle with burning cotton-wool. However, the learners were not able to explain what impact exactly the burning cotton-wool had on the interpreted phenomenon. A greater number of the respondents realize that the burning cotton-wool combusted all the air (oxygen) and lack of the latter inside the container extinguishes the candle. Some participants of the survey imagine that the burning cotton-wool absorbs the warm. Only a single learner decided that possibly the burning cotton-wool produced certain chemical substances and absorbed oxygen from the container (correct scheme of reasoning).

The interpretations of Task 4 indicate that the pupils understand the phenomenon of heat transfer but fail to grasp the processes of air expansion and reduction caused by the variance in temperature conditions. Only two respondents state that if heated, the air has no way out and therefore escapes through the tube whereas if iced, the air takes water inside the flask, and thus water rises in the tube. It is supposed to be the most valid interpretation. The most inaccurate descriptions provide that *'if heated, the flask shrinks and pushes the air out while if iced, the flask expands and takes water inside'*, *'water evaporates, and therefore the bubbles occur'*.

While getting on with Task 5, quite a few learners made only brief comments and pointed out that a sugar cube simply melted. Some of the respondents agree that when melting a sugar cube dissolves into a number of small elements and it is the way of observing the process of melting. Several participants of the survey state that temperature of water has impact on the process of melting (melting is more efficient in warm rather than in cold water). A part of the schoolchildren maintain that water dissolves the sugar cube into pieces. It seems likely that when interpreting this task the learners referred to practical knowledge.

Basic school respondents

The findings of quantity-based analysis

The undertaken statistical assessment revealed that knowledge of the eighth-formers varied depending on a task (Table 2).

Table 2. The average evaluations of the respondents' (eighth form) comments on the natural phenomena

Phenomena	Sex	N	Mean	Std. Deviation	Std. Error Mean	Total (Mean, N, Std. Deviation)
Phenomenon 1	*Girls*	50	0.6350	0.3820	0.0540	0.7106; 108; 0.3636
	Boys	58	0.7759	0.3367	0.0442	
Phenomenon 2	*Girls*	50	0.3750	0.2328	0.0329	0.3727; 108; 0.2202
	Boys	58	0.3707	0.2107	0.0277	

Phenomenon 3	*Girls*	50	0.2850	0.2902	0.0410	0.3519; 108; 0.2901
	Boys	58	0.4095	0.2798	0.0367	
Phenomenon 4	*Girls*	50	0.0250	0.1451	0.0205	0.0648; 108; 0.2225
	Boys	58	0.0991	0.2688	0.0353	
Phenomenon 5	*Girls*	50	0.5750	0.2999	0.0424	0.5370; 108; 0.3221
	Boys	58	0.5043	0.3393	0.0445	

The Table 2 shows that the best results have been achieved when dealing with diffusion. Though situation 1 clarifies that there is no big difference between girls and boys, the latter demonstrate a better knowledge – they were almost certain about the above mentioned situation. An interesting point is that in comparison with situation 2 the knowledge of the primary school learners is wider that that of the eighth-formers. It could be explained by the fact the fourth-formers in Lithuania are more focused on a physical/chemical component, whereas a course on physics in form 8 almost does not discuss these phenomena. Another important factor is that research was carried out at the beginning of a school year and certainly the effect of forgetfulness had a real impact. A negative point is that situation 4 was equally poorly interpreted by both the fourth and the eighth-formers. An assumption that the air qualities are harder grasped by the primary school learners can be made. The eighth-formers had been examining the air qualities in the previous courses on physics and geography and in the course *Human and Nature* taught in forms 5 and 6.

The examined answers of the respondents of form 9 are given in Table 3.

Table 3. The average evaluations of the respondents' (ninth form) comments on the natural phenomena

Phenomena	Sex	N	Mean	Std. Deviation	Std. Error Mean	Total (Mean, N, Std.Deviation)
Phenomenon 1	*Girls*	66	0.7045	0.2516	0.0310	0.7171; 114; 0.2813
	Boys	48	0.7344	0.3196	0.0461	
Phenomenon 2	*Girls*	66	0.4924	0.2277	0.0280	0.5110; 114; 0.2585
	Boys	48	0.5365	0.2962	0.0428	

Phenomenon 3	*Girls*	66	0.3750	0.3046	0.0375	0.4123; 114; 0.2918
	Boys	48	0.4635	0.2679	0.0387	
Phenomenon 4	*Girls*	66	0.1894	0.3370	0.0415	0.1930; 114; 0.3425
	Boys	48	0.1979	0.3534	0.0510	
Phenomenon 5	*Girls*	66	0.5038	0.2791	0.0343	0.4627; 114; 0.2686
	Boys	48	0.4063	0.2453	0.0354	

