DIDACTIC POSSIBILITIES OF REALISATION OF INTERDISCIPLINARY RELATIONS: SUBJECT FRUIT JUICE PROPERTY

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Annotation

Natural Science Education improvement remains one of the most important current challenges in education system. In general, 21st century raises new challenges for Natural science, Mathematics, Technology teachers. Young generation interest in Natural Sciences and Technology is poor. It is predicted that in not so far future, a shortage of qualified specialists will be felt in this sphere. It is obvious, that Natural science and Technology education basics is being formed in general education school. How to strengthen the pupils' Natural science and Technology learning motivation, to increase their interest? This is one of the most important questions of today's education. On the other hand, improvement has to be carried out in different directions. Not only motivation strengthening is important, but also creating proper educational environments (spoken here about green environment, so-called outdoor didactics, teacher competence and so on). Extra didactic material preparation for teachers becomes an urgent question. It is very important to help teachers prepare for practical work lessons and to give them, using ordinary and digital devices for the performance of practical-experimental works.

In this analysis, a didactic scenario is presented realising an interdisciplinary – integral teaching/learning. The investigated topic is "Juice properties". Natural sciences and Mathematics teachers' collaboration possibilities are revealed.
Key words: *interdisciplinary relations, natural science education, titration, vitamin C.*

Introduction

One of the most important aims of Natural science education is integral perception of biological, chemical, physical processes and phenomena, occurring in nature. Therefore, the main task of the teachers is to be able to find connection between separate natural sciences and manage to convey the perceived entire natural science understanding to the pupils during the research work. Mathematics is also closely integrated with Natural sciences, because learning all these subjects, mathematical competencies are necessary. In Lithuanian general education school General Programmes (Primary and general education…, 2008a; Primary and general education …., 2008b; Secondary education general…., 2011), defining educational content of Natural sciences and Mathematics, interdisciplinary relationship development importance is accentuated.

The pupil, learning Natural sciences, has to create for himself a unanimous, not divided into separate disciplines, worldview. Therefore, natural sciences has to be taught as an integrated subject, examining real animate and inanimate nature phenomena and objects. Interdisciplinary natural science education relations are developed mostly among Biology, Chemistry, Physics, Mathematics and Information Technologies. The teachers have to convey educational content, containing separate concepts, laws and theories as a sustainable wholeness, revealing the interrelationship of the examined phenomena. Organising Natural science teaching in this way, the teaching material is reorganized, systemised. Solving interdisciplinary integration problems, active communication and collaboration among separate Natural science subject teachers takes place.

It is impossible to systemise pupils' knowledge without interdisciplinary relationship, therefore, such teaching forms people so that they acquire a lot of theoretical material however, they cannot apply this material in practical activities. Interdisciplinary relationship, as a didactic condition, helps to form pupils' worldview and plays an important role, developing their creative abilities. For the teacher and even more for the pupil, it is not easy to perceive a tremendous amount of acquired knowledge and abilities at school, to find relations between related knowledge, abilities and to join them into unanimous system. The acquired knowledge systematization, ability formation are complicated processes. For Natural Science and Mathematics knowledge system formation, it is important, that the knowledge acquired at a certain teaching stage was consolidated interrelating it. Favourable conditions are formed for this, generalising, revising Natural science and Mathematics separate elements and using them in a concrete lesson, performing integrated tasks.

Solving interdisciplinary integration problems, active communication and collaboration between individual Natural science teachers has to take place. Educators who help students develop their confidence and ability in mathematics and science would have a positive impact on students' lives in the long term (Furner, Kumar, 2007).

Interdisciplinary integration realisation cannot go itself. The research results showed, that students accentuate the importance of integration relationship application, making the pupils interested in Natural science subjects, helping educate the abilities to apply the knowledge practically, however, they feel professional and methodical preparation shortage to apply Natural science integration in practical work (Cibulskaitė, 2015).

For the realization of interdisciplinary integration, it is necessary to specially organise teaching process itself, to prepare teaching material. First of all, it is necessary to single out the material which reflects interdisciplinary relations, to select teaching forms, methods and ways. For such material preparation, teacher collaboration is necessary. In other words, these are the results of their collaborative work together in the creation of interdisciplinary units connecting mathematics and science topics (Frykholm, Glasson, 2005).

