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CONCEPT FOR ASTRONOMY EDUCATION PROGRAM

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Foreword

The *Concept for Astronomy Education Program* (CAEP) is an applicable output of the STARS project realization. The *CAEP* is prepared based on our best knowledge of how to present astronomical topics to pupils at the primary and secondary level. It uses and enhances the STARS Methodological Handbook for Teachers and related STARS Training Program for Teachers. During the preparation of the Concept, we map and synthesize good practices of teaching of astronomical topics on national level. One of the purposes of the *CAEP* is to have a comprehensive material for discussion with policy makers to integrate these astronomical topics in the science education curricula. It provides concrete ideas how to teach astronomy in primary and secondary education.

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Introduction

Skills in science in general, but also specifically in astronomy, are becoming an increasingly important part of basic literacy in the present day's knowledge economy. To keep Europe growing, there is a strong need of science-aware citizens who can make informed decisions and develop critical thinking.

As confirmed by numerous EU education policy strategies and research analysis, motivation should be fostered among young people in early education, as missing this opportunity leads to many interrelated challenges occurring at later stage of life, such as: underachievement in basic skills, low interest towards science-related further education and career choices, gap between the current technology-based labor market and existing competencies.

On 1st of November 2017, the publishing house of primary and secondary schools´ textbooks EXPOL PEDAGOGIKA ltd., based in Bratislava have started implementing the transnational project STARS whose aim is to support the teachers teaching astronomy at lower secondary education. Project STARS has been funded with the support of the EU Programme for Education, Training, Youth and Sport – Erasmus+.

The target groups of the STARS project are mainly teachers teaching at lower secondary education, but also pupils in lower secondary education (age 10-14) and high-level decision makers responsible for introducing reforms and creating education programs at the national level. Project STARS is innovative, as it aims to combine different methods to strengthen the profile of the teaching profession and transform learning into an exciting venture. The project will equip teachers with comprehensive methods to improve their teaching practices, as well as concrete ideas of how to present a given topic in astronomy-related curriculum. For these reasons, we have set the following project goals:

- to equip teachers with innovative methodologies, knowledge, competencies and tools to deliver astronomy-related curriculum in a relevant and meaningful manner;
- to foster the acquisition of critical thinking, analytical and abstract reasoning skills, thus contributing to increasing the attainment levels among students, as well as the acquisition of relevant knowledge;
- to develop a concept for new educational program in astronomy which is reflecting current trends and students´ attitude towards the modern learning process;
- to equip target groups with open education resources on astronomy that are of high-quality, free to use and available in their national languages.

Based on the lessons learned throughout the Project realization, we have prepared a Concept for Astronomy Education Program.

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Chapter 1

Description of STARS project

The main goal of the STARS project is to prepare methodical support for primary science teachers teaching astronomy. It presents methodical material, which corresponds with the latest trends in theory of science education. Another aim of the project is to prepare teaching material covering suitable astronomical topics, which could be taught at primary level regardless of national curricula in participating countries. We guarantee the wider applicability of the project outputs and initiate discussion about current astronomical topics of the primary school curriculum.

At the beginning of the project, we set the basic astronomical topics. Based on these we created a Methodological Handbook for Teachers and a related Training Program for Teachers.

Current research in science education indicates that the decreasing interest in science and technology does not stem from the absence of pupils' interest in science and technology education during their compulsory education. The problem is that when choosing further study or careers, pupils do not feel competent "doing science", even though they have achieved excellent assessment in the subject (for more, see Archer, DeWitt, Osborne, Dillon, Willis, Wong, 2010).

Two institutions participating in the project prepared the Methodological handbook for teachers: University of West Bohemia in Pilsen (Czech Republic) and Bulgarian Astronomical Society (Republic of Bulgaria). The set of teaching activities was subsequently verified at three schools involved: Grammar School Metodova (Gymnázium, Metodova 2) in Bratislava (Slovak Republic), High School of Mathematics "Academician Kiril Popov" (Математическа гимназия „Акад. Кирил Попов") in Plovdiv (Republic of Bulgaria) and Primary school at Říčany wood (Základní škola u Říčanského lesa) in Říčany (Czech Republic). Using and testing the prepared material in three European countries helped us to show its potential and international applicability.

Based on the practical implementation of the activities at the participating schools, a set of recommendations for changes in teaching and science education were suggested and incorporated into the methodical handbook, thus creating a final guide for teachers. Experience with the application of innovative approaches in science education was fruitful for teachers as well as academics. The experience has become a prerequisite for identifying examples of good practice (presented in Chapter 2) and at the same time obstacles preventing wider application of activities into pedagogical practice (presented in Chapter 3). Based on examples of good practice and identified barriers to the implementation of innovations into primary science education, it was possible to formulate a Concept for Astronomy Education Program (presented in Chapter 4).

The identification of obstacles in astronomy education and the resulting formulation of recommendations for the concept are linked to a specific learning environment. Chapters 3 and 4 are therefore elaborated specifically for three different educational environments - Slovak, Czech and Bulgaria.

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Chapter 2

Examples of good practices

The first step in preparing the Concept for Astronomy Education Program was to identify the effective elements of innovative efforts. Throughout the STARS project, we created methodical material which can be used by the teachers to improve his/her teaching practices in the context of current trends in primary science education. Teachers used the activities in their classrooms and based on the experience, formulated examples of good practice. This chapter presents a description of the positive effects of the teaching materials when applied under ideal conditions (obstacles to the wider application of the concept are eliminated). The activities have been verified in three different educational environments, so the reader can compare how the effects of STARS teaching material were perceived by teachers in three different countries.