Though no major deviations exist, the knowledge of the ninth-formers is more thorough than that of the eighth-formers. The following results have been obtained after the chi^2 criterion was applied: statistically significant deviations in situation 1 ($\chi^2 = 14.58$; df=4, p=0.006), situation 2 ($\chi^2 = 20.66$; df=4, p=0.000), situation 4 ($\chi^2 = 14.87$; df=4, p=0.005) and situation 5 ($\chi^2 = 13.92$; df=4, p=0.008) and statistically insignificant deviations in situation 3 ($\chi^2 = 9.51$; df=4, p>0.05) can be observed. The results are understandable bearing in mind that the ninth-formers were learning chemistry for one year before. However, no visible improvement of knowledge can be noticed. The deviations are clearly seen having compared the averages of both groups of the respondents (Figures 2 and 3).

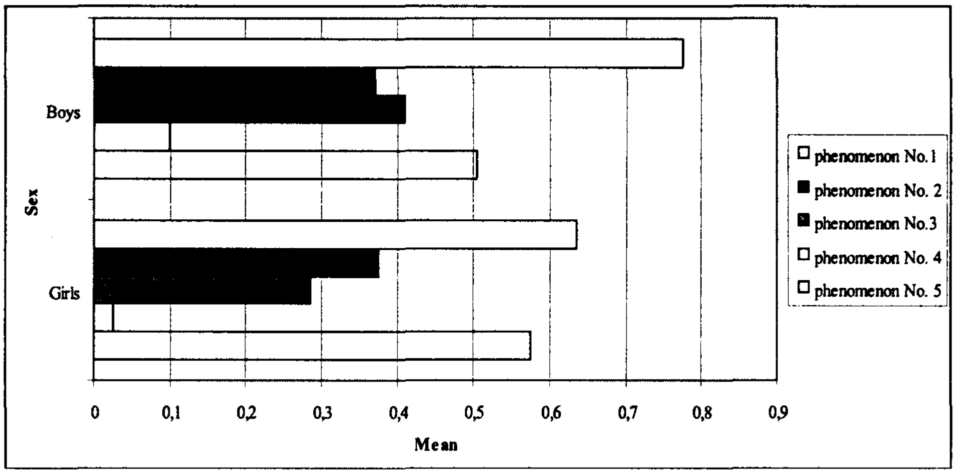


Figure 2. Distribution of task evaluation according to the sex (eighth form)

It is clear that the level of the explanation of situation 2 is below average. Although the phenomenon is mainly understood, it is not appropriately explained. Situation 1 (diffusion) has the most valid interpretation. Situation 5 is also fairly clarified. As it was mentioned above, situation 4 is provided with the vaguest description. The respondents fully failed to make proper comments on the air qualities – expansion and reduction.

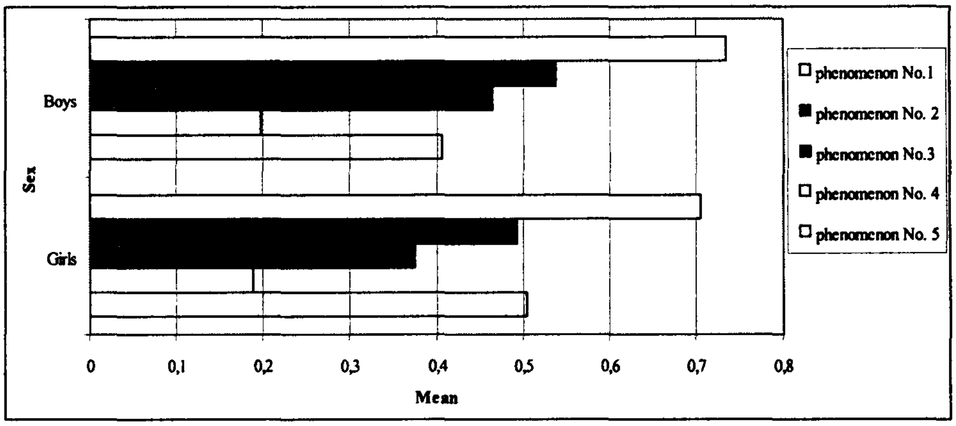


Figure 3. Distribution of task evaluation according to the sex (ninth form)

The diagram shows that the ninth-formers results are more positive. Alike the eighth-formers, the ninth-formers largely succeed in making comments on Tasks 1 and 2. The ninth-formers rather than the eighth-formers were more precise about task 2. An interesting point is that the eight-formers (both girls and boys) rather than the ninth-formers better defined the process of the sugar cube melting.