Interdisciplinary relations in the teaching process are inter-science relation didactic equivalent. Pupils have to understand, what unites and what separates Natural sciences and Mathematics. Using mathematical methods, it is convenient to analyze and describe natural phenomena. Mathematics enables closely and accurately describe test results, to evaluate biases. One of Mathematics and Natural science relation elements is functional dependencies. In Natural sciences it is always recollected, that symbols and formulas used in Mathematics must have the meaning, that they describe the real world, whilst Mathematics examines relations among abstract objects, without a concern if they find a place in the world. This is the essential difference of these sciences.

Interdisciplinary Natural Science and Mathematics relations have been analysed by the article authors, examining also the other Natural Science topics: Nanotechnology beginning – fullerenes (Šlekienė, Ragulienė, Lamanauskas, 2015a), Water salinity (Šlekienė, Ragulienė, Lamanauskas, 2015b).

The aim of analysis: to discover Natural Science and Mathematics relation realisation didactic possibilities, analysing different juice properties.

Lessons organization and methodology of research performance

During this lesson the experiment is carry out: vitamin C *concentration* in fruit juices of different types and different brands is investigated.

At the beginning of lesson students are asked about vitamin meaning in everyday nutrition, about significance of vitamins and minerals, what vitamin C sources they know.

Pupils are asked to recall from mathematics: fractions (proportions), percent calculation, to recollect error calculation. It is appropriate to repeat the basic feature of proportions (Figure 1), because, when solving the Science problems, noted that the students hardly perform operations with fractions, especially when instead of numerical values of science quantities, in the problem presented their letter designation.

Mathematical rule	Mathematical actions	Science task
Proportion's a: b = c: d members, a and d are called **edge**, b and c - **middle**. Edge Middle $\frac{a}{b} = \frac{c}{d}$ Middle Edge 1. In order to find the unknown edge member, middle members need to multiply and divide them from another known edge member. 2. In order to find the unknown middle member, edge members need to multiply and divide them from other known middle member.	**Given**: proportion $\frac{a}{b} = \frac{c}{d}$ a,b,c,d $\neq 0$ **Find**: a, b, c, d - ? **Solution:** $a = \frac{b \cdot c}{d}$ $b = \frac{a \cdot d}{c}$ $d = \frac{b \cdot c}{a}$ $c = \frac{a \cdot d}{b}$	From the relationship between the concentration of the solution and its volume to express all quantities. **Given**: $\frac{C_1}{C_2} = \frac{V_2}{V_1}$ **Find**: C_1, C_2, V_1, V_2 -? **Solution:** $C_2 = \frac{C_1 \cdot V_1}{V_2}$ $C_1 = \frac{C_2 \cdot V_2}{V_1}$ $V_1 = \frac{C_2 \cdot V_2}{C_1}$ $V_2 = \frac{C_1 \cdot V_1}{C_2}$.

Figure 1: The relationship between science and mathematics when applicable the basic feature of the proportions.

Students are presented with a consistent workflow and with a list of equipment needed for this activity. As the results of this work among students are not known in advance, the possibility of discussion in groups arises. Analysis of results and discussion effective when the work is done in groups of 2-3 students. In case class does not contain the necessary equipment and reagents, the teacher demonstrates researched juice titration.

With the more gifted pupils the question is discussed, in what capacity of one or another juice is the day norm of vitamin C. Students who complete the work quickly are asked to work on the extension tasks provided.

Expected Learning outcomes for this activity:

All students
- Will understand vitamin meaning in everyday nutrition.
- Will be able to arrange the instruments for work according to instruction.
- Will be able to apply iodometric titration method.

Most students
- Will be able to calculate molar concentration of the solution.
- Will be able to calculate vitamin C concentration in juice.

Some students
- Will be able to calculate the mean square error of the measurements.
- Will be able to calculate titration error.
- Will be able to evaluate the result accuracy.

Structural parts of the lesson:
- discussion of theoretical material,
- explanation of the practical work,
- performance of the experiment and tasks,
- discussion of the results and their significance.

