THESIS SUBMITTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Using Elements of Atmospheric Physics and Astronomy in Teaching Physics at Secondary Level

Ibolya Ságodi-Dömény

Supervisor: Prof. Péter Tasnádi, CSc

Eötvös Loránd University
Faculty of Sciences

Doctoral School in Physics
Supervisor: Prof. László Palla, DSc

Teaching Physics Doctoral Programme
Supervisor: Prof. Tamás Tél, DSc

2015

Introduction

"We start this pursuit in a modest form, with a modest number of associates, leading a team of novices: but we are aware of the fundamental importance of our work. We know that we will have to build foundation walls onto which a palace can be erected. The palace we have already constructed in our souls with its magnificent measures and ornaments pleasing to our eyes."

The words of János Wigand, the first Principal of the Garay János Secondary Grammar School, which he said at the opening ceremony of the very first academic year on 10th September, 1896, addressed the staff of the starting grammar school. In a figurative sense these words can also express my own goals, as I am trying to build a beautiful palace in the minds of my students; the palace of physics.

Over the last decade we could often read about the ill judgement of physics by students. The reasons of that are rather complicated. Most certainly one among them is the fact that students tend to consider the subject difficult and abstract. It does matter what we teach, at what level, how, and last but not least, to whom. Some previous, academically structured textbooks, following academic approaches seem uninteresting for many of today's students, as these books do not adjust to their age and interests. However, young students can be difficult to manage, because some of them tend to be rejecting with formal education, and the act of immersed thinking is almost unknown for them. I myself do not work with the most difficult students, but mainly with those who work consciously and understand that the roots of their future lies in higher education. Even among them there are differences in their attitude towards physics governed by their individual interests in disciplines. Raising students' interest is not always easy. Certainly there is no such problem in classes where mathematics and physics are taught in higher number of lessons; students have an innate urge to study physics. It is sometimes difficult to teach physics in classes specialized in humanities or languages, and it is not easy to find methods that can motivate pupils either. A common method cannot be suggested for the very reason that while the number of students in specialized language classes are between eight and ten, this number in classes specialized in humanities can even reach 36. The strongest presumed motivating force: experimenting can be rather challenging in classes with a large number of students. Regarding the current equipment in school supplies we can only dream about individually performed student experiments in these classes. Even if the adequate equipment is provided it is desirable to think about the conditions on which the experiments can be prepared, as well as how the effective supervision of students' work can be performed during the lesson. As means of motivation in these classes it is advisable to choose and process topics related to the everyday life of students.

We also have to fight against the prejudice that physics is exposed to within the society. A great many people do not believe in solving problems in a scientific way. Certain fiascos, such as the accidents in Chernobyl and Fukushima or the disaster of the space shuttle in 1986 begot disappointment and aversion. Many are worried about the untameable natural disasters occurring due to the climate changing effects of certain human acts, as well as about the unforeseeable results of consuming genetically modified foods, the growth of which is possible now thank to the advanced levels of biology. Several conspiracy theories assuming deliberate damage to our environment have been developed. According to some, for instance, large oil companies are impeding us from using the new, unstinted energy resources (machines operated on zero-point energy, cars running on water etc.) Among them I should like to highlight the so called *“chemtrail conspiracy theory”*, a currently spreading rumour, which could be disproved by atmospheric optics, the part of physics I find very important and pursue to be included in secondary education. (The rumour holds that certain harmful chemicals produced by industry are deliberately sprayed into the atmosphere by aircrafts.)

My personal interest within physics is overhanging the boundaries of geography: onto some meteorology-related issues, as well as the fields of atmospheric optics and astronomy. Almost every topic is in connection with light, therefore I am overjoyed at the fact that my dissertation was born in the International Year of Light initiated by the European Physical Society (EPS)

Objectives

The aim of my doctoral research was to prove that students’ negative attitude towards physics can be changed by involving interdisciplinary areas at the appropriate level in physics teaching, meanwhile utilizing this opportunity in talent management, too. What is more, it can positively influence students’ career choices in favour of natural sciences. Students attending the Environmental Physics Club do not possess extraordinary, but rather average abilities regarding their skills in mathematics, although they are more interested in the issues that physics deals with. The study group preparing them for KÖMAL, the national physics competition with a great tradition in the Garay Secondary Grammar School, would not provide these students with the feeling of success. However, they would require programmes on physics within the school which would satisfy their curiosity. Recognizing this gap have I begun my physics club, where we carry out tests and do researches into the field of environmental physics, generally speaking we deal with the current issues of natural sciences.

