Description of Case studies of – Optical microscope since the first to the contemporary one, for exchange within the HIPST project

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1. **Title:**

"Optical microscope since the first to the contemporary one."

Key words: *lens, history of microsope, microscope, micorscope's magnification, observations.*

2. Authors and Institutions:

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3. Summary:

In Polish National Curriculum for Lower Secondary School there aren't included standards related to the construction and rule of operation of optical microscopes. However, students have to know different kinds of lens and learn the lens' equation. This theme is an obligatory standard in National Curriculum for Higher-Secondary School, but there is no word saying about microscope's history. Students learn at once how microscope is built, how to construct picture of object that is observed by use of microscope and are acquainted with the magnification's formula. There is lack of historical elements of coming into existence microscope, that will connect all the above elements. It brought an idea ***– initiation one extra lesson about history of microscope!***

*This extra lesson (see Annex 1) was executed between two lessons: "Kinds of lenses and lens' equation" and "Optical instruments". The lesson allowed students for practical use of geometrical optic's laws. The lesson: "****Optical microscope since the first one to the contemporary one****" was aimed at raising an interest of students in historical aspects of emerging microscope, the most famous constructors of first microscopes and objects, that were discovered by the use of first microscope.*

This theme may be realized in lower-secondary schools and all types of higher-secondary schools.

4. Description of Case study

Lesson was given to students from different type of schools:

- *lower-secondary school, students' age: sixteen and seventeen,*
- *vocational school, students' age: eighteen and nineteen,*
- *secondary-technical school, student's age: nineteen and twenty.*

Lesson in all class was given in similar way. Firstly students were given "Worksheets", where were placed some exercises. Students completed exercises during watching presentation "Optical microscope since the first one to the contemporary one", which was prepared and talked over by the teacher. The presentation has started with explanation of word "lens" etymology and" magnifying glasses" origin. Secondly, I discussed Zacharias and Hans Jansens' contribution to the microscope construction.

Next I told about Antonie van Leeuvenhoek's life, his research and discoveries that he made using his own microscope (see Annex 4). Leeuvenhoek has sent letters to the Royal Society saying about his discoveries. Robert Hook was reading this letters and started to be interested in microscopes. He constructed also his own microscope. I discussed with students Hook's life, construction of his microscope and his investigations. Then, I told students about contemporary optical microscope, its construction and how it works (taking into account the optical geometry laws). Finally, I acknowledged students with magnification formula
of the microscope. After showing presentation In some classes I checked if students made exercises correctly, but in some others I didn't, because I would like to motivate them to work, by giving extra marks. Then students solved a problem about microscope's magnification that was implemented into worksheet. One of the students was solving a task on the blackboard and the rest of class wrote the solution in the worksheets. Last, but the most important lesson's element was watching different kind of microscopic preparations. Students willingly used microscopes and specimens, changed objectives and other set-ups of microscope's parameters, especially its magnification. Their happiness could be noticed when set-up of microscope was correct and image of preparation was well visible and clear. If they had problems with arrangement of the microscope, the asked each other for help, eventually they asked also teacher for help. At the end of this lesson students completed a questionnaire concerned with "opinion of students on nature of science".
During the next lesson students gave back worksheets, with completed tasks of homework. I checked homework and gave the marks. In classes in which I didn't check exercises during the lesson, I did this after lesson and also gave one more extra mark. I discussed with students their answers for questions that were given as a homework.
At one of these lessons there was visitation of headmaster Mrs Agata Dziedzic and Mrs Liszewska representing provincial education authorities. They evaluated lesson as very interesting. They told also that there have been good time organization, but students were very active and interested in the topic of the above lesson.

5. Historical and philosophical background, including the Nature of Science

First microscopes were constructed in Holland ica.1490. They were built by Hans and Zachary Jannsens, but at that time there wasn't any practical use of them. Galileo was interested in this device, but he paid attention to watching objects that were very far from the Earth and had big size. Antonie von Leeuvenhoek has been interested in magnifying glasses. At the beginning he was a student in fabrics store. There magnifying glasses were used to count the threads. He was trying to increase magnification of glasses. His grinding and polishing method used for thin lens gave a good result – gave magnifications up to 270 times. This method allowed Leeuvenhoek to construct his mentioned above microscopes and to make observations.
As the consequence Leeuvenhoek made the biological discoveries, from which He is known. Through the use of his microscope He saw and described: the bacteria and microbes in a drop of water, the particles of blood circulation in capillary vessels, red blood cells, sperm cells. Leeuvenhoek forwarded his findings to the Royal Society, where Robert Hooke played the role of President and who became interested in Leeuvenhoek's discoveries. Hooke made a copy of an optical microscope of Leeuwenhoek and improved its appearance.
Further his microscopes were improved inter alia by the three lenses. Hooke looking through a microscope at cross-sections of cork from oak cork discovered the