Primary school at Říčany wood, Czech Republic

The STARS project testing took place at our school during regular lessons. We did not create ideal groups nor determined a specific time and the teachers were only vaguely familiar with the content and goals of the tested chapters. This was done in order to get as close to real-life teaching conditions as possible. The testing teachers studied the topic and the connected activities on their own and created intellectual and practical conditions for their implementation in practice.

The teachers' feedback was entirely positive; they viewed the STARS materials as detailed, the topics of the individual chapters clearly explained and the model activities corresponding to the abilities of middle school students. The only minor obstacle was the equipment as astronomy has never belonged among the main topics taught at our school. Our colleagues however, managed to solve this issue by choosing some of the topics requiring less equipment.

The following tasks were chosen for practical demonstrations:

<u>Lunar Eclipse Demonstration</u>

This task does not require much equipment and gives the students a very good idea of the phenomenon and its causes in particular. The students got a gym ball representing the Sun and a number of balls and marbles from which they were to choose two best corresponding to the size of the Earth and the Moon based on the size of the Sun. To determine the right items, the students needed to do some basic calculations, which they did without any problems. They were then asked to place these items in the school garden in the distances corresponding to the real-life position of the objects in the Solar System, which again required a calculation. Once again, it went well.

This activity was not very time demanding and allowed the students to work outside and move around. The feedback from students and teachers was positive.

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Candle clock

This activity required the students to make a simple timer using a candle and steel balls; the students worked in groups of three and so we had several candle clocks in the end. Each group got two identical candles; they lit one and measured its burning time according to which they made marks on the other candle. They then inserted the steel balls into the marked places. When they lit the second candle, the sound of the released balls announced the given time intervals.

Even though we feared this activity might take quite a long time due to the slow burning of the candles, it proved to be a fun and informative task which allowed students to see the ways and development of measuring time in history.

Pinhole camera

We worked on this activity with 9-grade students as it is technically more challenging and requires a great deal of precision. The result, however, was worth it and the students were excited.

With the help of their teacher, the students followed the worksheet and using cardboard and alufoil they created simple optical equipment – a pinhole camera. The students worked in groups of four and required significant precision as the hole made in the alufoil needed to be really tiny. It was then possible to use this camera obscure and observe the image of Sun on the screen (in this case a simple sheet of white paper).

If we are to sum up the practical testing of the STARS Manual, we are happy to say that its authors have managed to create a great teaching material that corresponds to and reflect the requirements of elementary education in the field of astronomy and offers even more. It offers a wide range of fun activities that introduce students to the elementary and extended knowledge of astronomic phenomena and principles in an interesting way. There is a large number of activities and these can thus be chosen according to the students' knowledge but also depending on how time demanding they are or what equipment is needed. One of its great positives is that the Manual takes into account the learning process of talented students or students with an Individual Educational Plan (IEP).

High School of Mathematics "Academician Kiril Popov", Republic of Bulgaria

1. Description of the innovation

In our desire to instill different and more numerous skills in the students, we teachers often become less interesting and less stimulating to the students. Active learning, combined with innovative teaching methods, helps students to stay focused on the material and to obtain longer lasting knowledge. In order for a teacher to be successful, they must combine many qualities such as: professionalism, tolerance, respect and, last but not least, to be a good actor. The STARS project helps teachers by using fun interactive methods, which in turn helps students to acquire knowledge and skills

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in the field of astronomy. The methods are diverse, tailored to the age characteristics of the students. With the help of puzzles, computer programs, photos of various space objects and materials at hand, students acquire knowledge in the science of astronomy.

2. Examples of good practice

We worked with the students from the Mathematical High School in Plovdiv with great interest and enthusiasm on the project. With the help of the developed materials, the students gained knowledge about the different constellations, galaxies, nebulae, star clusters, etc. They searched for materials for their tasks on the Internet, worked with the Planetarium program, filled in tables, studied graphs, made models of various space objects. Some of the tasks were individual, but others were in groups. Tolerance and mutual assistance were observed in the group work.

The students worked with great enthusiasm and showed creativity in the practical tasks. The biggest advantage of the practical tasks is that they require materials that each student has, namely scissors glue, colored pencils, glossy blocks. Another advantage is that some of the tasks can be set for group work or homework, so that parents can participate in the educational process. Working in groups is very useful for the students because it forms qualities such as: tolerance, respect, mutual assistance and, thus, students prepare for the future when they will have to work with other people. For this one method, it is extremely important that students are distributed randomly and not on a friendly basis. In other words, there should be no children who feel unwanted in a group, because in this case the task is doomed to failure from the beginning. The method we used is one of random selection, i.e. if there are about 25 students in the class, 5 coloured cards are used, cut into 5 pieces each, then all the pieces are mixed in one hat (or other opaque container). Each student draws a piece from the hat, the groups are formed and they start working on the task. Usually the leader of the group distributes the tasks among the participants. It is important to set times for each task/part of a task. It is good for the teacher to always allow time for discussion of the results in order for the students to hear the opinions, questions and comments of the participants from the other groups.

It is also extremely useful to do homework, because then students seek help from parents, friends, relatives. In this way, relatives are involved in the learning process and the lesson becomes a topic of conversation at home. Students are motivated to look for answers to the tasks on the Internet. It is good to arouse interest, because in their quest to perform better in school, they enrich their knowledge in the field of astronomy. The methods of group work and homework allow students to enrich their knowledge of astronomy in the process of completing the tasks.

