The use of interdisciplinary approach for the formation of learners' situational interest in Physics

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Abstract

The aim of this article is to prove the advisability of using the interdisciplinary approach for the formation of learners' situational interest in physics. The general method of using the interdisciplinary approach in physics teaching has been created. The study of new material, the formation of abilities and skills, and the work on projects are the forms of the interdisciplinary links in physics teaching. The scheme for interest formation towards physics in the context of development of situational and individual interest has been analyzed. According to the interdisciplinary approach, the tools for the formation of learners' situational interest in physics have been allocated. These are phenomena of nature, phenomena of everyday life, link between theory and practice. The results showed that interdisciplinary approach in physics teaching increases the level of learners' situational interest. Proposed general method of using the interdisciplinary approach can be used for teaching other sciences.

Keywords: learners, situational interest, physics, interdisciplinary approach, science

Choose a job you love, and you will never have to work a day in your life.

Confucius (551 BC – 479 BC)

Introduction

To teach without motivation is difficult. Therefore, the problem of learners' motivation is relevant in education (e.g., Krapp, Hidi & Renninger, 1992; Chow & Yong, 2013; Leung, 2015; Ghbari, 2016; Baran, 2016). A small number of learners like to study physics in schools of Ukraine. This affects the choice of professions by learners and on the prestige of professions of technical directions. Often learners do not like to study physics because its complexity. In this way, the tasks of the teacher are to make physics teaching more accessible, understandable, and interesting. An analysis of educational journals makes it possible to determine the different approaches for the formation of learners' interest in physics (Table I).

Table I. Different approaches for the formation of learners' interest in physics

Authors	**Offers**
Fischer & Horstendahl (1997)	discource oriented learning environment
Kazachkova, Kasperskiy & Polikhun (2010)	cognitive presentations with elements of show
Shulika (2010)	tasks with everyday content
Hong & Lin-Siegler (2012)	images of scientists
Koç & Böyük (2012)	hands-on science experiments
Kazachkova (2013)	use of non-standard equipment for experiments

Peciuliauskiene (2015)	digital physics experiments
Pečiuliauskienė & Dagys (2016)	physics experimental activities

Many branches of modern science are related closely. Therefore, the school subjects cannot be isolated from each other. The problem of interdisciplinary approach is relevant in current education (e.g., Bayer, 2009; Boix-Mansilla, 2010; Crowther, 2012; Lipszyc, 2012; Steiner-Khamsi, 2014; Holubova, 2015). According to Casey (2009), "the interdisciplinary approach has become an important and challenging technique in the modern curriculum" (p. 76). Manolea (2014) said that "learning the basic sciences in interdisciplinary spirit ensures the enhanced effectiveness of the school performance, allowing student to understand that physics, chemistry, biology, mathematics are open systems whose structure may be changed and whose borders are pushed increasingly on humanity (p. 81). Turna and Bolat (2016) proved that interdisciplinary approach provides the didactic conditions and means of deep and comprehensive mastering the basics of science. The possibility of using the interdisciplinary approach for the formation of learners' interest in physics has been not investigated enough. The aim of this article is to prove the advisability of using the interdisciplinary approach for the formation of learners' situational interest in physics.

Method

According to Krapp (2002), an interest can be caused either by an already existing dispositional interest (individual interest) or by the special conditions of a teaching (situational interest) (p. 388). Situational interest is caused primarily by external factors. Situational interest is real topic of concern as teachers have no influence over students' incoming personal interest (Mitchell, 1993, p. 425). Hidi and Renninger (2006) have proposed a Four-Phase Model of Interest Development: triggered situational interest, maintained situational interest, emerging individual interest and well-developed individual interest. According to this model, situational interest is a basis for the formation of individual interest. Therefore, the formation of learners' situational interest is important for teaching of any school subject.