structure, which today is called a cell. In the eighteenth century several technical innovations were introduced, which facilitated holding of microscope, which made the microscope was becoming a more popular device among scientists. In 1830 Joseph Jackson Lister reduced the problems of spherical aberration - several weak lenses joined together while maintaining a distance between them. The result was a good zoom and picture without haze. In 1878, Ernst Abbe formulated the mathematical theory, which correlated the resolution with the wavelength of light. His model allowed to calculate the maximum resolution of the microscope. In 1903, Richard Zsigmondy expanded ultramicroscope, which allowed viewing the objects smaller than the wavelength of light. In 1932 Frits Zernike invented phase contrast microscope, which allowed the study colorless and transparent biological materials. In 1938 Ernst Ruska built an electron microscope. The possibility of using electron microscopy has contributed significantly to increase the resolution and the boundaries of research have expanded. In 1981, Gerd Binnig and Heinrich Rohrer invented the scanning-tunneling microscope, which gives three-dimensional image of objects smaller than atoms.

6. Target groups, the importance for curriculum and educational benefits

The target groups are the students of secondary schools and junior high schools of various types. It is the youth between 14 and 18 years of age. The activities may be carried out during a lesson at school (high school and upper-secondary education), or as extracurricular activities such as physical circle at school.
Concepts faced during this lesson are: magnifying glasses, lens, microscope, microscope zoom, the focal length of eyepiece, focal length of objective. Some of these concepts are familiar to students. During the course, students familiarize themselves with the construction of a microscope, which is correlated with the teaching of biology. They learn how the image of the object viewed through a microscope is created. Using a school microscope they are watching the various samples (plant and animal tissues), which are also watching at the lessons of biology. Besides this, the course is to teach the calculation of microscope magnification, if the following data are known: length of tube, the focal length of eyepiece and focal length of objective.
After these activities is expected that students would be better at using a microscope and understand how the microscope work. The inclusion of historical elements encourage students to deepen their knowledge on the subject and motivate for action – observations with the use of microscope.

7. Activities, methods and tools of learning

The methods used in the conducting of of classes are:
- Seeking: a talk with the students (by way of questions and answers);
- Practical: completion of work papers, solving tasks, carrying out observations using optical microscopy.

Educational tools, which were used during classes:
- the ppt presentation "Optical microscopes", computer, multimedia projector, worksheets, optical microscope.

8. Difficulties in teaching and learning

In the course of activities I didn't encounter any difficulties as regards to the acquisition of knowledge by students, lack of the right concepts or the proper use of the microscope.
After the lesson, the special survey on „Nature of science" was carried out, but the first class we had to improve the questionnaire. This was due to its too complicated structure, which the Polish students didn't understand. They had difficulty answering, because the questions (especially in the II part) were too long. After simplification of survey form, there were not problems at all. (see Annex 2 and 3).

9. Teacher's pedagogical competencies

Nowadays Polish practice of teaching doesn't value implementation of History and Philosophy of Science in education. For that reason teacher who would like to teach in the above proposed way, should be interested in source historical materials and literature (this kind of materials are published mostly in foreign languages in different magazines or in Internet) and should be convinced of his own pedagogical success.

10. Documentation (evidence) of studies

Questionnaire about student's consciousness of the range of researches and about the spectrum of understanding the nature of science and its importance for society and themselves.
Analyses of questionnaire – see Annex 3.

11. Further professional development of users

A. K Wróblewski, History of Physics, Wydawnictwo Naukowe PWN, Warszawa 2007.
D. Halliday, R. Resnick, J. Walker, Podstawy fizyki, t. 4, Wydawnictwo Naukowe PWN, Warszawa 2003.
http://inventors.about.com/od/mstartinventions/a/microscope.html
http://www.nauka.gildia.pl/ludzie_nauki/antoni_van_leeuwenhoek
http://www.arsmachina.com/micromenu.htm
http://nobelprize.org/educational_games/physics/microscopes/timelin_e/index.html
http://www.mindspring.com/~alshinn/Leeuwenhoekplans.html

12. Written literature resources

- *Scenario of lesson with the worksheet,*
- *presentation ppt: „History of microscope", "Optical microscope since the first to the contemporary one"*
- *Paper on: „Leeuvenhoek's microscope replica,*
- *Description of Case studies: "Optical microscope since the first to the contemporary one"*
- *Publication M. Sadowska: Optical microscope since the first to the contemporary one"- proposition of lesson within HIPST Project, Science Teaching, 31/2009, pp. 26-36..*

Scenario of the lesson on:

Optical microscope since the first untill modern ones.

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The general aim: knowing history and how an optical microscope works.

Detailed aims (a student):

➢ can:
- name two first famous constructors of microscope,
- say, what was discover by using first microscopes,
- discuss a construction of microscope,
- calculate a microscope's magnification.