Vitamin C concentration ascertainment

Fruit and vegetable juice is produced from ripe fruit, berries and vegetables squeezing them for extraction. The most valuable part of the juice is the pulp, because all cellulose fibres get into it, for example, tomato, carrot, sea buckthorn, apricot, plum. Produced juice is used fresh, you do not have to boil it, preserve or pasteurize, otherwise all ferments and a part of vitamins will be destroyed. Juice with sugar is of less value. In a lot of juice, there are vitamin C, potassium, calcium ions, and in very small amounts of iron, copper, manganese, cobalt, zinc, nickel ions, necessary for the body.

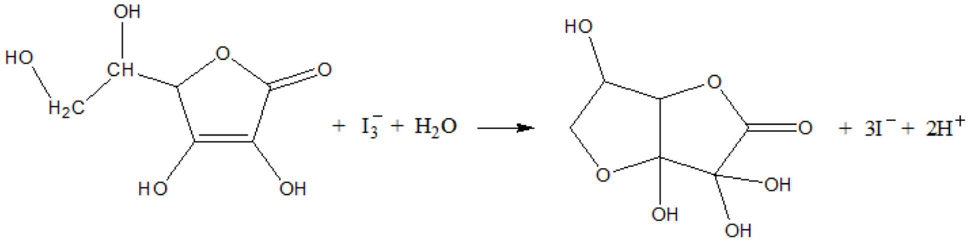
Fruit drinks have up to 30 % of fruit juice; e.g., in grape drink there is 6 %, lemon – about 10 % of juice. These drinks are very widespread, because they are cheaper.

The cellulose fibre, being the major structural component in vegetables and fruit, influences fat circulation, decreases the level of cholesterol in blood, helps to remove poisonous materials from our body. Potassium – regulates the transmission of nerve impulse, muscle activity, water balance in the cells. A day potassium dose is 2000 mg. Potassium is the major compound of bone and teeth mass. There body stores about 98% of potassium in human cells, for example Potassium citrate helps strengthen bones. Potassium, which is not in the bone tissues, plays a great role transmitting nerve impulse for ribs and heart muscle fibres. This part of potassium is important for coagulation systems, fermentation reaction regulation. A day potassium dose is 800 mg.

Vitamin C, ascorbic acid (C6H8O6), is one of the most unstable water-soluble vitamins. Reacting with oxygen, it quickly oxidizes, it is unstable for the influence of temperature, therefore thermally processed, the juice decomposes. The cells of almost all mammals can synthesize vitamin C, unfortunately, human cells do not possess this feature therefore, its demand is satisfied, eating food of plant origin. Vitamin C is in all organism liquids and cells, however, it is not stored in the organism, and the excess is excluded with urine. Vitamin C is also important as co ferment and as an antioxidant, takes part in collagen synthesis, the adrenal cortex, steroid hormone and other hormone synthesis. Vitamin C deficiency results in scurvy, increasing blood vessel fragility, occurring bone tissue changes, teeth becoming loose and falling out; developing heart function failure, anaemia.

A day dose of vitamin C is 75-100 mg. Since the human body is not synthesize vitamin C, it has to be ingested from vegetables, fruit or berries.

Vitamin C concentration can be determined by iodometric titration method, carrying out its oxidation with iodine solution.



Ascorbic acid Dehydroascorbic acid

Molecular iodine dissolves in water very weakly (only a 1,3 ×10^{-3} M at 20^{o}C temperature), however, when it bound to the iodide ion, dissolves significantly better.

$$I_2\,(aq) + I^- \rightleftharpoons I_3^- \qquad K = 7 \times 10^2 .$$

0,05 M I_3^-solution is usually prepared dissolving 0,12 mol KI and 0,05 mol I_2 in one litre of water.

Performing the titration with iodine solution, starch is used as an indicator. If there are no other colour combinations in iodine solution, one can still see the iodine colour at a concentration of at least ~ 5 μM. Performing the titration with the starch, determination limit widens almost ten times.