Lanina (1985) offered the following scheme for the formation of learners' interest in physics: curiosity – active curiosity – attempts to understand – strong knowledge – scientific research (pp. 5-6). We analyzed this scheme in the context of development of situational and individual interest (Korsun, 2017a, p. 119). The situational interest begins to form on the first step, "curiosity". After this step, learners show the increasing importance of the object for their interest. So, curiosity turns into an active curiosity. The next step, "attempts to understand", is characterized by the desire of learners to learn more about the object or the phenomenon. The step "strong knowledge" is associated with volitional efforts of learners and application of knowledge in practice. On this step individual interest begins to form. The final step, "scientific research", is the highest stage of interest, during which learners formulate their own tasks and will deal solve them. In this way, the development of situational interest is associated with steps "curiosity", "active curiosity" and "attempts to understand".

Williams et al. (2003) have revealed some of the reasons why students might lose interest in physics over the course of secondary school. According to Williams et al. (2003), interdisciplinary links is one of ways in which we might attempt to enhance students' interest in physics (p. 329). Tan (2007) substantiated that "plain knowledge dissemination will not adequately prepare students to cope with the changing world. Hence, schools need to train students to be reflective in their learning habits – that is, getting students to be observant, to generate relevant alternatives and to make sense of these ideas". One of the challenges of the modern teacher – show to student the interdisciplinary communication on concrete examples. This is an extremely important condition for building a quality education system ("Interdisciplinary communication geography and other sciences"). According to this approaches, we consider the possibility of using the interdisciplinary approach for the formation of learners' situational interest in physics. Physics has interdisciplinary links with the many school subjects because physics is a fundamental science. Each learner has favorite school subjects or hobbies (e.g., soccer, figure skating). Therefore, the knowledge of these favorite school subjects may underlie for the formation of learners' situational interest in physics. The examples of related topics are presented in Table II.

Table II. Examples of related topics

School subject	**Themes**	**Physics**
Mathematics	1. Function	equation of body motion and graphics of motion
	2. Scalar and vector quantities	work, the force
	3. Scalar product	mechanical work

	4. Derivative	speed, acceleration
	5. Integral	numerical value of work
Astronomy	1. The movement of celestial bodies	The Universal Law of Gravitation
	2. Energy of Sun	thermonuclear reaction
	3. Flying of rockets	The Law of Momentum Conservation
	4. Observation for celestial bodies	telescopes
	5. The study of celestial bodies	radiation, spectra
Chemistry	1. Atomic-molecular theory	kinetic molecular theory of matter
	2. Periodic table of elements	atom, mass number, charge number
	3. Electrolytes	Faraday's laws of electrolysis
	4. Isotopes	radionuclides
	5. Exothermic reactions	nuclear reactions
Biology	1. Photosynthesis	the quantum properties of light
	2. Thermoregulation	heat
	3. Biopotential	electric charge
	4. Plants	capillary phenomena
	5. Human vision	lenses
Geography	1. Atmosphere	atmospheric pressure
	2. Northern Lights	Earth's magnetic field
	3. Geysers	mutual transformation of liquids and gases
	4. Volcanoes	aggregate states of matter
	5. Earthquakes	infrasound

Holubova (2015) has found out that learners can be motivated by various instructional methods based on their own activity. The author proposed to use the problem based learning, project based learning, team work, inquiry based learning, interdisciplinary approach, experiments – from very simple and low cost experiments to computer based experiments and remote laboratories. According to this approach, we have analyzed the works of scientists (Sergeev, 1979; Dik & Turysheva, 1987; Kats, 1988). It helped to determine the forms of the interdisciplinary links in physics teaching (Korsun, 2017b; pp. 109-110). These forms are presented in Figure 1.