Methods
- *searching:* conversation with students (asking questions);
- *practical*: complementing „a work's card", making calculation of microscope's magnification, seeing samples with microscope.

Work forms
- collective,
- individual.

Didactic measures
- a PPT's presentation – „A microscope", a computer, a multimedia projector,
- a blackboard, chalk,
- "work's cards",
- sheets with homework.

The lesson's scenario

TEACHER'S ACTIVITIES	STUDENTS' ACTIVITIES
1. *Start.*	
- Welcome and presence checking.	- They are sitting down.
- Giving work's cards to students. Telling students that completing work card is obligatory during watching the presentation.	
2. *The amplification of lesson.*	
- Showing the presentation – „A microscope". The presenation contains: history and the way that microsocpes work. There are information about first microscopes built by Jannsens, Leeuwenhoek, Hooke and modern microscopes. There are also: schemes of Hooke's and modern microscope (You can tell how the microscope works using school's one), scheme that helps understanding an image's	- They are completing work cards. - They are completing a scheme of microscope with names of components of the Hooke's microscope.

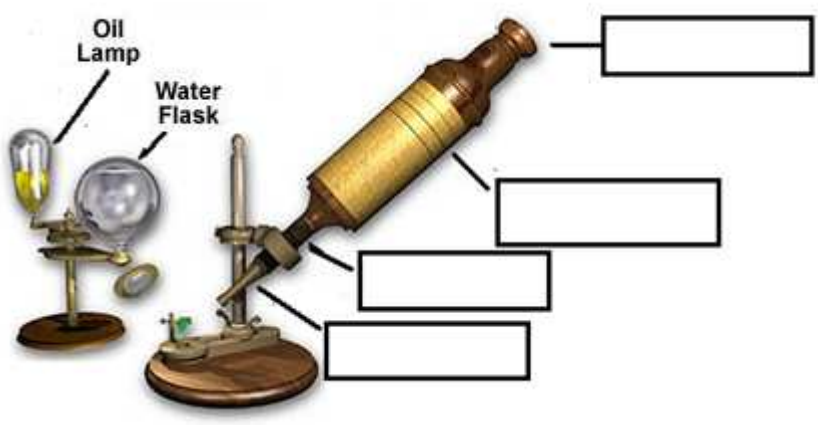
obtaining, the formula for microscope's magnification.	
- Discussing right answers (first part from work's cards).	- They are checking if their answers are right or not. If answer is wrong, they correct.
- Going over right answers – names of elements of the Hooke's microscope's construction.	- They are checking if names of components Hooke's microscope are right or not. If name is wrong, they correct.
- Discussing the formula of a microscope's magnification.	- They are checking the formula of a microscope's magnification, if they wrote it right or wrong. They're correct, if formula is wrong.
- Asking student for reading the fourth (IV.) exercise's instruction.	- They're reading. (One of them is reading an instruction out.)
- Helping students in analyzing the exercise.	- They're analyzing an exercise. They're reading and writing on a blackboard: data, an unknown quantity and formula. (It can be made by one student or by a group of students.)
- Monitoring students' work.	- One of students is working the exercise out on the blackboard and the rest is making it on the work's cards. Data: Unkown: Formula: f_{ok}= 5 cm m = ? $m = \frac{s}{f_{ok}} \cdot \frac{25\ cm}{f_{ob}}$ f_{ob} = 1 cm s = 10 cm $M = \frac{10\ cm}{5\ cm} \cdot \frac{25\ cm}{1\ cm} = 2 \cdot 25 = 50$ Answer: The microscope's magnification is equal 50.
- If lesson is finished before the time, teacher can give students a school's microscope(s) to see same samples by using different objectives that give different magnification.	- They are watching different samples by using microscopes with different objectives.
3. *Finish.*	
- Reassuming students' work, giving a note for theirs activity during the lesson. Giving sheets with homework. Bidding students goodbye.	- Bidding the teacher goodbye.

The worksheet

I. Complete sentences during watching the presentation.

1) Magnifiers and "burning glasses" were mentioned in the writings of _____ and _____.
2) Leeuwenhoek built a microscope which magnification was equal _____, therefore it was built with _____ lens/lenses.
3) Antonie van Leeuwenhoek was the first who saw and described _____, _____, _____ and _____.
4) Robert Hooke constructed his first microscope about _____a.d. He built the microscope which had _____lenses.

II. Name the marked elements on the Hooke's microscope's scheme .



III. Rewrite from the one of the presentation's sidle the magnification formula.

s – the length of microscope tube

f_{ob} *– focal length of* _____

f_{ok} *– focal length of* _____

IV. The focal length of objective of a microscope is equal 1 cm and focal length of eyepiece 5 cm. How big is the microscope's magnification, if the length of tube's microscope is equal 10 cm?

Homework

1) A microscope's objective has focal length equal 4 cm, its eyepiece's focal length is 8 cm and length of its tube is 13 cm. How big is the microscope's magnification?