In my work on the practical tasks with the students, I was impressed by the diligence with which the students looked for constellations to group them by signs: people, animals, objects. After distributing the tasks, some of the students worked with a star map, some of them searched for information on the Internet. Other students answered that these constellations should be colored in different colors according to the signs: zodiacal, equatorial and non-setting. They distributed the tasks very well among themselves and each student knew their role in the team. It is very important to cope within the set time. After completing the task, each of the groups present their work. We all solved the puzzle together. I had prepared the puzzle on the board, and each student said which constellation he/she had discovered. This task can also be set by the teacher printing it out or providing it in a file, then each student working individually and then we discuss the results. The task of recognizing a constellation or a nebula, star cluster or galaxy we worked frontally. With the help of multimedia I showed the images, and they recognized the objects and shared their opinion. They dealt with the constellations faster. They encountered difficulty with nebulae and star clusters. The task of cutting out stars and sticking them on the constellation aroused great interest. They diligently cut out the stars and glued them to the constellation, constantly asking if the star was glued in the right place. Very successful was their work with the Planetarium program as well. All students had smartphones and had downloaded the program in advance. If not all students have this program, the teacher can divide them into groups or assign this task for homework. I left the task of naming stars and constellations for homework because the students were looking for information on the Internet and it took more time. Then we discussed in class the different constellations and which are the brightest stars in them. The task of the seasons I set in groups as each student was looking for certain information. And the task of visible movement of the starry sky we worked frontally.

When discussing their work, they said that they liked the non-standard approach to training the most.

3. Problems in working on the project

During the work on the project I did not encounter any difficulties. The work was pleasant and fruitful for both parties. During my work on the project I found that the students are extremely interested and work hard on all their tasks.

Grammar school Metodova, Slovak Republic

Our personal experience with the implementation of the STARS project in the educational process in our school was very positive. Thanks to the verification of the resulting materials, we also paid more attention to science literacy and the development of students' science competencies. We selected topics that we considered to be reasonably demanding for students, interesting enough and manageable in terms of material equipment.

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We chose the group work of students. Such a form requires time preparation before the implementation of activities - students must be appropriately divided, assigned a suitable function in the group. During the work, it is necessary to harmonize the activities of individual members, appropriately correct the mutual discussion and set rules for reporting the results and outputs of the group's work. We can state that the students were active, cooperated effectively, communicated appropriately with each other, used the provided tools correctly.

By observing the work of students and evaluating its results, it can be stated that students through activities

• have mastered professional terminology,

• develop their research skills,

• trained mutual communication and their presentation skills,

• improve the ability to listen to the opinions of others and argue.

During the implementation of the activities, we also appreciated the emphasis on the relationships between different subjects. We connected physics with mathematics, computer science, geography. At the same time, the students realized that they already have a lot of knowledge gained in advance from the previous study or from the media on a specific topic.

From the teacher's point of view, we want to praise the created methodological materials. They are processed very well. We liked:

• the theoretical part and the practical part - Activities are separated in the materials,

• the following are processed in the Activities:

  - the goals
  - instructions for the teacher,
  - methodological notes,
  - model solutions,
  - a worksheet for the student

• Activities are diverse in terms of

  - about the duration,
  - on difficulty,

- on suitability for different ages of pupils,
- the degree of involvement of the student in the process,
- about the necessary material equipment,

• several alternatives for implementation are proposed in the Methodological Notes (according to the possibilities and conditions of the school),

• links to suitable websites are also beneficial,

• special attention is paid to adaptation to students with SEN,

• additions are proposed for particularly gifted students,

• inclusion of search activities, sorting of information from various sources,

• representation of tasks for the development of different competencies of students.

When selecting verified activities, we used the fact that in Slovakia we had a year dedicated to Milan Rastislav Štefánik. This important Slovak was a respected astronomer. Together with the students, we first obtained basic information from Štefánik's scientific career:

M. R. Štefánik developed from a poor student of Prague universities through astronomy in Paris to a minister of war in the newly formed Czechoslovak Republic. He was an astronomer, traveler, and photographer, general of the French and Czechoslovak armies, politician, and minister of Czechoslovakia. He met the scientific leader of French astronomy of the time, as well as the world leader in the research of the Sun. He observed the Sun and its atmosphere - the corona, the planets of the solar system, comets and stars, planetary nebulae. He published the results in scientific journals. Astronomy was the only area for which M. R. Štefánik had a comprehensive education, in other areas, with the exception of technology and meteorology; he was actually an amateur, although very successful. He established a network of meteorological stations in French Oceania. He climbed Mont Blanc six times for observation. He traveled to various parts of the earth's surface to observe a total solar eclipse or Halley's Comet. He was responsible for the establishment of a network of regular meteorological service in the French Air Force (he was also one of the founders of military meteorology). In a provisional form, he built a new observatory in the southern hemisphere, advocating the reorganization of astronomical research in Ecuador (diplomatic-scientific mission). Against strong German competition, he was able to push through the construction of a telegraph network in Ecuador and adjacent islands by France.

During his scientific career, M. R. Štefánik was extremely helped by his technical skill. Just as he knew how to empathize with people's souls, he was able to understand the "soul of the instruments," which he was constantly improving. He was a technical type, very skilled in repairing various instruments, in the preparation of optical components or in the assembly of his own astronomical instruments, or their improvements. In the sketch he had about 27 names of new or redesigned technical devices, e.g.

electric ballot counters, color film projectors, etc. He obtained permission to work regularly at the observatory in Meudon near Paris when he helped repair a broken device there and proposed the modification of another, thus gaining the sympathy of the observatory's director Jules Janssen, who helped him in his professional scientific growth.