The topics I have chosen are on the border of physics and geography, although they only occur marginally – there is little time spent with them during the lessons and students can only absorb a little knowledge on them. I had looked for topics that would enable students to perform individual tests and researches because this way, besides raising their interest, students’ creative problem solving skills would also be developed. Because of their unique nature the topics studied in the physics club can be attractive (as one of my students put it) and can generate serious interest. For today’s students tasks that can be performed or problems that can be studied with the involvement of computers can be very motivating. My goal was to find some issues related to atmospheric physics or astronomy, which are sensible, suitable for using in secondary school classes and where computers can be used when solving them (such as processing radar images, or simulations).

Research methods

My research methods can be divided into two groups. One group embraces the research methods of physics as a natural science: when working out students’ tests and projects for the physics club I used measuring tools appropriate for the topic: measuring, photographing, and computer simulations. The other group consists of research methods for evaluating pedagogical efficiency: primarily, my personal experiences served as methods for monitoring the successfulness of teaching. As for pedagogical methods, I applied proceedings used for teaching practices with small samples. I monitored the knowledge that students had gained with worksheets and short presentations delivered by students. To prove my hypothesis regarding the change of attitude I used personal conversations and conducted in-depth interviews. During the examination of the pedagogical efficiency I applied qualitative research methods as feedback (surveys, in-depth interviews, then analysing the content of the discourses) to unfold subjective information, first of all attitudes, values and motivations. This is when the features of a qualitative research prevail: we do not work with previously defined categories but interpret what we have read and try to get closer to the world of those who have produced the discourse, to their very own way of understanding the world.

THESES

1. Processing the halo phenomena in the physics club

Motivation: Scientific cognition obviously begins with observing phenomena, leads through experimenting towards the theoretical explanation of certain phenomena. Optical spectacles of the atmosphere, such as rainbows, halos, Northern Light, lightning, iridescent clouds have always amazed people, though in medieval times people were terrified by them. Even hundred years ago people were closer to nature and watched its spectacles like a hawk, including the optical phenomena of the atmosphere, as they used to forecast the weather by reading them. Within the physics of the atmosphere the range of spectacular natural phenomena offered by atmospheric optics (rainbows, halos) attract students' imagination. However, neither the textbooks in physics nor the ones in geography deal with them in detail. I conducted a survey among students whether they had heard of such occurrences in the sky and I learned that most of them had never heard of the halo phenomena. Therefore, among all those phenomena that atmospheric optics deals with I chose to my goal the observation and interpretation of halos at secondary school level.
The topic is related to the curriculum through the subject matter of optics. Students' knowledge of geometrical optics can be extended by studying it, though strong understanding of the rudiments of reflection, refraction and dispersion is necessary. Children learn the basics of them at primary school then they extend their knowledge further in year 11. Nonetheless the way of the light passing through crystals requires some knowledge of the structure of materials, as well as geometry.

In connection with the halo phenomena I elaborated on a teaching module for the physics club, which I have also put into practise. Students learn how the shape of the developing crystals depends on the physical circumstances dominating in high-level clouds. By this means I revise and extend their knowledge in the field of thermodynamics. We analyse how the shape, number, orientation, quality and homogeneous nucleation of ice-crystals affect the spectacularity of a phenomenon, whether it is regular or irregular in shape. Through a particular example of a halo I demonstrate what topics of geometrical optics we can revise by simple consideration. I familiarized my students with the methods of recording the phenomena (they took photographs), then with the help of a computer software we created the simulations of the photos.

The syllabus for ten lessons (shown below) is appropriate for raising interest and understanding some more common phenomena. For more thorough studying more time would be needed.

1. Historical halo phenomena
2. Photographing halos
3. Revision of the basic terminology and notions of optics (of reflection, refraction and dispersion)
4. About atmospheric ice-crystals
5. Modelling with cardboard
6. Common halos caused by plate crystals
7. Common halos caused by columnar crystals
8. Halos caused by pyramidals
9. Simulating halo phenomena: An introduction to Halosim 3.6 software
10. Simulating photos and historical halos

Results and experiences: I managed to make my students familiar with Halosim 3.6 software, then we run some other software capable of simulating halo phenomena. After the theoretical revision of the topic, photographing and modelling the realized complex optical phenomenon and several average phenomena, one of my students had the opportunity to join in the Student Research Programme run by the Faculty of Sciences of the Eötvös Loránd University (ELTE TTK).
Related Publications: [1], [2], [4], [5]