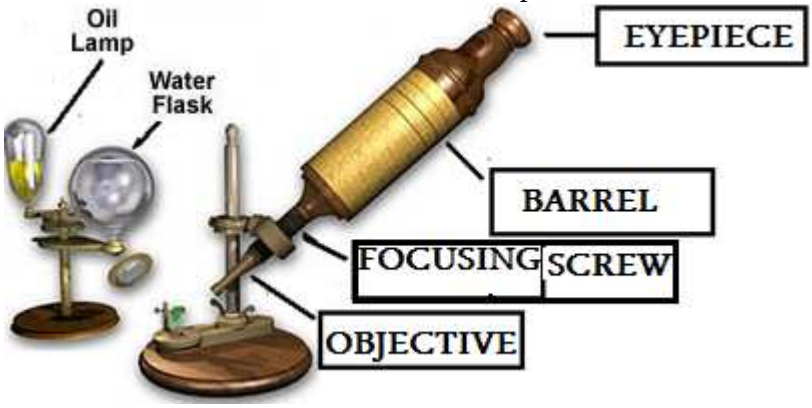
2) Using internet find answers for questions:
   a) What is the biggest magnification of modern optical microscopes?
   b) Is it possible watching cell or its elements by using the modern optical microscopes? (What elements?)
   c) What is the price of that kind of microscope?

Predicted right answers in the worksheet

I. Complete sentences during watching the presentation.

1) Magnifiers and "burning glasses" were mentioned in the writings of ***Seneka*** and ***Pliny the Elder***.
2) Leeuwenhoek built a microscope which magnification was equal ***270***, therefore it was built with ***one*** lens/lenses.
3) Antonie van Leeuwenhoek was the first who saw and described ***bacteries, the existence of tiny living organisms in a drop of water, the circulation of blood corpuscles in capillaries,yeast.***
4) Robert Hooke constructed his first microscope about ***1660*** a.d. He built the microscope which had ***three*** lenses.

II. Name the marked elements on the Hooke's microscope's scheme .



III. Rewrite from the one of the presentation's sidle the magnification formula.

$$m = \frac{s}{f_{ok}} \cdot \frac{25\ cm}{f_{ob}}$$

s – the length of microscope tube

f_{ob} *– focal length of* ***objective***

f_{ok} *– focal length of* ***eyepiece***

IV. The focal length of objective of a microscope is equal 1 cm and focal length of eyepiece 5 cm. How big is the microscope's magnification, if the length of tube's microscope is equal 10 cm?

Data: Unkown: Formula:

f_{ok}= 5 cm m = ?

f_{ob} = 1 cm, s = 10 cm

$$M = \frac{10\ cm}{5\ cm} \cdot \frac{25\ cm}{1\ cm} = 2 \cdot 25 = 50$$

Answer: The microscope's magnification is equal 50.

Questionnaire analysis related to the lesson:

"Optical microscope since the first to the contemporary one"

by Magdalena Sadowska

Annex 3

The survey on awareness of students in the substance of research and understanding the nature of science and its importance for society and themselves, developed by the Partner of HIPST project (Annex 2) was carried out before the lesson in two classes of vocational school(2nd grade) and in two classes of junior high school (2nd and 3rd grade). Altogether, 49 students took part in the survey. After the lesson there were only 22 surveyed students from 2nd and 3rd grade of junior high school. A small number of students involved in the survey conveyed after the lesson was due to the fact that the lesson "Optical microscope since the first to the contemporary one" took place in June, the end of school year. The survey consisted of two parts. The second part was slightly changed by us- adapted to our conditions.

PART I

The first part of the survey consisted of general statements. The students responded to the questions using the Likert scale choosing from among five answers: strongly disagree, disagree, neither agree nor disagree, agree, strongly agree.