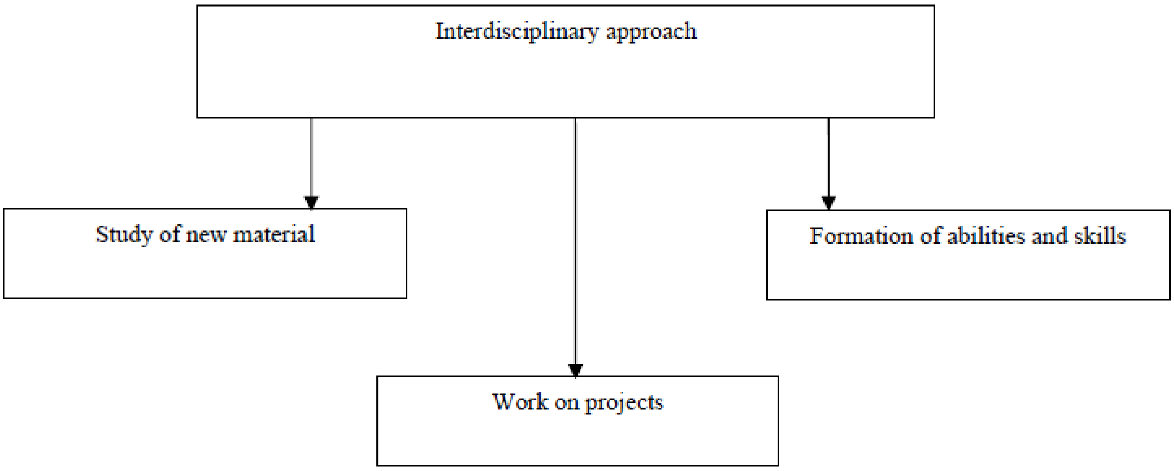

Figure 1. The forms of interdisciplinary links in physics teaching

Study of new material. Erinosho (2013) has proposed to use the concrete examples for the learners' motivation in physics (p. 151). Interdisciplinary approach allows to formulate the problems. For example, the study of the lesson "Thermonuclear reactions" (Physics) begins with the formulation of the problem (step "curiosity"). The Sun is the energy source (Astronomy). This energy reaches our planet during radiation. The mass of the Sun is reduced about by 4.2×10^9 kg during 1 s. But the next day, the Sun continues to shine (step "active curiosity"). Why the mass of the Sun is not reduced? Thermonuclear reactions are the energy source of the Sun (step "attempts to understand"). Thermonuclear reactions occur in the other stars (step "strong knowledge"). Is it possible to create a thermonuclear reaction on the Earth? Explosion of the hydrogen bomb is an example of uncontrollable thermonuclear reaction. Now scientists are working on creation a controlled thermonuclear reaction (step "scientific research").

Formation of abilities and skills. Most learners do not understand the practical use of physics laws (results of pre-test). According to Wang (2005), "what we must do is not only teach students knowledge, but also develop their problem solving skills and lifelong learning skills" (p. 1). Any physical law describes the link between certain physics phenomena. Mathematics formulates the law of physics with using formula. For example, we consider the task about radiocarbon dating (practical exercises "Tasks on radioactivity"). Nitrogen atoms are constantly in the Earth's atmosphere (78.082% by volume of dry air). Nitrogen nuclei are transformed into radioactive Carbon nucleus under the influence of cosmic radiation (Chemistry). Carbon enters into the plants (Biology). The amount of this radioactive isotope decreases gradually when plant dies. Archaeological godsend is made of wood (History). Scientists determine the radioactivity of Carbon A in archaeological godsend using radiocarbon dating. This value is compared with the radioactivity of Carbon A_0 in the tree, which had just cut down. Learners have determined the age t of archaeological godsend using the law of radioactivity change ($A=A_0\ 2^{-t/T}$, where T is half-life of Carbon).