Carrying out the titration with I_3^- , starch is added at the beginning of the titration. Having reached the equivalence point the first excess I_3^- drop turns the solution dark blue. Iodine and starch complex formation return reaction depends on temperature. Raising solution temperature from 25^{o}C to 50^{o}C, colour intensiveness decreases ten times. In order to reach the biggest sensitiveness, it is recommended to chill the titrated solution in ice water.

Standard I_3^- solution is made dissolving solid I_2 in a significantly bigger concentration KI solution (to be an I^- excess). For making standard solution, sublime I_2 is that suits. As, in the process of weighing, the iodine evaporates a little, it has to be standardised by $Na_2S_2O_3$ solution.

The solution is comprised of a solvent and a dissolved substance (solute). One of the main characteristics of a solution is its concentration. Solution concentration shows the dissolved substance mass and quantity, existing in a certain mass or capacity of a solution or a solvent.

Molar concentration shows, how many moles of the solute are dissolved in one litre of solution:

$$C_{\mathrm{M}} = \frac{n}{V}, \ \mathrm{mol/\ell};$$

Where n is the number of moles of the solute; V – solute volume in litres.

Or

$$C_M = \frac{m_1}{M \cdot V}, \ \mathrm{mol/\ell};$$

where m_1 is solute mass; M is solute mole mass; V is solute volume.
Instead of measurement unit mol/ℓ often one letter M is written. Solutions, in one litre of which there is 0,1; 0,01 moles of substance, are correspondingly called *decimoles and centimoles.*

To describe solution concentration ppm units are used - parts per million. 1 ppm = 1 mg/ℓ.

Often, from concentrated solutions one has to make solutions of smaller concentration. In such cases, it is very comfortable to use dilution rule:

$$C_1 \cdot V_1 = C_2 \cdot V_2,$$

Where C_1 and V_1 – molar concentration and capacity of concentrated solution;
C_2 and V_2 – molar concentration and capacity of dilute solution.
If solution concentrations are expressed in parts per mass, for calculation such formula is used, then:

$$C_1 \cdot V_1 \cdot \rho_1 = C_2 \cdot V_2 \cdot \rho_2,$$

Where C_1, V_1, r_1 – concentration, capacity and density of a concentrated solution;
C_2, V_2, r_2 – concentration, capacity and density of dilute solution.

The essence of practical work and stages of experiment

An explanation of practical is given.

The research problem. How vitamin C content in the juice depends on the juice type and brands.
The research hypothesis:

- Vitamin C is more in freshly squeezed juice than in juice from the trade network.
- Vitamin C in orange juice is more than in apple juice.

Equipment needed for this activity (Figure 2):

- scales;
- burette with a holder;
- 250 ml measurement flask;

- conical flasks for titration;
- chemical glasses;
- pipettes;
- washing dish with distilled water;
- Textbooks;
- Activity sheet.

Reagents:

- 0,01 M I_3^- solution (0,63 g I_2 and 1,00 g KJ is dissolved in approximately 200 ml of distilled water, poured into 250 ml measurement flask and diluted up to the mark .)
- 1 % starch solution.
- Fruit juice, squeezed by hands or from trade.

Figure 2: Equipment and reagents.

Main Activity

Pupils begin work on *Ascertainment of Vitamin C concentration* in fruit juice.
Students in groups of 2-3 carry out juice titration:

- Burette is washed twice with iodine solution and filled again up to 25 ml capacity;
- 20 ml of prepared juice is poured into a conical flask;
- 20 ml of distilled water is poured with a pipette;
- 5 drops of 3 M HCl;
- 10 drops of starch solution;
- The iodine solution is dripped from the burette until blue colour occurs, not vanishing for at least 20 seconds;
- During the titration, the solution is stirred with the magnetic stirrer or by hand;
- The titrated iodine solution capacity is measured;
- Titration is repeated three times;
- All juice samples are titrated in this way.

Completion of the tasks

Pupils are asked to complete the activity work sheets individually, pupils are asked to record results, to fill in data table (Table 1), according to equivalence law, to calculate vitamin C concentration (Table 2), to compare vitamin C concentration in different fruit juice.