2. The 2012 Transit of Venus

Motivation: According to my earlier experiences astronomical observations can have serious motivating effects in teaching physics. With a little group of students from the physics club we have observed and processed several different kinds of phenomena, such as lunar- and solar eclipses, the transit of Venus, an unexpected eruption of a returning nova, the changing / periodicity of solar activity, conclusions drawn from observing simultaneous fireballs, asteroids whose orbits were possible to follow, expected and unexpected comets. In my doctoral thesis I discuss in detail the preparations for studying the transit of Venus on 6th June 2012 and the observation of the phenomena together with the members of my physics club. In this century so far, those who are interested have already been able to observe two transits of Venus. The whole phenomenon - from Venus entering the area in front of the sun until it passes it - could be followed in 2004, while in 2012 there was a partial transit, when only the last third of the phenomenon was visible. Due to the peculiar periodicity only a few people can admire the occurrence, since the pairs of transits eight years apart are separated by long gaps of approximately 100 years. Considering their age my students were able to see only the latter one, as they were only very young children at the time of the first occurrence, and those born very recently will see none in their lifetime.

Out of the many theoretical descriptions I have chosen an explanation for the phenomenon that secondary school students can also understand, and I have adapted a simplified version of it for my students in the physics club. The different orbital periods of the Earth and Venus, as well as the 3°4' inclination of the Venusian orbit to the plane of the Ecliptic results in a unique periodicity in the occurrence of the phenomenon. In the description, for easier understanding, we used simplifying conditions (round orbit, orbiting in the same plane), similar to when we used simplified calculations for calculating the distance between the Sun and the Earth, where we tried to minimize the necessary background knowledge, too.

Results and experiences: Observing the Transit of Venus, the peculiar, irregular occurrence of the transit arouse students' curiosity and created the opportunity for me to tell them about some astronomical facts and with the aid of basic geometry we managed to construe the periodicity of the transit – though, only approximately. I have both pedagogical and educational goals with the observation and demonstration of the phenomenon. I actively involved secondary school students in the preparation process, such as the preliminary research for related written resources, then we observed the phenomenon together and recorded the data series when Venus left the Sun's disc, finally, we deduced the consequences together. This way I managed to familiarize my students with the methodology of scientific cognition. I introduced them different expeditions and their Hungarian connections throughout history, which were essential for tests and measurements to establish the astronomical unit. Methods for calculating the distance between the Sun and the Earth would require more advanced mathematical skills but following a simplified, understandable method students succeeded in understanding the gist of the matter. I drew the attention of those who live in my immediate surroundings to the event, and through media I managed to share substantial information with those interested. By the end of the project students were able to see clearly how lucky they were to have experienced at least one of the transit pairs.
Related Publication: [6]

3. Simple geographical localization

Motivation: The question may arise in many people: why do we need today geographical localisation with simple tools, since there are the modern GPS devices and with the help of them it only takes a click to define the coordinates of our location with great accuracy. We know it well, that a couple of hundred years ago those who set off for a journey had to use a compass and astronomical measuring instruments to localize their geographical position because their lives could depend on it. For us geographical localization can be useful when we want to place the data of our astronomical or meteorological test on a map. My goal was to elaborate on a simple method of geographical localization based on using tools and instruments found in the school's equipment store. It also means using the knowledge obtained during mathematics geography lessons in new situations.

I have worked out a simple way of defining geographical latitude and longitude, during the preparation process and by performing localization students can synthetize their knowledge which they have gained in different subjects. We performed the test with the help of the Sun. The Sun's height above the horizon at a certain place at noon is in simple relation with the geographical latitude of the place. Therefore, we had to measure the Sun's height above the horizon with the appropriate instrument (a quadrant). We were able to calculate longitude from the exact time of noon (local noon) with certain corrections. With an appropriate tool (a gnomon) we had to define the exact time of local noon. Then we came across the problem of defining north and south appropriately.

Results and experiences: Together with my students we created a homemade quadrant out of the protractor we had found in the school's equipment store. We transformed it into a double-function tool, so the two measurements could be performed with less and smaller instruments. We could even use it when setting off for a longer trip or in a holiday camp. While realizing the project, students had to revise and apply to practice much of the knowledge they had gained from textbooks. It also extended their geographical knowledge in connection with the movement of the Sun and the Earth, in addition, they also needed to use some of their mathematical skills, particularly their skills in geometry. Geographical localization with simple tools was an excellent project for students, after completing it both their practical skills and resourcefulness developed by designing and making a measuring instrument with a help of a teacher.