The following information is linked to its activities related to the Mont Blanc Observatory:

Stays in the alpine environment convinced M. R. Štefánik of the advantages of alpine observatories. Years ago, astronomer Jules Janssen informed generous donors about their positives, with the help of which he was able to build a permanent astronomical station at the top of Mont Blanc. However, his stays in such extreme conditions had an impact on his health, in the form of crookedness and the difficulties he felt when walking on flat terrain. Nevertheless, he did not hesitate, albeit with the help of porters and sleighs, to ascend three times to Mont Blanc (1890, 1893, and 1895). The observatory on Mont Blanc was built between 1890 and 1893 according to the project of the famous French engineer Alexander Gustav Eiffel. It was located at an altitude of 4,810 m. It was the tallest observatory in the world and at that time became unique in the world. They brought 15 tons of material for its construction from Chamonix. The wooden building of the observatory was built on a glacier and terminated by a tower that resembled a pyramid. In addition to the main telescope, the observatory also housed meteorological instruments and a chronometer. Astronomical expeditions to Mont Blanc usually took place only in the summer months, when the peak was the best available and living conditions at least a little acceptable. The air pressure at this altitude is only slightly higher than half the air pressure at sea level, and the temperature rarely reaches positive values above zero. Strong winds also made the stay difficult. Food, wood, occasional equipment had to be carried on the back using carriers.

We drew the mentioned facts from the publication of Vojtech Rušín entitled M. R. Štefánik - Slovak Astronomer. They were the starting point and motivation of verified activities related to the activities of M. R. Štefánik, specifically the topic of the Solar Eclipse:

- Activity 1: Demonstration of a solar eclipse
- Worksheet 1: Demonstration of a solar eclipse
- Activity 2: Solar eclipse model in the field
- Worksheet 2: Solar eclipse model in the field
- Activity 3: The nearest solar eclipses
- Worksheet 3: Upcoming solar eclipses

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Good practice - teachers

Slovak teachers struggle with the difficulty of highlighting the interrelationships between subjects due to lack of resources and sometimes even lack of professional information on certain topics. In order for students to acquire relevant knowledge, it is very important that they learn in a conceptual structure, make observations, cooperate with each other and make the most of current technological progress.

Teachers are offered materials that are innovative and combine different educational methods to strengthen the profile of the teaching profession and to turn the teaching process into an exciting adventure. Educational modules will equip teachers with comprehensive methods that will improve their teaching methods as well as specific ideas on how to present individual topics related to astronomy within the current curriculum.

STARS Teacher Training Program (O2) - a program that offers an innovative and comprehensive approach to improving teachers' practical skills to provide relevant information to students in the teaching process. The content of the program will be created in the form of text, but also in a digitized version, which will allow teachers distance learning.

Positives of the training program:

• creation of the concept of a new educational program for teaching astronomy, which will reflect the current trends and attitudes of students towards the modern teaching process,

• support for critical thinking, analytical and abstract perception in order to increase the level of knowledge acquisition of students, as well as the acquisition of relevant knowledge,

• equipping the target groups of the project with freely available, language-relevant and high-quality educational resources for teaching astronomy.

The educational program is directly linked to the Methodological Manual for teachers. Both materials are among the intellectual outputs of the project. Among the processed topics we can mention:

1. Kepler's laws
2. Weightlessness
3. Dwarf planets
4. Small bodies
5. Lunar eclipse
6. Solar eclipse
7. Solar system - distances and sizes
8. Exoplanets

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9. Light year - Parsec - Parallax
10. Distances in space
11. Binoculars

Observations, comments, suggestions:

We liked:

1. the materials offer a large number of activities for students,

- the activities include:
  - the goals
  - instructions for the teacher,
  - methodological notes,
  - model solutions,
  - a worksheet for the student
- activities are diverse in terms of
  - about the duration
  - on difficulty
  - on suitability for different ages of pupils
  - about the degree of involvement of the student in the process
  - about the necessary material equipment
- in the methodological notes several alternatives for implementation are proposed (according to the possibilities and conditions of the school)

2. educational materials offer a lot of illustrative material - pictures, diagrams, graphs, animations

3. the teacher is proposed a whole range of practical exercises analyzed from a professional astronomical point of view and from a didactic point of view and consistent recommendations for implementation in the school process

In conclusion, we would like to commend the authors for doing a great deal of work and creating useful material that will work well for both teachers and students. They deserve a big THANK YOU.

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Chapter 3

Identification of obstacles on national level

The second step in the preparation of the Concept for Astronomy Education Program is to identify the obstacles that prevent or otherwise complicate the application of innovative tendencies in primary science education. The application of innovation to education is viewed from different angles. The teacher who is working with pupils in the classroom usually perceives different obstacles as the person who suggests innovation, works on curriculum and standards. Academics and teachers have identified the list of obstacles that complicate the process of implementing innovations to the learning process separately.

Given that the identified obstacles stem for the most part from the specific characteristics of the particular education system, their lists are formulated at the national level and cannot be automatically generalized to other learning environments.

3.1 From academic point of view

Based on the implementation of the project, the following key obstacles to innovation in primary science education were identified by academics.

Bulgarian Astronomical Society, Republic of Bulgaria

- There are a small number of teachers in primary school prepared in astronomy education.

  In Bulgaria, up to and including grade 6 in primary school, there is no no separate physics/astronomy subject in the curricula. Instead all natural sciences are included in a 'Humans and nature' class, including some basic concepts of astronomy. Most of the teachers teaching this class have NO preparation whatsoever in astronomy, they may be biology, chemistry, geography or math teachers instead. This is due to the fact that teacher's education in the universities is specialized. Thus, only the physics and astronomy teachers get some education in astronomy.