Surprise for me was the fact that most of the students think that "in science, most of the questions have only one correct answer". Before the lesson 20% of 2nd grade students, 50% of 3rd grade junior high school students and 75% of 2nd grade vocational school students chose the answers: strongly agree, or agree. After the lesson many students changed their answers from strongly agree to agree, but the percentage rate hasn't changed. On the question "anything that they have ever read in scientific books is true" 40% of 2nd grade students, 32% of 3rd grade junior high school students and 10% of 2nd grade vocational school students answered that they neither agree nor disagree. But most students, 60% of 2nd grade students, 55% of 3rd grade junior high school students and 90% of 2nd grade vocational school students, answered - I agree or strongly agree. In the survey conducted for the second time 100% of 2nd grade students and 69% of 3rd grade junior high school students stated that anything that they have ever read in scientific books is true. Most of the students agreed that "science helps understand the world" but there were some to disagree (at the first and second time the survey was conducted- 20% of 2nd grade students, for the first time 23% of 3rd grade junior high school students and for the second time 6% of them). It was hard for the students to say whether national policy, the economy, financial and family situation, religion and art influence the scientists. " 80% of 2nd grade students, 45% of 3rd grade junior high school students and 45% of 2nd grade vocational school students chose the answer – neither agree nor disagree, similarly in the second survey. The vast majority of the students agreed that in science there is always one truth – in the first survey 100% of 2nd grade students, 60% of 3rd grade junior high school students and 55% of 2nd grade vocational school students, and in the second survey 88% of 2nd grade students, 56% of 3rd grade junior high school students. In the first survey 100% of 2nd grade students,72% of 3rd grade junior high school students and 95% of 2nd grade vocational school students agreed that scientist can explain one thing in a variety of different ways. In the second survey in the 3rd grade the amount of these answers rose to 82% . " Scientists start research having an idea in their minds" – with this statements agreed 60% of 2nd grade students, 40% of 3rd grade junior high school students and 90% of 2nd grade vocational school students, and in the second repeated survey 84% of 2nd grade students, 69% of 3rd grade junior high school students chose this answer. Students believe that a way of explaining something scientific may change over time – before the lesson 40% of 2nd grade students, 63% of 3rd grade junior high school students and 95% of 2nd grade vocational school

students agreed with this statement while after the lesson the rate dropped from 40% to 33% in 2nd grade and to 56% in 3rd grade. I was surprised with this drop.

Interesting are responses to the statement: " all scientists use the same scientific method" illustrated by diagram (Fig. 1a and 1b).

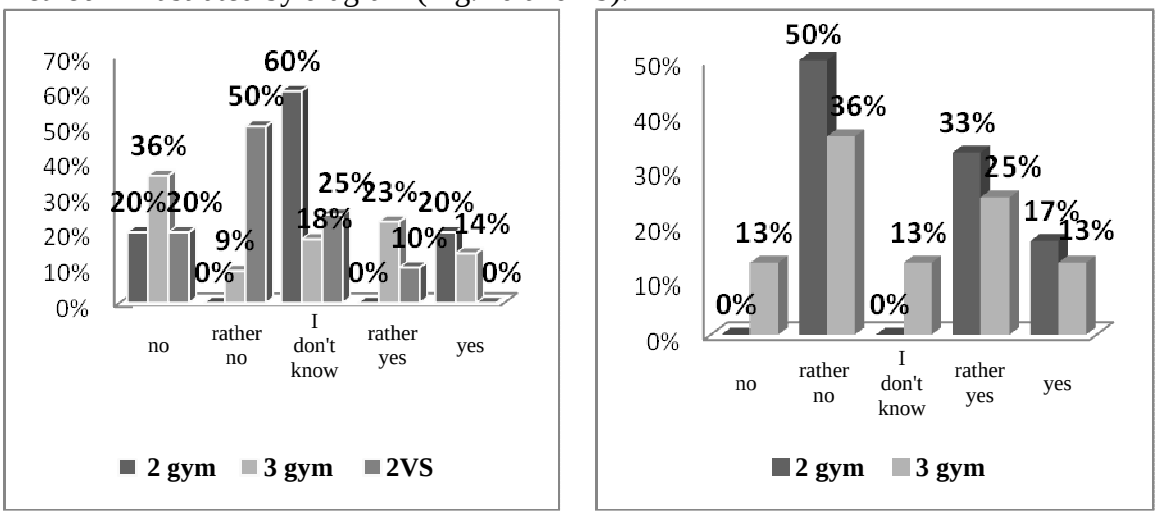


Fig. 1 Answers of students on the question: „All scientists follow the same scientific method" a) before lesson b) after lesson

Most students believe that scientists conduct scientific research in different ways, 80% of 2nd grade students, 77% of 3rd grade junior high school students and 95% of 2nd grade vocational school students chose the answer – I agree, I strongly disagree. However, in the second survey the number of these answers rose to 88% in 2nd grade and to 82% in 3rd grade.

An interesting distribution of students' responses is observed on statement that science helps to make our life, healthier, easier and more comfortable – Fig.2.