4. Using radar maps for preparing simple prognoses

Motivation: In everyday life it is a common problem whether there will be rain in the near future or not. It is quite obvious in my family that we use the meteorological radar images from the website of OMSZ (National Meteorological Service) to answer this question. Composite images created from meteorological radar maps can be easily found on the Internet, and we can simply use them to make our own short-term rain forecasts. The mini forecast is an excellent way of using the knowledge students obtained from textbooks, and demonstrating it among family or friends can guarantee the success for our students.

I have worked out a method for my students; with some basic knowledge in physics and with the help of the radar cineloop found in computers they can easily use it. They can give quite reliable short-term "predictions" regarding when it will rain at their location. The essence of the method is extrapolating the movement of the rainfall zone.

In such simple case, it can be done only by "looking at them with bare eyes", but for better results, we must use the print screen option and print the images frame by frame, so that by following a certain feature of the images we can establish the average speed of the rainfall zone. The later position of it can be deduced by using the information on its speed. To introduce this method I have prepared a didactic recommendation. First of all, students' sensitiveness for the topic is needed. I asked them that according to their opinion, how much certainty do meteorological forecast come true, as they all had experiences when the weather events that had been forecast did not happen. When discussing this topic, it is worth talking over how many different atmospheric physical features should be known to make a good prognosis. I suggest looking up the relevant technical material at the OMSZ website to do that. (It is a far-reaching topic, and the chaos theory or the butterfly effect can be mentioned too, but only with informational purposes. If the subject awakens students' interest, they will google it on the Internet.) Then we shall establish our goal: We should make some simple calculations ourselves, if not foretelling the weather, then forecasting the rainfall. After choosing the appropriate radar images, we perform the measuring and calculations.

Results and experiences: In relation to the topic, concentration on the study material can be naturally accomplished, mainly using the following parts of the curriculum in mathematics, physics, and geography: from geography – recognising certain topographic formations, distinct rivers, hills; from mathematics – measuring distance, the notion of proportion, and from physics – the simple formula to calculate velocity and time regarding an approximately uniform linear motion. To practice the method, by recording radar images frame by frame, I have made a radar database, the help of which students can practise while colleagues who are interested can adopt the method.
Related Publication: [3]

5. Light pollution, a type of environmental pollution

Motivation: While searching for the most appropriate places for our astronomical observations, my students from the environmental physics club and myself naturally bumped into a problem of environmental protection, namely the issue of light pollution. With my pedagogical work my aim is also to promote the shaping of an environmentally-aware attitude, behaviour and lifestyle in my students. I find it important to protect both the natural and artificial environment, I teach that to my students, too. A good tool for that was examining sky glow, through which my students were able to become familiar with s specific form of environmental pollution: light pollution. This is the sort of pollution that could be eliminated the cheapest way. In order to find dark patches in the night sky we performed some measuring on the slopes plated with wine grapes in the immediate surroundings of Szekszárd, as well as the further "Hegyhát". As we had heard about the plan regarding the reconstruction of street lighting in our town, in 2013 we performed a situational analysis, an evaluation of the conditions in Szekszárd. We are planning to repeat the analysis in the near future, after the replacement of the lights have been completed. When we have the new data, we will be able to compare and analyse them. Measuring light pollution had a dual aim: one was monitoring the area of the "Hegyhát", the other was mapping the light pollution situation regarding the town of Szekszárd. I worked out a project for evaluating the light pollution situation of our region and we have completed it. Because of the circumstances of the modelling and measuring the summer was not the most appropriate time for that. While planning carefully, my first consideration was the lunar calendar, as measuring can only be performed during the phases of new moon. Apart from that, the times of sunset and sunrise of these phases had to be known to enable the planning of the beginning and ending of measurements. I managed to finance the purchase of the necessary measuring instrument on the money I had won on a tender. First, with the help of the astronomy researchers from Baja and some tools we calibrated the instrument and performed the measurements for Tolna county.