- The education in astronomy for primary and secondary school teachers is not sufficient.

  Astronomy is not sufficiently represented in curricula if at all. This situation leads to the inability and/or reluctance of the teachers to prepare adequately for the astronomy classes and to present the material in a systematic and engaging manner. This is one of the major factors, contributing to the very low level of the student's knowledge in astronomy at these ages.

- The equipment for teaching astronomy subjects in schools is lacking.

  Teaching astronomy properly is dependent on equipment that is not available in most schools in Bulgaria. Some of the needed aids, e.g. small telescopes, are not cheap and the schools cannot afford them. For others, such as computer software, star maps, etc., there are very few suppliers. In addition, the lack of knowledge of most of the teachers for how to use such aids leads to schools not obtaining them in general.

- Astronomy education requires a larger portion of inquiry-based learning than other subjects.

  Effective teaching of astronomical (in general scientific) knowledge requires practical work of pupils and teaching forms including excursion, experimental teaching and especially inquiry-based learning. These forms of education are challenging for physical instrumentation, tools and materials, but also require more time. If these conditions are not met at the schools, either science education is suppressed in general or active teaching methods are suppressed and replaced by frontal teaching ones.

- The present curriculum for primary and secondary schools is not optimal for a successful basic education in astronomy.

  - Lower secondary education (grades 5, 6) – no separate physics/astronomy subject; Instead all natural sciences thought in a 'Humans and nature' class

  - Grade 5 – some physics and astronomy in the curriculum

  - Grade 6 – some physics, but no astronomy in the curriculum

  In Grade 7 and onwards, students have a subject called "Physics and Astronomy, but:

  - Grade 7 – some astronomy in the curriculum

  - Grade 8 – no astronomy in the curriculum

  All above grades (5 to 8) – no practical activities in astronomy included

- Dissemination of topics and good examples to individual teachers in Bulgaria is unsystematic and ineffective.

  A wide range of supporting materials and a topic for improving teaching quality, including STARS project, is prepared in Bulgaria. However, these materials are not effectively distributed among the community of teachers. Teachers do not very often share new methods and ideas and their usage is limited to a few teachers or schools. Teachers learn about new methods, forms and topics only if they visit educational events, usually regional, or seminars organized by faculties of education or other educational institutions, or personal meetings of individual teachers.

- Lack of national and international astronomy contests for students from secondary schools.

  At present, the only such event is the National and the International Astronomy Olympiad, which is not sufficient to motivate the teachers to increase their knowledge levels and to efficiently prepare the students for participation in astronomy contests. Thus, there is no competitive medium in this aspect.

- Lack of centers for extracurricular education in astronomy

  In Bulgaria at present, there are only about 10 centers for extracurricular education in astronomy and only 6 planetaria, the latter mostly situated in the eastern part of the country. All these are important and helpful for the teachers who can use them to introduce the night sky and basic astronomy concepts to the students and to obtain additional information on astronomical topics from specialists.

University of West Bohemia, Czech Republic

- Teachers for primary schools are not sufficiently prepared in astronomy education.

  The preparation of teachers for primary schools in the Czech Republic is carried out on 8 faculties of education in the form of five-years master's degree. The focus is devoted during the preparation to pedagogical-psychological disciplines, mathematics with didactics, Czech language with didactics and more recently to disciplines preparing teachers for inclusion, working with pupils with special educational needs, pupils with different native language, etc. So, there is not enough time to prepare for astronomy. Astronomy is not sufficiently represented in curricula. This situation leads to the reluctance of teachers to teach knowledge in these fields. So, astronomy tends to be very poor in teaching at the primary level. It is like the education for existing teachers.

- There is insufficient material equipment for astronomy subjects in schools.

  Teaching of astronomy is demanding on material equipment. The situation in the supply of aids has deteriorated significantly in recent years, and so not only funds, but also companies that supply the aids are missing. Aids imported from abroad are in a significantly higher price range and they are therefore unavailable to most schools.

- Astronomy education requires a larger portion of inquiry-based learning than other subjects.

  Effective teaching of astronomical (in general scientific) knowledge requires practical work of pupils and teaching forms including excursion, experimental teaching and especially inquiry-based learning. These forms of education are challenging for physical instrumentation, tools and materials, but also require more time. If these conditions are not at school, either science education is generally suppressed in general or active teaching methods are suppressed and replaced by frontal teaching.

- The introduction of astronomical knowledge into education is complicated by insufficiently prepared implementation of curricular reform.

  The curriculum reform took place in the Czech Republic in 2007 without being sufficiently prepared. Insufficient preparation manifested in the above-mentioned problems of time, material, but especially insufficient preparation of teachers for this reform. There is still a large group of teachers who do not identify with the direction of education in the Czech Republic. Further progress of the curricular reform (adjustments of the Framework Education Programme for Primary Education in 2013) did not bring a significant change in correct direction.

  In addition, the current situation in which the changes of the Framework Education Programme for Primary Education are constantly postponed, questioned and disputed, thus causing teachers uncertainty in the direction of further development of education in the Czech Republic. No one of the STARS team is actively involved in the current process of changing the Framework Education Programme for Primary Education.

- Dissemination of topics and good examples to individual teachers within the Czech Republic is unsystematic and ineffective.

  A wide range of supporting materials and a topic for improving teaching quality, including STARS project, is prepared in the Czech Republic. However, these materials are not effectively distributed among the community of teachers. Well and excellent ideas are not very often shared by teachers and their usage is limited to a few teachers or schools. Teachers learn about new methods, forms and topics only if they visit educational events, usually regional, or seminars organized by faculties of education or other educational institutions, or personal meetings of individual teachers.