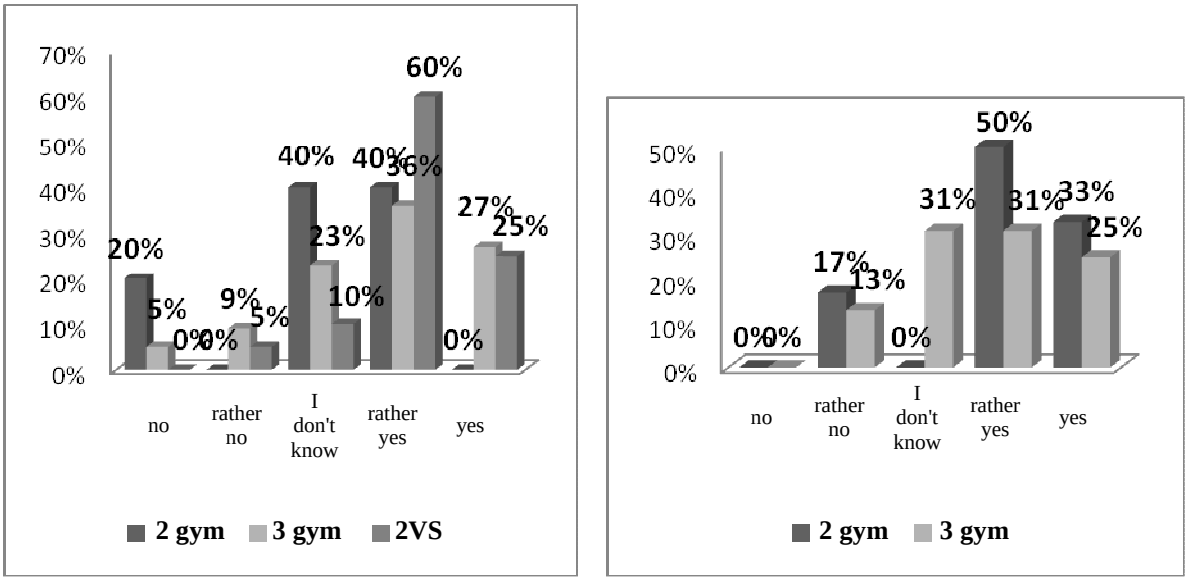


Fig. 2. Answers on the question: „Science helps to make our life healthier, easier and more comfortable" a) before lesson b) after lesson

The students answered that science is both for men and women. Most of them didn't agree that "science is only for talented people". On the statement: "Anything that we learn thanks to science can considerably help us to make decisions in everyday life" only 20% of 2nd grade students, 23% of 3rd grade junior high school students and 10% of 2nd grade vocational school students chose the answers – strongly disagree and disagree before the

lesson. Opposite view had 80% of 2nd graders, 64% of 3rd graders of junior high school and 75% of 2nd grade vocational school students. In the survey conducted after the lesson the answers were alike. Over 50% of the total sample of students questioned both before and after the lesson agreed that we should know anything about science no matter whether it will be helpful or not in our jobs. The answers were as follows: before the lesson , 20% of 2nd grade students, 59% of 3rd grade junior high school students and 90% of 2nd grade vocational school students and after the lesson 66% of 2nd graders and 63% of 3rd grade junior high school students. Both before and after the lesson comparable percentage of students chose the answer – neither agree nor disagree – for the statement: " The way scientists work is influenced by what people consider important". (Fig.3)

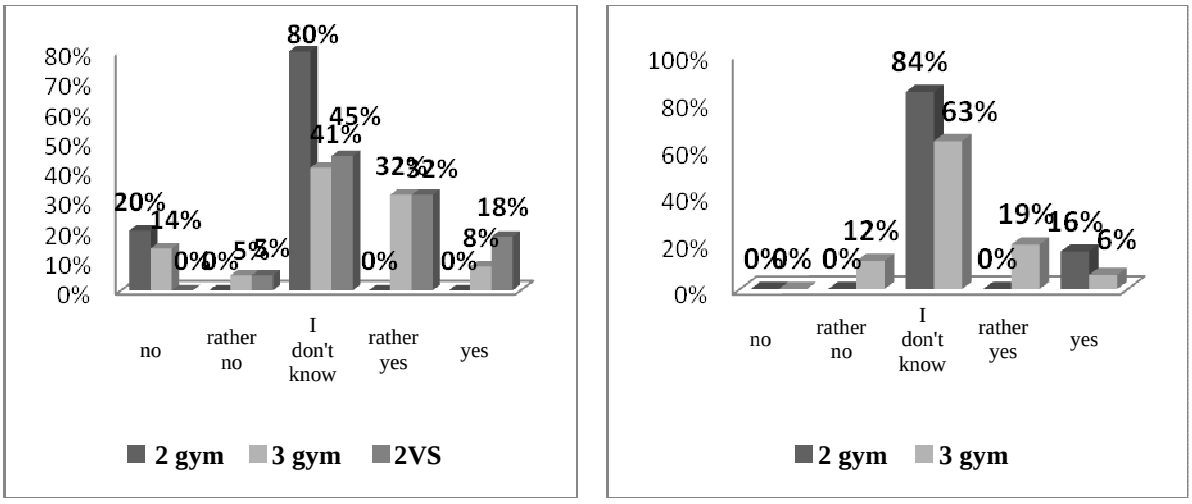


Fig. 3 Answers related to: „The way scientists work is influenced by what People consider important „ a) before lesson b) after lesson

The students had also different opinions of the statement: " we are all responsible for the way scientific research results are used in everyday life" – Fig. 4.