Photometry is not part of the national curriculum for secondary schools. As measuring the background brightness of the night sky is basically a photometric measurement, when preparing the field-work tests, discussing the basics of how the instrument works, I explained my students a few basic principles of photometry. We will need these notions later on as well, when fulfilling our future plans (photographic photometry of variable stars). We set up a hypothesis for the condition of the night sky over our town and its surroundings, based on Hungary's light pollution map, we performed some measurements, and after evaluating them we could decide whether our hypothesis was proved or disproved.

Results and experiences: Monitoring the light pollution conditions of the area of "Hegyhát" resulted in proving by photometric modelling that the quality of the starry sky over this area is similar to those over Hungary's internationally recognised dark-sky preserves. The topic was very popular among students.
Related Publication: [7]

6. Motivation and talent management, elaborating syllabuses for the environmental physics club

Motivation: *"The best school, where a young man can learn that the world makes sense, is its direct relation to nature." (Konrad Lorenz)*

With only one exception, my theses were motivated by natural phenomena that can be observed and modelled. According to my experience, the fascinating beauty of natural phenomena guides students towards deeper understanding more easily. Students attending the natural physics club in the Garay Secondary Grammar School gained immerse knowledge in the fields of atmospheric physics and astronomy. The club serves a dual purpose: one is to improve student's motivation for physics, the other is talent management. The project work done outdoors has had a positive impact on their demeanour. The study trips to different towns of the country, keeping touch with other natural physics clubs, and meetings strengthen this positive attitudes even further. Joining in international astronomical movements (Globe at Night, Earth Hour, Sidewalk Astronomy, etc.), nevertheless the year 2009, which was also known as The Year of Astronomy, had an important role in motivating students. The other area was the world of regular physics lessons for classes with non-science specifications, where I managed to direct students' attention towards physics. The best proof of that is to have students from classes specialized in humanities and languages - where I used to teach physics - choose science for their career: two students decided to study to become physics teachers, one continued their studies in geophysics, and one chose technology.

By analysing the interviews I pointed out that among the students attending the physics club further positive effects can be experienced in the change of attitude towards physics.

Gift for physics can occur in several subfields of physics, although the most desirable is when there are more of such in the case of an individual student. Most of the students in my physics club are gifted with practical skills, their other skills need to be encouraged. Having completed their projects, my students showed their results at school level as well as at meetings for students' science clubs. Owing to their excellent results at TDK conferences, we were allowed to accommodate the semi-final of the national conference of student clubs in science and technology in 2015.

I have shown, that certain environmental physics topics, particularly the ones I preferred, can be used successfully in talent management. I evaluated the development of students' knowledge due to the physics club by surveys. I have revealed that when leaving the club students' knowledge on atmospheric physics and astronomy has improved, while their insecurity regarding certain sub-areas has weakened.

My experience forced me to treat the planning of a year's work flexibly, as the students attending my club have changed every year both in person and regarding their abilities. During the years I have prepared different plans and syllabuses; for the duration of a single academic year: a syllabus for a meteorology students' club, a two-level (beginner and advanced) and a three-level (for one primary school-aged and two secondary school-aged groups) syllabus in astronomy. As it may be seen, the environmental physics club is open for students, they can get involved in the club's work continuously. Besides the syllabuses I have also elaborated on a series of suggestions for observation of those objects in the sky that can be easily achieved (Andromeda-galaxy, Perseus double cluster, the Ring Nebula in Lyra) I have also provided detailed descriptions of them. I have worked out a system of field trips, during which students can apply in practice what they have learned in the club sessions.

Results and experiences: As a consequence of the work done in the environmental physics club students' motivation towards physics has improved, the curiosity for a career in natural sciences has evolved. There was a student, who after a long-long search, simply here, in the physics club managed to "find himself". As a result of talent management, the knowledge of students has become more immersed, and owing to that in 2014 we won the national competition in astronomy for primary school teams and we performed well at the student conferences, too. Among secondary school students, their choice of career was greatly influenced by the work done in the physics club: for instance, three of my former club members continued with their studies at the Eötvös Loránd University (aka ELTE) specialized in geophysics, physics and astronomy.
Related Publications [4], [5]

Summary, future plans

In my doctoral thesis I examined how certain natural phenomena, the ones that can be observed and modelled, could be fitted into the curriculum of physics in secondary schools. These topics are on the boundaries of geography and physics, owing to their interdisciplinary nature even students attending specialized humanities or foreign languages classes find them interesting, therefore they can be used for motivational purposes among them. Protecting our natural and artificial environment, as a realization of an important aim of education becomes possible by the fact that one of our tests can be utilized in environmental protection. For talented students of physics projects mean performing interesting tests, therefore they can also be used with good results in talent management.