The findings of quality-based analysis

Considering that the eighth-formers were studying physics and the ninth-formers – chemistry for one year, hypothetically, an assumption that while completing the tasks the surveyed pupils referred not only to practical experience unrelated to the process of formal education but also to the formally obtained knowledge about education can be made.

An assessment of the data revealed that the eight and ninth-formers quite clearly understood the process of diffusion. A part of the eight-formers correctly pointed out to the glass with cold water but failed to make comments on their choice. The majority of the respondents reasoned their choice that substances faster melted in warm rather than in cold water. A few eight-formers applied knowledge about molecule movement and mentioned that the warm water molecules moved faster, and thus speedier mixed with the molecules of the paint substance. Some eight-formers named the described phenomenon as diffusion. The others reached the wrong decision and thought that precipitate formed in hot water. Their choice could possibly be determined by the practically experienced visual that displayed how precipitate formed in lime juice diluted with hot water. Nonetheless, a part of the respondents (eight-formers) did not manage to identify which glass contained cold water and did not succeed in recognizing the previously introduced phenomenon.

The ninth-formers' answers were clearer than those of the eighth-formers, yet they did not sharply vary. Some pupils gave a correct answer and did not make any comments while the great majority of the respondents (ninth-formers) knew that the paint in cold water melted/mixed slower and harder. More ninth-formers rather than eight-formers had information that the first presented phenomenon was diffusion. A significant part of the surveyed ninth-formers referred to the knowledge about the movement of the warm and cold water molecules. The ninth-formers' questionnaires contained single answers demonstrating a more extensive knowledge of chemistry: *warm water flows up and takes paint substances, cold water is not a proper dissolvent, density of cold water is low, expansion of substances start when the temperature is getting warmer, wider gaps open up among the molecules in warm water, and therefore a paint substance mixes easily* (the respondents' language has not been corrected – authors). The answers of two ninth-formers reflected the learners' ability to apply theoretical knowledge in practice: *in order paint melted faster in cold water, it needs to be mixed and poured in warmer water*.

A quantitative assessment of the researched data shows that an explanation of phenomenon 2 is more divergent rather than that of explanation 2: the ninth-formers were more precise than the eighth-formers. A big majority of the eighth-formers did not manage to interpret the represented phenomenon or the interpretation was rather narrow. They stressed only the process of ice melting. Some eighth-formers correctly named not only ice melting but also the reason of the process which is evaporation of heated water. Only two respondents from form 8 accurately described that apart from everything that had been mentioned before the process of water vapour condensation took place (one of the surveyed participants used this term). Two pupils knew that the depicted phenomenon reflected a process of how *liquid substances turned into gas*. Many more ninth-formers rightly pointed out to all stages of phenomenon 2 including water heating, evaporation and vapour condensation. However, the larger part of the respondents ninth-formers demonstrated an inaccurate perception of the phenomenon: alike the eighth-formers they realized it was a chemical reaction and showed they did not know the main features of the reaction. The most typical examples of the answers are *when heated, water evaporates, and therefore ice on the top plate starts melting, if heated, water starts evaporating and vapour makes the process of ice melting faster* etc. However, a greater number of the respondents of form 9 did not mention condensation. Moreover, none of those envisaged that basically it was a cycle of water circulation (analogy between a model and a real phenomenon taking place in nature). Only a small part of the ninth-formers did not understand the mentioned phenomenon.

Burning is a hardly understandable process for the surveyed eighth-formers. Only a few learners managed to give a full and correct interpretation of why the candle went out after the cotton-wool rings were fired. The learners' answer was based on knowledge about the conditions necessary to maintain the burning process. They also were able to apply the gained knowledge for a specific situation. Slightly more eighth-formers understood the burning process but did not note the reasons why the candle lacked oxygen. A few eighth-formers, participants of the survey, indicated only the reason why the candle went out and did not make any comments: *the candle did not receive oxygen*. A few cases illustrate the above discussed reason insufficiently precisely: *the candle went out as when the cotton-wool ring started burning, smoke began rising and no oxygen left*; *a candle really needs oxygen for burning*. Nevertheless, the majority of the pupils showed a wrong knowledge about burning or completely failed to make comments on the phenomenon. For example, a statement that *the whole oxygen necessary for burning is contained in the cotton-wool ring* is absolutely mistaken.

Not many differences between the eighth and ninth-formers answers can be noticed. On the basis of a formal knowledge, the ninth-formers also related their answer to the conditions necessary for burning. However, not everyone was able to make comments on the reason why the candle went out i.e. to apply the acquired knowledge in a specific situation. One of the differences is that more ninth-formers interpreted this phenomenon almost/partly correctly or were exactly right: *the burning cotton-wool ring uses circumjacent oxygen and forms carbon dioxide*; *the candle is beneath cotton-wool, takes less and less oxygen, more carbon dioxide is formed and finally, the candle starts feeling shortage of oxygen...* Hypothetically, it can be maintained that it was determined by knowledge of chemistry.