Work on projects. Physics is a fundamental science. Therefore, the interdisciplinary links between physics and other sciences form the scientific outlook of learners. Work on projects implies the existence of learners' individual interest (Rosales JR & Sulaiman, 2016). For example, consider the main issues of the project "Discovery of Higgs boson". The Large Hadron Collider (LHC) is the most larger experimental setup in the world. LHC lies near Geneva, Switzerland, in a tunnel 27 km in circumference and runs underground at a depth of 175 m. The aim of study is to test the predictions of different theories. In 2012, scientists opened a particle similar to the Higgs boson which is the only missing link of Standard Model. Data from collisions have been analyzed with a grid-based computer network infrastructure connecting 140 computing centers in 35 countries (Informatics). The Worldwide LHC Computing Grid is the world's largest computing grid ("What is the Worldwide LHC Computing Grid?", 2011). British physicist Peter Higgs predicted this particle half a century ago (History). The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider" ("The Nobel Prize in Physics 2013").

Research Design

In this study, quasi-experimental design is used. The hypothesis of the research project is: the use of interdisciplinary approach in physics teaching will raise the level of learners' situational interest.

Schraw, Flowerday and Lehman (2001) have concluded six specific suggestions for increasing situational interest in the classroom, such as offer meaningful choices to students; use well-organized texts; select texts that are vivid; use texts that students know about; encourage students to be active learners; and provide relevance cues for students (pp. 220-221). According to these specific suggestions, we analysed the proposed forms of the interdisciplinary links in physics teaching. It helped to identify the tools for the formation of learners' situational interest (Figure 2).

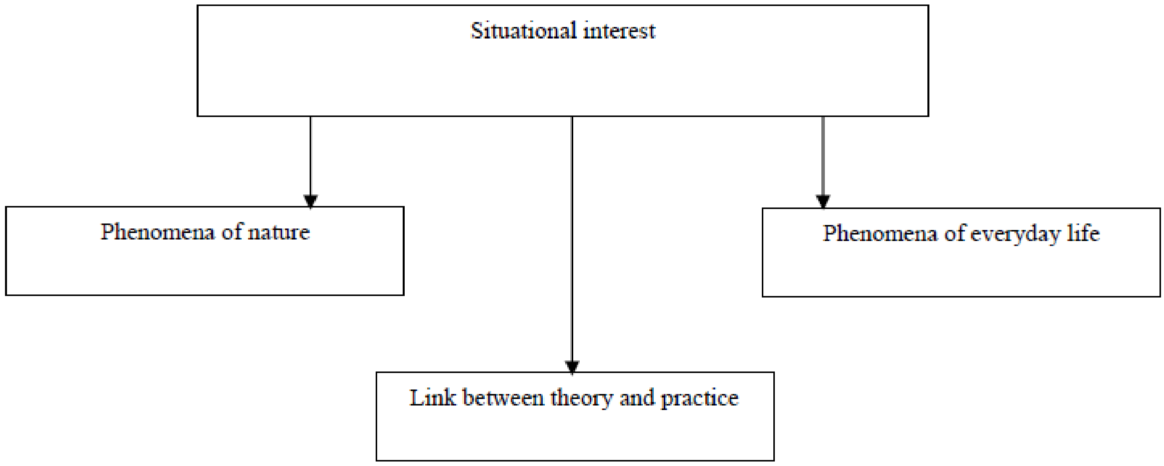

Figure 2. The tools for the formation of learners' situational interest in physics

Phenomena of nature and everyday life. The knowledge of physics makes it possible to explain the natural phenomena and events of everyday life. Woolnough (1994) proved that subject is interesting for learners when they perceive it as "relevant". Therefore, application of theoretical knowledge for explain of the phenomena in surrounding world always attracts the learners' attention. Appendix A contains the examples of interdisciplinary links between Physics and Biology (Korsun, 2013, pp. 59-60), between Physics and Geography and sports (Korsun, 2013, pp. 24-25).

Link between theory and practice. Often learners are not study physical laws, explaining that these physical laws do not need them for a future profession. Examples of practical use of physics laws allow the teacher to show the importance of physical knowledge (Dik & Turysheva, 1987, p. 6). It allows the learners to make sure that the development of physics made possible the development of technological progress. Appendix B contains the examples of practical use of magnetism for search of minerals.