My future plans are aiming to work out some new projects. The study areas demonstrated in the thesis, the ones I have researched so far, will provide new opportunities. To perform meteorological observations on a regular basis I would like to create a meteorological station in our schoolyard and with its tests and measurements we would like to join the GLOBE programme. I have already taken several steps in order to realize it. Obtaining a sun photometer is also among my plans; with the help of it we could measure the aerosol content of the air. As for the other study area, astronomy, I should not be afraid of running out of subjects, since there are always some interesting phenomena happening in the sky: a comet appearing unexpectedly, a nova erupting, (like the T Pyxidis recurring nova in 2013), a supernova, or even a the solar activity, the observation of the planets can have some surprises in store. Observing events that can be forecast or calculated in advance; modelling them, processing the data have also proved to be a fun programme for the physics club students. A good example of that was the observation of the partial sun eclipse on 20th March, 2015. Our sessions for measuring the background brightness of the sky will be continued with comparing and contrasting data. Apart from measuring the changes in brightness of the variable stars, photographic DSLR photometry can result in discovering so far unknown variable stars. Certainly, after the projects having been realised I would continue monitoring the impact of them both on attitudes and knowledge of students. My further objectives include participating in various competitions in astronomy (for teams of primary school students as well as for individual candidates among secondary school students; and with the most gifted, I would like to aim the Student Olympics in Astronomy and Astrophysics).

There is an old observatory in Szekszárd which used to serve the great public but now it is in adverse condition due to unresolved property ownership issues. Saving and renovating it cannot be postponed any further as its condition is rather critical. Our county seat would need a public observatory. At my initiative a large-scale civil partnership was started to save it as we will celebrate the 50th anniversary of its foundation in 2016.

Publications the theses based upon:

[1] Ibolya Ságodi Döményné, Péter Tasnádi:
Atmospheric Physics As A Tool For Making Physics More Interesting For Students
Web and CD on MPTL14 Udine University, 2009.
(http://www.fisica.uniud.it/URDF/mptl14/ftp/full_text/T3_81_Tasnadi
In: Proceedings of the of 14th International Workshop on Multimedia in Physics Teaching and Learning (MPTL 14). Udine, Olaszország, (2009)
Udine: Paper T3_79_OP. (10 oldal)

[2] Ibolya Ságodi Döményné: Atmospheric Phenomena in Physics Teaching
Physics Competitions 12(2), 2010. p. 61-70.

[3] Döményné Ságodi Ibolya: Amiről a radartérkép mesél
In: Juhász András, Tél Tamás (szerk.)
Fizikatanítás tartalmasan és érdekesen: magyarul tanító fizikatanárok nemzetközi konferenciája az ELTE Fizika Doktori Iskola szervezésében. Budapest, Magyarország, (2009)
Budapest: ELTE Fizika Doktori Iskola, pp. 245-250. (ISBN: 978-963-284-150-2)

[4] Döményné Ságodi Ibolya: Égre néző szemek a Garay Gimnáziumban
In: Juhász András, Tél Tamás (szerk.)
Fizikatanítás tartalmasan és érdekesen: magyarul tanító fizikatanárok nemzetközi konferenciája az ELTE Fizika Doktori Iskola szervezésében. Budapest, Magyarország, (2009)
Budapest: ELTE Fizika Doktori Iskola, pp. 257-262. (ISBN: 978-963-284-150-2)

[5] Döményné Ságodi Ibolya: *Szakkör a Garay János Gimnáziumban*
In: Tasnádi Péter (szerk.)
Természettudomány tanítása korszerűen és vonzóan. Budapest, Magyarország, (2011)
Budapest: ELTE TTK, pp. 432-436. (ISBN: 978-963-284-224-0)

[6] Döményné Ságodi Ibolya: *A fekete Vénusz*
In: Juhász András-Tél Tamás (szerk.)
A fizika, matematika és művészet találkozása az oktatásban, kutatásban
Nemzetközi konferencia magyarul tanító tanárok számára. Marosvásárhely, Románia (2012)
Budapest, ELTE TTK, 2013. pp. 223-228. (ISBN 978-963-284-346-9)

[7] Döményné Ságodi Ibolya: *Nemcsak a Zselicben pompázik csillagfényben az éjszakai égbolt*
Fizikai Szemle (közlésre elfogadva)