Phenomenon 4 was the most complex to be grasped by both groups of the respondents the eighth and the ninth-formers. Quite a lot of respondents in both learners' age groups did not manage to explain (or completely failed) the above mentioned phenomenon of the air qualities. Some students referred to particle expansion when heating, yet the following one was not exhaustive enough: *heating makes impact on particle expansion, freezing – on reduction*. Only a minor part of the learners from forms 8 and 9 made full and precise comments on this phenomenon: *if heated, the air in the flask gets warmer, starts expanding and the air bubbles 'escape' through the glass tube; when the flask is cooled, the process of air reduction starts and water takes up its place*... It is supposed that such answers among the ninth-formers were more frequent and thus determined a better situation on their results of qualitative testing.

The eight-formers rather than the ninth-formers made fairer comments on melting (the last phenomenon). The short answers with no comments such as *sugar melted in water* and *sugar dissolved in water*... were the most common versions of the task *'Identify the observed phenomenon?'* Even a greater number of the eight-formers described the above mentioned phenomenon very accurately and mentioned the molecular structure of substances and molecule flow. The ninth-formers had no comments on this issue. All the respondents of this age group knew about the process of melting represented in the picture, yet a smaller part of the ninth-formers in comparison with the eighth-formers were able to pass absolutely clear and exhaustive comments. More typical comments of the ninth-formers are as follows: *'sugar melts in water as the particles of water and sugar mix up'*; *'sugar melts in water and starts mixing with the molecules of water'*; *'it's a chemical phenomenon'*; *'the particles of a sugar cube mix with those of water'*; *'due to a larger amount of water, we cannot see sugar'*; *'more sugar than water can form instant mass'*.

Conclusions

Having summarized the results of the carried out research the following conclusions can be drawn:

- The learners' knowledge of the introduced phenomena of nature (diffusion, air expansion and reduction, combustion, evaporation and condensation, melting) is not exhaustive. Moreover, frequently the obtained information is false and not accurate;
- The pupils find difficulties combining the acquired knowledge into the wholeness. Such situation encounters certain problems in the process of

science education in primary school. The evaluation of the programmes and standards discloses that primary school-leavers should be able to interpret the discussed phenomena at acceptable level;

• This research confirms a general conclusion of the previous studies conducted in Lithuania and proves that primary science education (physics, chemistry, biology, integrated knowledge) is paid scant attention. It seems likely that teachers frequently avoid discussing these topics and give priority to other subjects including languages, mathematics etc. Such position is first of all determined by insufficient primary school teachers' competence in science education;

• A burning issue is the quality of natural science education in primary school. Research indicates that the primary school-leavers' knowledge of natural sciences in Lithuania does not agree with the established educational standards. This pilot research only approves an assumption that incorrectly formed visuals and concepts remain unchanged in basic school. It is obvious, that in some cases, the fourth and eighth-formers knowledge about certain natural phenomena almost have no differences and is even poorer;

• The eight-formers' ability to understand the process of water evaporation and condensation is much lower than that of the fourth-formers. The fourth-formers as well as the ninth-formers made comments on the phenomenon of melting at similar level. Only the eighth-formers' knowledge about melting was more exhaustive. Relatively, the primary school learners' knowledge about the air qualities is better than that of the eighth-formers. Only the ninth-formers information about the air qualities arrives at the average. An assumption that despite the altered teaching content and varied techniques natural science education in basic school is not sufficiently systemized can be made. The pupils face difficulties with interpreting everyday phenomena, i.e. the content of natural science education poorly relates to practical reality. The gaps in teaching/learning left in primary school have a tendency to survive;

• Unlike the national research on pupils' achievements conducted in Lithuania, this survey did not reveal any statistical significant deviations in terms of the sex. Concerning the analyzed phenomena the knowledge of both boys and girls is similar.

Notes

[1] The paper was presented at the First Annual Conference of the Bulgarian Society for the Chemistry Education and History and Philosophy of Chemistry, Varna, 26–28 October 2006.

[2] http://www.xplora.org/ww/en/pub/xplora.nucleus_home/pencil/heureka.htm

[3] http://www.pedagogika.lt/puslapis/nactyr2003.pdf

[4] Constructivism in Chemistry: A Special Issue of *Foundations of Chemistry. Philosophical, Historical, Educational and Interdisciplinary Studies in Chemistry* (Springer). Volume 8, Issue 1, 2006.

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