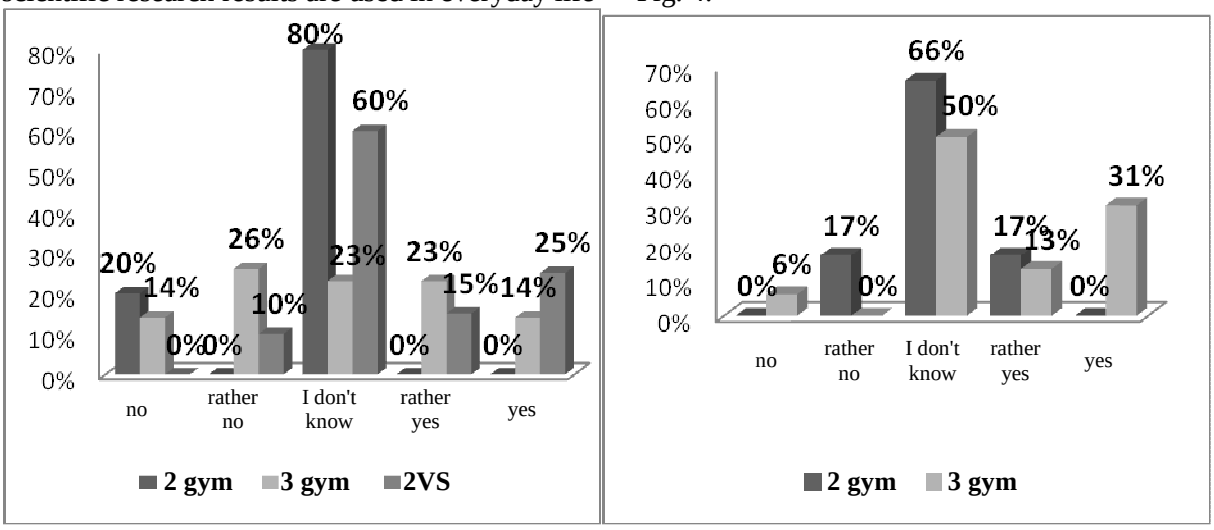


Fig. 4. ***Answers related to: „We are all responsible for the way scientific research results are used in the everyday life" „ a) before lesson b) after lesson***

PART II

The questions in the second part of the survey related directly to the students. There were five responses to choose from: describes me perfectly, describes me moderately, neither agree nor disagree, disagree and strongly disagree. It turned out that in all classes students like discussing their ideas with teachers – before the lesson 40% of 2nd grade students agreed, 64%

of 3rd grade junior high school students and 60% of 2nd grade vocational school students and after the lesson the same opinion had 66% of 2nd graders and 59% of 3rd graders. Surprise the fact that the students like teachers to explain them what to do in science course. Their opinion has not changed after the lesson. This is worrying as it shows that students prefer to reconstruct the knowledge rather than to explore it on their own. The students of both schools indicated in both surveys that they do not like to find out the topic of the lesson on their own. The results of the survey show that some junior high school students and some vocational school students like working alone in science course and the rest of them like working with friends – Fig. 5 and 6, the results were identical in both surveys.

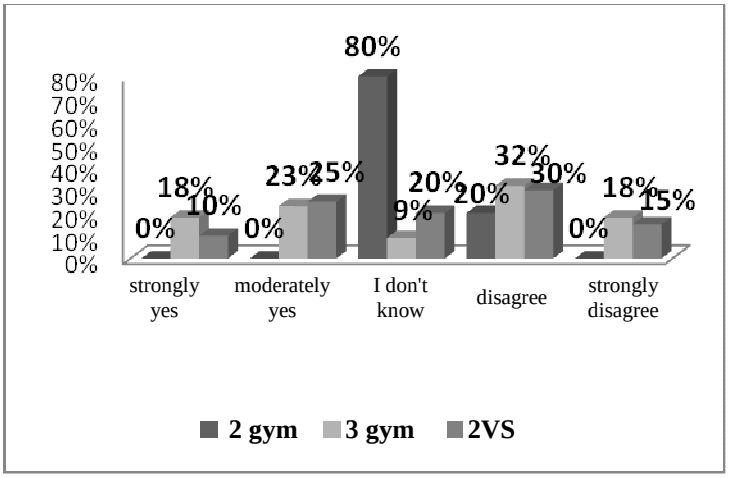


Fig. 5 Answers on: „Some People like working alone in science courses"

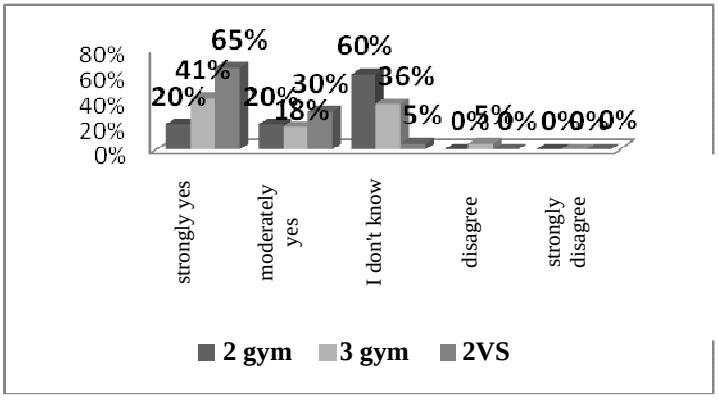


Fig. 6. Answers on: „Some People like working with friends in science courses"