Knowledge of physics are used in medicine (e.g., fluoroscopy), in engineering (e.g., construction of buildings), in technique (e.g., designing of rockets), in aviation (e.g., flight of aircraft), in industry (e.g., car manufacturing), in agriculture (e.g., crop growing), in meteorology (e.g., weather forecasting), in geology (e.g., study of earthquakes). There are number of related sciences (e.g., Biophysics, Geophysics, Physical chemistry). Learners have to realize that without the necessary knowledge of physics they cannot become professionals in their future work. It will promote to the conscious choice of profession by learners. Appendix B contains the example of interdisciplinary links between Physics and Engineering (Korsun, 2013, pp. 31-33).

Participants

Pedagogical experiment has been conducted in 10 and 11 classes (age of learners is 16-17) during the first semester 2015-2016 academic year. Pre-service physics teachers who are studying at the Physics and Mathematics Faculty in Ternopil Volodymyr Hnatyuk National Pedagogical University (Ukraine) conducted an experiment during the pedagogical practice. Two classes of the control group (45 learners) and two classes of experimental group (42 learners) took part in the study.

Instrument

Teachers used the questionnaire method. Each learner filled in the questionnaire. The list of 10 open-ended questions is presented in Table III.

Table III. List of questions

1.	Please write the example of using the physics in mathematics
2.	Please write the example of using the physics in astronomy
3.	Please write the example of using the physics in chemistry
4.	Please write the example of using the physics in biology
5.	Please write the example of using the physics in geography
6.	Please write the example of modern research in physics
7.	Please write the title of book on physics
8.	Please write the title of scientific journal
9.	Please write the title of the scientific site
10.	Please write the name of scientist, who is a winner of the Nobel Prize in Physics or in Chemistry or in Medicine

Evaluation:
0-4 answers indicate a low level of situational interest;
5-7 answers indicate an average level of situational interest;
8-10 answer indicate a high level of situational interest.

Procedure

The three levels of learners' situational interest are low, average, and high. According to questioning, the level of each learner's situational interest in control group and experimental group was determined by pre-test. During the semester, the physics teaching in the experimental group (EG) was conducted using the interdisciplinary approach; and in the control group (CG), the physics teaching was conducted without using the interdisciplinary approach. An assessment of learners' situational interest in both groups was performed by post-test.

Results

Data Analysis

The number of learners for each level of situational interest has been determined. The results of the experiment are presented in Table IV.

Table IV. Results of measurements in CG and EG

The level of situational interest	Pre-test (number of learners)		Post-test (number of learners)	
	CG	EG	CG	EG
low	14	12	16	5
average	24	24	24	28
high	7	6	5	9

Statistical analysis

Pearson's chi-squared test $\chi 2$ for the analysis of received data has been used. Measurements were conducted in a three-level scale of gradation. As a rule, significance level of 5% is used in pedagogical researches. Critical chi-squared value for this significance level in the three-level scale of gradation equals 5.99. Pre-test results show that no difference between control and experimental groups because chi-squared statistic $\chi 2$ is less than value 5.99. Post-test results show that there is a difference between two groups because chi-squared statistic $\chi 2$ is more than value 5.99. In this way, post-test results have confirmed the alternative hypothesis: the difference between critical chi-squared value and calculated chi-squared value is due with not accidental, but with essential reasons – the use of the interdisciplinary approach in physics teaching. Since we used significance level of 5%, then the reliability of difference is equal to 95%.

Discussion

Any country always needs people who able to rapidly develop new manufacturing processes. Many years ago Sergeev (1979) argued that the "establishment of interdisciplinary links to physics course increases the effectiveness and practical orientation of polytechnic education" (p. 15). Marcu (2007) said that, "interdisciplinary education has a crucial role in science teaching, because it supplies new resources for the progress of science and technology" (p. 53). In this way, the use of interdisciplinary approach in physics teaching demonstrates the link between theory and practice.