Table 1. Fruit juice titration data (Solution volume of titrated iodine)

Juice title	I titration, V_I, mℓ	II titration, V_{II}, mℓ	III titration, V_{III}, mℓ	Mean value, $\bar{V}\bar{V}$, mℓ
Orange, freshly squeezed	7,2	7,4	7,3	7,3 ± 0,1
Orange, CIDO	5,5	5,5	5,4	5,5 ± 0,1
Apple, freshly squeezed	3,0	3,1	3,0	3,0 ± 0,1
Apple, CIDO	1,0	0,85	1,0	1,0 ± 0,1

Titration was carried out using a burette that systematic error P (sys) = 0,1 ml.
Vitamin C concentration is calculated according to equivalence law, expressed in mol/ℓ.

$$V_1 \times C_1 = V_2 \times C_2;$$

Where: V_1 – solution volume of titrated iodine, V_2 – volume of juice, taken for titration, C_1 – molar concentration of iodine solution, C_2 – vitamin C molar concentration in juice.

$$C_2 = \frac{V_1 \times C_1}{V_2}.$$

Vitamin C concentration, calculated according to equivalence law, expressed in mol/ℓ. The units used in food industry are - mg/100 mℓ.

Recalculate vitamin C concentration in units used in food industry mg/100 mℓ juice.

Calculation results is presented in table 2.

Table 2. Vitamin C concentration in fruit juice

Fruit juice title	Vitamin C concentration, mg/100 mℓ
Orange, freshly squeezed	64,3
Orange, CIDO	48
Apple, freshly squeezed	26,4
Apple, CIDO	8,8

Plenary

After discussion of the results students are asked to

- Compare vitamin C concentration in different fruit juice.
- Compare vitamin C concentration in freshly squeezed juice and in juice from shops.
- Ascertain, how much of each fruit juice is needed to give the daily recommended intake.
- How do experimental results correlate with the results presented in the literature (labels)?

Students are asked to make a conclusion about vitamin C concentration in different fruit juice. With the more gifted pupils the question is discussed, in what capacity of one or another juice is the day norm of vitamin C.

Extension activity

Pupils who complete the work quickly are asked to work on the extension tasks provided.

Calcium ion Ca^{2+} concentration in various fruit juice

In chemistry lesson, the pupils investigated Calcium ion Ca^{2+} concentration in various fruit juice. Calcium ion concentration in solution was calculated in ppm (*parts per million*) units. The results of the experiment are given in table 3. It is accepted to express concentration in nutrient substances in mg/100mℓ. Fill in the table, having calculated Ca^{2+} concentration in mg/100 mℓ of juice. It is known, that 1 ppm = 1 mg/ℓ.

Table 3. The results of the experiment

Fruit name	Ca^{2+} concentration in juice, ppm	Ca^{2+} concentration in juice, mg/100 mℓ
Freshly squeezed orange	44	
CIDO orange	34,8	
Freshly squeezed apple	23,6	
ELMENHORSTER apple	25,6	

- Compare calcium ion concentration in freshly squeezed juice and in juice from shops.
- Estimate, how much one or another juice one has to drink, that it contained the day norm of $Ca^{2+.}$

Summing-up

Seeking to implement one of the most important Natural science Education aims – subject integrity, the teachers have to be able to discover and to convey to the pupils the connection between separate Natural Sciences. It is necessary to specially organise teaching material and the teaching process itself for this.

First of all, it is necessary to discern the material, which reflects interdisciplinary relations, to select teaching forms, methods and ways. The teacher has to be ready to work in a constantly changing teaching/learning environment, be able to realise the newest interdisciplinary didactics principles, to use information communication technologies.

In the presented analysis according to one lesson example, were revealed Natural science and Mathematics relation realisation didactic possibilities. An example scenario “Fruit juice research” was presented. Structural parts of the lesson were presented: discussion of theoretical material, practical work meaningfulness and explanation of the experiment procedure, the experiment and the task performance, the obtained results and discussion of their meaningfulness will allow Natural science teachers to give a lesson about vitamin C amount in juice and its significance to human organism, using integration possibilities.

Extra tasks, taken from real environment are likely to make the pupils interested in natural objects, and will show interrelationship of the examined phenomenon.

Note

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