On the basis of this survey it can be assumed that the students also like discussing their ideas with friends. 40% of 2nd graders, 35% of 3rd graders and 95% of vocational school students state that this statement refers to them strongly or moderately. 34% of 2nd graders,47% of 3rd graders and 50% of vocational school students agree with the statement that "young people believe that it is hard to explore new things in science courses". Many students, namely 20% of 2nd graders, 50% of 3rd graders and 30% of vocational school students believe that they have to do too much work in science courses. 2nd grade students state that they do not do well in science courses. On the contrary 68% of 3rd graders and 45% of vocational school students do very well. The analysis of the results of the survey show that the students are not very fond of science courses. None of the 2nd graders stated that science course is one of his favorite subject. About 38% of 3rd grade students and 30% vocational school students says that it is one of their favorite subject. Very interesting are the opinions of students about doing well in exams and tests in science courses. Fig.7.

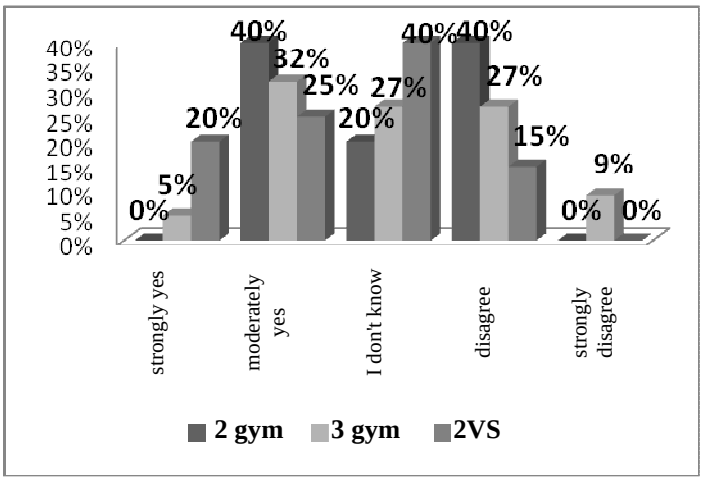


Fig. 7. Answers on: 'Some People usually do well in exams and tests in science courses"

I was positively surprised at the answers to the statement that: "some people like science courses" Fig.8

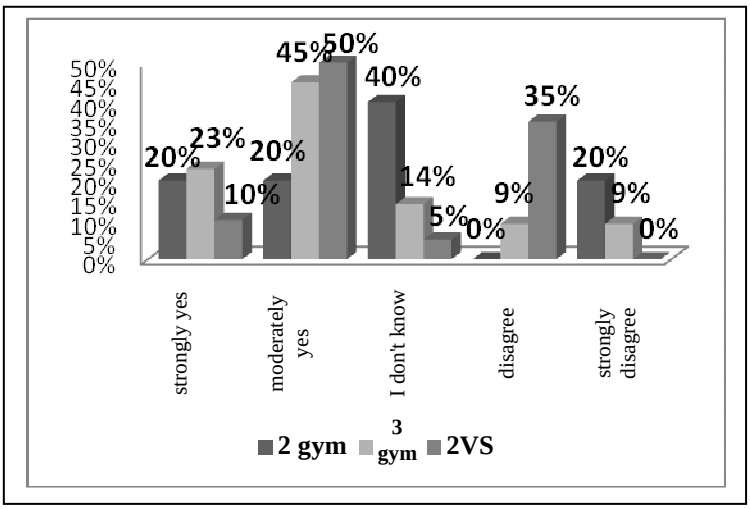


Fig. 8. Answers related to: „Some People like science courses"

SUMMARY

Elements of the history of physics put into lessons contributed to a growing students' interest in its content. Innovative themes increased the activity of students. Students in the talks expressed its appreciation and satisfaction with the form of lesson, which differed significantly from the traditional ones.

However, if it comes to students test results conducted on the basis of the above „nature of science" surveys, given the fact that this type of research had place for the first time, it can be assumed, that the results can be unreliable, as particularly at the junior high school level. It seems that after only one lesson conducted in such a way, the views of students on the nature of science can not fundamentally change. In our view, it should be as often as possible to reach the physics teaching both by incorporating elements of the history and philosophy of science, as well as apply adequate to this subject matter the active teaching methods. However, according to the analysis of the responses of students to the conducted re-survey after the lesson in some cases awareness of students about the nature and importance of science has changed positively .