According to Veloo, Nor and Khalid (2015), "Physics teachers should give more emphasis in not only the learning of Physics but more importantly on students' attitude towards the learning of Physics" (p. 35). The authors have established link between achievement in Mathematics and achievement in Physics. Physics is a fundamental science because the laws of physics are used in other natural sciences (e.g., Chemistry, Biology, Geography). In this way, progress of physics is inextricably linked with the achievements of mathematics and natural sciences.

You (2017) said that "if nobody teaches students how to integrate the different disciplines, students are prevented from discovering and creating links between relevant subject matter" (p. 73). Acccording to You (2017), "this could prevent interdisciplinary understanding in science and even lead to poor academic performance, which puts constant pressure on both the educators and students" (p. 73). In this way, the existence of artificial gap between natural sciences partly explains problem of decline in learners' interest towards physics. Decline of learners' interest towards physics enhances the relevance of interdisciplinary approach in physics teaching. Results of our study showed that the interdisciplinary approach in physics teaching increases the level of learners' situational interest. Consequently, our results were agreed with the findings of Marcu (2007), Veloo, Nor and Khalid (2015), You (2017).

Conclusion

The value of interdisciplinary approach in physics teaching has been analysed. The interdisciplinary approach provides a holistic view of natural phenomena. This contributes to a better assimilation of knowledge by learners, forms the scientific concepts, laws, theories and scientific outlook. The general method of using the interdisciplinary approach in physics teaching has been created. The study of new material, the formation of abilities and skills, and the work on projects are the forms of the interdisciplinary links in physics teaching.

Learners will be not able to understand the educational material, if will not feel the need to study it. Therefore, it is necessary the formation of learners' interest. The scheme for interest formation towards physics in the context of development of situational and individual interest has been analyzed: curiosity – the active curiosity – attempts to understand – strong knowledge – scientific research. According to the interdisciplinary approach, the tools for the formation of the learners' situational interest in physics have been allocated. These are phenomena of nature, phenomena of everyday life, link between theory and practice.

The results showed that interdisciplinary approach in physics teaching increases the level of learners' situational interest and scientific level of teaching. This contributes to formation the learners' scientific outlook. The use of interdisciplinary approach in physics teaching develops the abilities in solving of tasks and measure of physical quantities, and forms the scientific abilities and skills. Working with textbooks, reference books and online resources, project scheduling, formulation annotations are the scientific abilities and skills of learners. Proposed general method of using the interdisciplinary approach can be used for teaching other sciences. Prospects for the results of this research are: study of the formation of learners' individual interest in physics using interdisciplinary approach, and study the interdisciplinary links between other school subjects.

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Appendices

Appendix A

Phenomena of nature

Why we can hear the "voice of the sea" in the sea shell? (Biology: sea organisms, Physics: acoustic resonance)

It is known that sea shell contain an air (Figure A1). Ambient sounds excite the sound waves in this air. These vibrations resonate with the surrounding sounds. Strengthening and attenuation of sound vibrations in the sea shell creates the illusion of sounds tides.

Figure A1. Sea shell

Figure A2. Tuning fork on resonance box

We used the tuning fork on resonance box as a model of the sea shell. Tuning fork is set on resonance box for strengthening of sound vibrations (Figure A2). Air in box and tuning fork varies in resonance. Minimum length of air resonant column is equal to 1/4 wavelength of the sound in air. This numerical value determines the length of the resonance box.

Phenomena of everyday life

Football and gravity (Geography: latitude; sport: football; Physics: gravity)

Those interested in football, know that usually the team of any country plays better at home. Often this fact explained by the support of the fans. Consider some physical aspects of this game.