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3.2 From teacher' point of view

Teachers participating in the project form a specific group of teachers who are constantly trying to change their approach to teaching, adapt various changing conditions in society and reflect on the current situation. They are willing to invest time in educational innovations in order to make their teaching more effective. Active teachers typically identify different types of problems compared to passive teachers. These obstacles, which identify an active, innovative teacher, can be more objective, as these teachers have the endeavour and the ability to overcome every day, less significant, problems and focus on solving the key problems of the learning environment.

Teachers identified following key obstacles preventing implementation of innovations into their science classes:

Primary school at Říčany wood, Czech Republic

The teaching of astronomy at primary schools in the Czech Republic remains overshadowed by other topics. Even though some astronomy topics intersect with other subjects (physics, biology, geography), the overall requirements for the students' knowledge are very low. The main guidance document (RVP, general educational plan) only expects very basic knowledge which also reflects in the number of lessons dedicated to these topics. This subsequently manifests in the teaching materials which contain only little information and do not offer any possibility to build up on the basic knowledge of astronomy.

Also, teachers obtain information with great difficulty as teachers' guides and school materials prove to be insufficient; it is then only up to the teachers and their abilities to look up suitable sources, whether websites or encyclopedias.

Another serious issue is the equipment of schools. Only few primary schools have available the demonstration or observation equipment and most schools are thus not able to provide their students an appropriate starting point to attract their interest and extend their knowledge of astronomy. The STARS Manual offers great possibilities to make do with close to no equipment and introduces students to the required knowledge in a suitable manner.

Students are often presented astronomy only as a peculiar part of physics and not as a promising field of vast knowledge that have practical use; this is a shame not only because astronomy is an interesting field per se but it is also an unsubstantiated and to a certain extent an inexcusable step back.

High School of Mathematics "Academician Kiril Popov", Republic of Bulgaria

The standard training for teachers in physics and astronomy provides mainly information related to physics and less about astronomy. That is why the experience we have with teaching astronomy is much less than teaching physics. The main problems, in my opinion, are the late start of the study of the subject and the lack of additional qualification of teachers. Maybe it will be good as in the Bulgarian language classes they study ancient Greek myths and legends, in this way to start teaching the subject by introducing students to myths and legends about the different constellations. The other problem in education is that in Bulgaria the subject "Man and Nature", which lays the foundations of astronomy, is taught by a large number of teachers of biology and chemistry. In order to study astronomy in more depth, it may need to be studied as a separate subject. Another serious problem is the lack of star charts, telescopes and tools needed to teach astronomy.

Grammar school Metodova, Slovak Republic

There are still many teachers in Slovak schools who not only strive to improve and enhance the teaching of science subjects, but are also willing to invest their free time and make an effort to put innovations into practice. However, they face various obstacles.

Gradual "reforms" of the school system reduce the time allowance devoted to science (but also technical) subjects. The result is a lack of time that could be set aside at school for the implementation of various innovative activities (which are not directly in the textbooks used). Often, a change in the organizational form of teaching would also help - instead of the classic 45-minute lessons with breaks, it is often more appropriate to carry out the activity in larger time units, for example two hours or in blocks throughout the morning. However, such adjustments are not possible in many schools.

Even the best prepared activity is often not possible to implement effectively, because there are simply many students in the class - the teacher does not have time to pay attention to them individually, due to lack of tools they have to form groups with more members than would be appropriate, events in the classroom become difficult to manage, noise increases and problems accumulate. In this respect, it would be helpful if classes could be divided into smaller groups during practical activities.

Recently, we have also registered an increasing shortage of necessary teaching aids in schools. The old ones, which the schools received in the previous period, are already spoiling and devaluing and, of course, obsolete morally. Although a large number of different modern teaching aids are already on the market today, they are often unavailable to schools for financial reasons. When one or two devices are bought from a limited financial limit, their number is not enough for the simultaneous work of several groups.

When choosing educational activities, the teacher must consider for which students in the class he is planning the activity. Classes and students are quite diverse and have different abilities. Some activities look very interesting, they are attractive for students, but on the other hand they can be difficult to implement and the students' input knowledge. On the other hand, some activities that should be mastered even by weakly prepared students are not so motivating and attractive at first glance.

New teaching methods and forms require more intensive and often more demanding teacher training. Not every teacher is willing and able to prepare well for a new activity. Subsequently, he is not satisfied with its course and result, and in the future he may refrain from introducing innovative methods ... therefore it is very useful if the teacher receives quality methodological support in the preparation and implementation of new student activities. From this point of view, we consider the submitted materials created within the STARS project to be of very high quality.

This project has been funded with the support of the Erasmus+ Programme,
KA2, Strategic Partnerships in School Education.

Chapter 4

Concept of Astronomy Education Program – **Slovak case**

4.1 Concept from teachers' point of view

Within the STARS project, a lot of quality material for teachers and students was created. They are difficult to apply in practice because the national curriculum for science education has objectives and content formulated differently. There are many teachers who loved to teach Astronomy while it was still part of the pedagogical documents.

To compare the current situation with the past, we present selected parts of pedagogical documents related to the teaching of astronomy in the period before the reform.

In the physics curriculum for the 6th to 9th year of primary school (Approved by the Ministry of Education of the Slovak Republic on 3 April 1997 by decision number 1640 / 97-151 with effect from 1 September 1997), the Astronomy unit is defined as follows:

Goals

• Describe the solar system and search for data on solar system bodies from the MFCHT and atlases.

