

Description of Case studies: „Studies of Witelo on rectilinear propagation of light” - - for exchange within the HIPST project

1. Title:

„Studies of Witelo on rectilinear propagation of light”.

Key words: history of optics, Witelo, replica, experiment, rectilinear motion of light, shadow

2. Authors and Institutions:

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3. Summary:

Topics related to the light and its role in nature in the Polish curriculum is divided into topics related to the geometric optics, which only in approximate way describes propagation of light and wave optics, where phenomena associated with the wave nature of light as interference, diffraction and polarization are discussed. Later, in the modern physics, second, molecular (quantum) nature of light is also considered. One of the first - if not the first - theme is the phenomenon of reflection and refraction of light falling on the boundaries between the various media. Most teachers just take this opportunity to talk about the basic assumption of geometric optics – on rectilinear propagation of light and the light itself present in the form of radiating rays. Later, this model of light is used in constructing the images produced in mirrors, lenses as well as in more sophisticated optical instruments. In general, however, the large volume of material that must be achieved within a lesson unit, omitted an explanation of the basis on which the light "emerges" in the form of straight lines or section that is fair view of light rays, as well as physical considerations and observations confirming the validity of this assumption. We take it as certainty (axiom). **So, lacking in our curriculum introductory lesson to geometrical optics!** Lessons, during which the students themselves could conclude on rectilinear motion of light, and the consequences of such motion.

Aim of this lesson would be also illustration, as sometimes long way leads from the observation of the phenomenon to drawing the correct conclusions, showing its explanation.

The shadow is accompanied by the People "always". Probably many a time was asked what is the reason for its creation and what are the conditions on which his "look" depends. The discovery - the shadow of light arises because the light in the homogeneous space move along straight lines – drew out Witelo, but only in the thirteenth century.

This subject can and should be implemented at both (lower and higher) secondary schools and at every level of education.

4. Description of Case study

Lesson, which the theme is "Studies of Witelo on rectilinear propagation of light" (Scenario - see Annex 1) in the form proposed by us, has been carried out in the second class of higher secondary school (adolescents of 18 years) with mathematical - physics profile.

Essential part of the lesson was preceded by the fulfilment of the student survey, in which they had the opportunity to comment on: what about is science, whether and to what extent are they

aware of the fact that the achievements of science are used almost everywhere, who is a scientist for them, what is his style of work and what are the conditions of the scientific work. The results of the survey, together with student developments can be found in Annex 3 (Nature of Science - NoS Questionnaire).

Fundamental lesson was divided into two parts: the first - in which using replica of Witelo equipment and today known methods we evidenced the rectilinear propagation of light, the second - during which we were acquainted and also "played" with the consequences of such phenomenon.

Lesson itself proceeded as follows. Students after completing the survey were familiar with the figure Witelo. For this purpose, not to spend too much time on Witelo CV, but only indicate its importance for the world of science, a multimedia presentation was used (Annex 2- in Polish so far). Teacher is asking a few questions like: What is light? What its sources you know? In this way the teacher is trying to determine the level of knowledge of students on the topic, errors in reasoning, and expression of the understanding by students. Afterwards, the students are familiarize with the definition of light and the light ray given by Witelo. The students pay attention to the archaic language of these definitions. Using a laser pointer, and an aquarium containing water with dissolved in the drops of milk shows that the light in the homogeneous media, if does not encountered any obstacles, propagates in straight lines. To show that not only the laser light (which is collimated and targeted beam), but also light from the continuous source runs rectilinearly, we reconstruct the original experiment of Witelo. This experiment is carried out independently with two pairs of students, other students are watching, drawing conclusions. A simple consequence of the rectilinear propagation of light is the formation of a shadow, what was also the subject of Witelo. research. Willing, the students played the role of researchers I divided them roughly into equally-numerous groups. Each group have been equipped with various light sources (spotlights and continuous), transparent and not transparent objects of all sizes and shapes, etc. Using the above. instruments they had to answer the questions: What is the shadow? "Where we see it?, What determines the intensity of the shadow?, What is a penumbra?, What determines the number of formed shadows? Is the phenomenon of the shadow and penumbra related to the sun or the moon eclipse observations?

Active, enquiry work of students during the lesson has been documented by them, while by the teacher's positively evaluated. Pupils discovery was that they fill very well in the role of "researchers", "fun" with shadows caused them a lot of fun. At the end of the lesson they reported the need for more frequent lessons organised in this way.

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

Witelo was the first in the history of Polish scholars (such as historical sources indicate - he was the son of Poles and Turyngian). The first, and once one of the greatest in Europe in the thirteenth century. Was one of the closest leading contemporary intellectual elite and his works were known to Nicolaus Copernicus, Johannes Kepler and Leonardo da Vinci. Thirteenth-century deep Middle Ages - a time of superstitions, prejudices, witches, demons and devils. However, as the case of Witelo and others like him, became a time fascinated by the logic and Aristotle's rationalism. Indeed, for Witelo empirical facts were more important than intuitive studies.