Imagine that the Ecuador national football team plays with the Ukrainian national football team. It is known that Ecuador and Ukraine are located at the different geographical latitudes θ and different altitudes h above sea level. Ecuador's capital: Quito ($\theta \approx 0°$, $h \approx 2800$ m), Ukraine's capital: Kyiv ($\theta \approx 50°$, $h \approx 179$ m). These and others reasons determine different values of gravity acceleration g in Quito and Kyiv. In this way, the values of gravitational acceleration g are equal to: g_{Quito} = 9.77 m/s^2, g_{Kyiv} = 9.81 m/s^2. It is known that the magnitude of weight is given by formula: $W = mg$ (1), where m is the mass of object, g is the gravity acceleration. We can calculate the weight of the football player and the weight of the soccer ball using formula (1). Assume that the mass of football player equals 75 kg. The weight of this football player equals 732.75 N in Quito, and equals 735.75 N in Kyiv (difference equals 3.00 N). Soccer ball has a mass 0.45 kg. It weighs equal 4.40 N in Quito and 4.42 N in Kyiv (difference equals 0.02 N).

What does the Ukrainian players feel when they arrived to Ecuador for the game? Their bodies have less weight, and the ball also has less weight in Ecuador. But the force of hitting on ball is remained the same because football players from Ukraine. All this leads to the fact that the ball flies along a trajectory, which unusual for them (above, further). So, do not be surprised that transfer of ball will be inaccurate maybe. Thus, the phrase "home team" has a real physical confirmation.

Appendix B

Link between theory and practice

Mineral exploration (Physics: the interaction of magnetic fields, Geography: minerals)

Iron ore in the surface of our planet increases the vertical component of the Earth's magnetic field. Magnetic arrow is a model of magnetometer, by which scientists measure the Earth's magnetic field. The jar with sand is a model of Earth's surface.

The metal filings are the model of iron ore. The presence of metal filings in sand affects on the orientation of magnetic arrow (Figure B1).

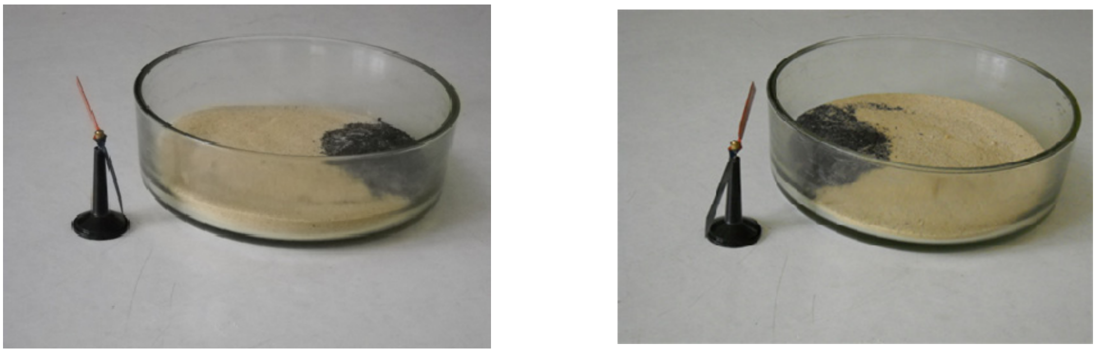

Figure B1. Magnetic arrow recorded the presence of iron ore in the Earth's surface

Why Tower of Pisa not falling? (Engineering: construction of buildings, Physics: equilibrium)

Tower of Pisa has been built during about 200 years (from 1173 to 1360). The height of Tower of Pisa equals 55.86 m on the lowest side and 56.70 m on the highest. The slope from the vertical equals about 4.6 m. But the tower does not fall. Model of Pisa Tower can be demonstrated by the device "Slanted prism" (Figure B2). Prism remains stable when a vertical line, which comes out of its center of gravity, does not go beyond the area of basis.

Figure B2. Device "Slanted prism"