• Explain the origin of gravitational force on the movements of the planets of the solar system.

• Make a record of a longer observation of the Moon, the Sun.

• Orientation in the country and in the sky using familiar constellations.

• Describe the development of ideas about the Earth and the solar system from the geocentric Ptolemy and heliocentric model (M. Kopernik, Tycho Brahe, J. Kepler, G. Galilei, I. Newton) to today's model.

• Characterize the galaxy and the Milky Way.

• Describe opinions on the origin of the universe (Big Bang) and its further development.

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Contents

Bodies and motions in the solar system, orientation in the sky, milestones in the historical development of ideas about the Earth and the solar system, stars, our galaxy, the structure of the universe, the evolution of the universe, the evolution of stars

The educational standard in physics for the second level of primary school (Approved by the Ministry of Education of the Slovak Republic on 9 April 1999 by Decision No. 546 / 99-4 with effect from 1st September 1999) defines the requirements for pupils in the Astronomy thematic unit as follows:

Contents

... phases of the Moon, eclipses of the Moon and the Sun, ... solar spectrum

Requirements for knowledge and skills

Explain the formation of the phases of the Moon, the eclipse of the Moon and the eclipse of the Sun.

- What is the origin of the phases of the Moon related to?
- When is the Moon new and when is it full?
- Draw the shape of the moon between two new ones.
- Use a light bulb, table tennis ball and rubber ball as models of the Sun, Moon and Earth. Depict the lunar and solar eclipses.

Thus, before the education reform of 2008, the topic of astronomy was also represented in textbooks. A selection from the contents of the textbook for the 4th year of grammar school will tell us how the topic of astronomy in the grammar school learned before the reform (Ján Pišút a kolektív, SPN, 1985).

ASTROPHYSICS

Radiation - a source of information about stars and the universe:

- distances in the solar system,
- distances of stars,
- mass of stars,
- radiant powers and surface temperatures of stars,

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- spectra of stars,
- basic information about stars.

Energy sources, construction and evolution of stars:

- energy sources in stars,
- state diagrams of stars,
- evolution of stars,
- the final stages of a star's life,
- the emergence of our planetary system.

The structure and evolution of the universe

- basic data on the structure of the universe,
- expanding the universe,
- relic cosmic rays,
- current idea of the evolution of the universe.

Many teachers lack the topic of astronomy in their teaching and therefore include them in their school curricula. They use available lessons for this, which either add physics to the subject or create a subject with a new name. We therefore recommend creating pedagogical documents related to the whole or individual subject of astronomy. We submit a proposal:

OBJECTIVES OF THE SUBJECT

Students

- understand the methods of obtaining information about the visible and invisible universe,
- perceive the transformation of ideas into the universe in history,

• understand the connections between different natural sciences,

• realize that the sky is common to all cultures and political regimes; the view of the stars unites,

• understand vocabulary, maps, aids used in astronomy,

• know how to find and use source information (eg NASA websites, satellites, etc.),

• understand the known laws of the universe,

• acquire basic knowledge about the objects of the night sky,

• understand the methods used to measure the position, distances, composition and evolution of space objects,

• are able to plan, implement and evaluate the observation of night and day sky objects by appropriate means.

EDUCATIONAL STANDARD

Within the thematic unit Time Measurement, the student knows / can:

- ✓ understand the necessity of observing the day and night sky in the creation and creation of a reliable calendar, in measuring time,
- ✓ characterize periodic events related to the terms day, year and month,
- ✓ describe the movement of the Sun in the daytime sky and the movement of the Sun between the stars,
- ✓ understand the qualitative relationship between the height of the Sun and latitude.

Within the thematic unit **Measurement of position**, the student knows / is able to:

- ✓ be aware of the change in the direction of sunrise and sunset, the change in the height of the Sun at noon during the year,
- ✓ to propose a method of measuring the height of the Sun above the horizon and a method of determining the direction of sunrise,

- ✓ determine unambiguously the position of the object in the sky by a pair of angles with respect to the observer,
- ✓ use horizontal coordinates: terms horizon, zenith, meridian, height above the horizon, azimuth,
- ✓ display in the Stellarium application e.g. rising sun on any day of the year and find out the azimuth of its sunrise,
- ✓ change the position of the observer on Earth in the Stellarium application, change the latitude and find out the height of the Sun in the sky,
- ✓ understand equatorial coordinates: celestial equator, celestial pole, declination, right ascension,
- ✓ describe the uniqueness of determining the position of an object in the celestial sky with respect to the center of the Earth and the star,
- ✓ understand the concept of ecliptic, spring and autumn point,
- ✓ can display horizontal and equatorial coordinates e.g. in the Stellarium application,
- ✓ can display the ecliptic and search the Moon and the planets of the solar system near it.

Within the thematic unit **Measurement of distance**, the student knows / is able to:

- ✓ describe qualitatively and quantitatively the Eratosten determination of the Earth's radius,
- ✓ describe and explain a qualitative first measurement of the distance to Mars,
- ✓ describe the method of measuring the distance of nearby stars,
- ✓ use units of length astronomical unit, light year, parsec,
- ✓ measure the change in the angle of the near point with respect to the more distant when viewed with the right and left eyes,
- ✓ measure the distances of an object of known height by the triangulation method.