Both the political situation in the country, as well as generally accepted belief, rising to the highest rank of the church, were not conducive to the development of Witelo, who had just started his studies at the University of Paris. There he met St. Thomas, who as himself was an advocate of

the theory of Aristotle. At the same time at the University of Paris taught St. Bonaventure representing the other side of the ideological barricades. Ultimately, however St. Bonaventure, but not St. Thomas instilled young Pole his fascination with light. Witelo since then he had his own theory of the mechanism and the physiology of vision, particularly his own theory of the formation of optical illusions, writing that "the eye does not receive any other information outside the light, colours and size of the angles, but only the mind is processing impressions with the help of performances taken from the experience". Witelo used the advantage of his theory, without reference to the "satanic power" for explaining the event that took place in his homeland. Well, gray dawn, a certain Henry Cat profession knight, while hunting for wolves in the woods of Legnica saw a wolf the size of the wall of forest. Gigantic beast ran into pig strapped as the bait near the trap. Knight Cat, although "in great fear", but managed to remain in position long enough to see an extraordinary thing - the wolf as he approached the pig, was smaller and smaller, and when the victim was already at him become of natural size. Witelo pointed out, that the observations were made at very low light (dawn), which has prevented proper evaluation of the distance. Hence, there was an optical illusion, resulting from a deficiency of information received by the eye.

Serious scientific work on optics, Witelo started at the Papal court - during the conclave after the death of Pope Clement IV. As the result of that work, a work of life of Witelo "Perspectivorum libri decem" was created. In this Book the contemporary knowledge in the field of optics Phenomena: the rectilinear propagation of light, its reflection, refraction and dispersion were discussed in a precise way, that is most closely based on mathematics and geometry. Witelo in the work "Perspectivorum ..."describes a devices that served him to obtain an empirical knowledge on physical phenomena, in particular a device by which in a simple, though ingenious way he has proven rectilinear propagation of light.

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

The target group are students of all types of schools at every level of education. This lesson can be done also in extracurricular activities, such as the physics circles. Study of rectilinear propagation of light as well as "shadow party" creates an opportunity to make it one of the elements of interactive exhibitions arranged in the exploratory or technology museum. The lesson has inquiry character, ie: students do their own historical experiment demonstrating a straight run of light and looking for simpler, more modern methods of presentation. Performing simple experiments with a shadow they are answering the questions: When is the shadow coming into existence? Why does it arise? A Where a shadow arises? What determines "look" and the number of emerging shadows?

The lesson is a fun, during which the following concepts are assimilated: a light beam, a stream of light, shadow, penumbra, and also in a qualitative way the phenomena of solar and the moon eclipses are explained. Pupil doing their own experiment ceases to be real doubt whether the light propagates in straight lines, which is relevant in its further studies. Introducing of the historical elements aims to encourage students to learn "from bases", stretching to the beginning, the first things, the basic concepts and definitions. We think that only then knowledge of students will be complete and reliable.

7. Activities, methods and tools of learning

Teaching Methods:

- based on the word,

a talk - presentation in a clear and transparent manner of the necessity to conduct research by Witelo in optics, and to quote some definitions, postulates and theorems formulated by him,

- **based on the observations and measurements,**

demonstration and measurements – repetition (with details) of the Witelo experiment Witelo by two pairs of students, reading the results and drawing appropriate conclusions

Educational tools:

- a copy of the presentation device of Witelo (replica) for rectilinear propagation of light,
- multimedia projector, computer, ppt presentation,
- overhead projector, a sample of transparent and not transparent items,
- three light sources (candles, light bulbs),
- three different sizes of balls or round fruits,
- board, chalk.

8. Difficulties in teaching and learning

Lesson conducted in the project HIPST was preceded by a survey in which students demonstrated knowledge related to the science and scientists, as well as have the opportunity to identify their relation to science, popular –scientific and the scientific literature, etc.

Fundamental lesson was a fun. Students correctly answered questions and formulated their own conclusions and proposals related to the made observations. Demonstrated also the creativeness in the search for modern methods of presentation rectilinear propagation of light. A little problem was with the historical experiment of Witelo, where we used continuous source of light. Students didn't know that as a consequence of rectilinear transmission of light, after removing the obstacle from the Witelo device, width across the beam on both sides of the hole in the wall of cylinder will increase the same. This difficulty can be solved by enriching experiment with simulation, replacing the beam of light in the original experiment by the rays in the computer simulation.

After the lesson, Questionnaire (on NOS), which has been previously completed was repeated.

9. Teacher's pedagogical competencies

To carry out a similar lesson does not require any additional capacity or skills, but only those which are necessary to work as a teacher. Everything what decided to undertake our tasks, the mission of learning and teaching others is completely enough here. Little difficulty, can make only the construction a replica of Witelo device. To achieve the desired results we can use just the simplified version of this instrument – e.g. the paper cylinder with indicated on its inner side the angle in degrees, a pair of concentric holes in the walls of the cylinder and small block with small holes at an appropriate height. Necessary is also an appropriate source of light.

10. Documentation (evidence) of studies

Documentation of the survey research is eg. awareness studies of students on the use of science in everyday life, the need for scientific research as well as the impact of determinants of the age in which scientists are living on the process of creation – discovering.

11. Further professional development of users

1) L. Bieganowski, A. Bielski, R.S. Dygdała, W. Wróblewski,

Witelona Perspektywy Księga II i III, Wydawnictwo Polskiej Akademii Nauk, 1991,

2) A. Bielski, L. Bieganowski, Studia i Materiały z Dziejów Nauki.

3) J. Turlo et al, Europejski projekt FP7 HIPST, Nauczanie Przedmiotów Przyrodniczych, 30/2009, ss. 41-48

12. Written literature resources

1) Scenario of the lesson on: Studies of Witelo on rectilinear propagation of light”.

2) Multimedia presentation – „Studies of Witelo on rectilinear propagation of light ”ppt,

3) Analysis of Questionnaire on Nature of Science

4) Description of Case studies” on the same topic,

5) Paper J. Chojnacka, on: „Studies of Witelo on rectilinear propagation of light”- proposition of inquiry based lesson within HIPST project, Science Teaching, No 32/2009, pp. 16-22 .

6) Multimedia presentation at the II National HIPST Meeting in Olsztyn 12.09.2009.