Within the thematic unit **Earth and its Moon**, the student knows / can:

- ✓ explain the difference between a sunny and a stellar day,

- ✓ explain the alternation of seasons, polar day and night,
- ✓ characterize the Platonic year, the necessary movement,
- ✓ display the change of the position of the Polaris during the Platonic Year in the Stellarium application,
- ✓ explain the phases of the moon,
- ✓ characterize the difference between synodic and sidereal circulation,
- ✓ solve qualitative problems such as: The moon is in the first quarter, the sun is setting, determine where the moon is,
- ✓ describe the occurrence of solar and lunar eclipses and justify why there is no eclipse at every orbit,
- ✓ justify that the apparent same angular size of the Sun and the Moon does not mean that the Moon and the Sun are the same size, but that the Sun is as many times larger as it is farther than the Moon,
- ✓ justify the difference in the duration of a lunar eclipse and a solar eclipse,
- ✓ justify why you can never see the Sun from the far side of the moon,
- ✓ search for information, prepare and present a project about the Moon or about a specific solar or lunar eclipse,
- ✓ display a solar or lunar eclipse in the Stellarium application based on the searched information.

Within the thematic unit **Solar System**, the student knows / can:

- ✓ understand the terms conjunction, opposition, elongation, retrograde motion of planets,
- ✓ to model the projection of the Earth's motion around the Sun on the motion of the planets Venus and Mars with respect to the stars,
- ✓ understand the origin of the loop from the point of view of a terrestrial observer in the motion of planets with respect to the stars,
- ✓ explain why we can't observe Venus, Mercury at midnight,

- ✓ justify the difficulty of observing the planet Mercury,
- ✓ justify the origin of the phases of Venus,
- ✓ characterize the ellipse, draw the ellipse as a geometric place of points with the same sum of distances from two foci,
- ✓ understand the terms focus of the ellipse, large and small half-axis, perihelion, aphelion, inclination of the trajectory with respect to the ecliptic,
- ✓ describe Römer's determination of the speed of light by long-term measurements of Jupiter's moons,
- ✓ describe the change in velocity of a comet with a markedly elliptical orbit,
- ✓ describe the origin of the comet's tail,
- ✓ explain the difference between the terms meteor and meteorite,
- ✓ characterize the difference between a planet and an asteroid,
- ✓ prepare and present a project about a selected object of the solar system or about a probe traveling through the solar system,
- ✓ to prepare a paper on the life of an astronomer who contributed to the knowledge of the laws of the solar system (eg Copernicus, Galileo, Kepler, Newton, Römer, Haley).

Within the thematic unit **Stars**, the student knows / can:

- ✓ describe the method of determining the position of stars in the sky by two angles: declination and right ascension,
- ✓ describe the basic ideas of how to measure the distance of stars,
- ✓ imagine the projection of the Earth's motion around the Sun on the apparent motion of nearby stars with respect to distant stars,
- ✓ understand the historical meaning of the term star size - magnitude as a way of comparing the brightness of stars with the human eye, the brightest stars visible to the naked eye have zero brightness - zero magnitude 0 mag (or their brightness is expressed as a negative value) and

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the weakest stars visible to the naked eye have a brightness of six magnitude 6 (in the area without light pollution),

- ✓ explain that the object of the sixth magnitude is 100 times weaker (emits 100 times less light in the visible region) than the object of zero magnitude, the object of the first magnitude is 2.5 times weaker than the object of zero magnitude, the difference is related to the properties of the human eye,
- ✓ describe the difference between apparent and absolute stellar size,
- ✓ recognize absorption lines in the star spectrum,
- ✓ obtain the spectrum of the light source in a suitable way (eg by passing light through a prism or grating),
- ✓ divide the stars according to the spectral class,
- ✓ carry out an experiment in which it observes a continuous, emission and absorption spectrum,
- ✓ read Hertzprung-Russel diagram,
- ✓ describe the life of a star,
- ✓ put forward arguments leading from the observation of a large number of stars in a short time to the emergence of a theory about the life of stars lasting millions to billions of years,
- ✓ name the basic characteristics of stars,
- ✓ describe the energy source of stars, the conversion of hydrogen into helium,
- ✓ characterize a binary star.

Within the thematic unit **Star Sun**, the pupil knows / can:

- ✓ to classify the Sun among the stars,
- ✓ state the characteristics of the Sun as a star,
- ✓ describe the differential rotation of the Sun,
- ✓ describe the magnetic field of the Sun and solar activity,

- ✓ to suggest a way and when to observe the Sun,
- ✓ determine the rotational time of the Sun.

Within the thematic unit **Constellation**, the student knows / can:

- ✓ describe the historical division into constellations,
- ✓ explain that stars in the same constellation can have different distances and form a group of stars only when viewed from Earth,
- ✓ to understand that the circumpolar constellations are those we see in our latitudes throughout the year, revolving around a pole near the Polaris in the constellation of the Little Bear,
- ✓ find the Big Bear in the sky, the Big Wagon in it and use the stars in the car to find the Polar Bear,
- ✓ find in the sky the circumpolar constellation Cassiopeia, which looks like a large double W or M,
- ✓ understand that during a stellar day, each star rotates around the celestial pole by 360o,
- ✓ understand that constellations are those that pass through the ecliptic,
- ✓ to find in the sky the winter constellation Orion, the winter hexagon and in it the brightest star in the sky Sirius,
- ✓ use appropriate observation aids (sky map, red light).

Within the thematic unit **Galaxy**, the student knows / can:

- ✓ characterize the galaxy,
- ✓ name different types of galaxies,
- ✓ describe the distance of galaxies,
- ✓ characterize Our Galaxy and can find some of the nearest galaxies in the sky,
- ✓ to include objects belong to our galaxy.

Within the thematic unit **Development of the Universe**, the student knows / is able to:

- ✓ describe the connection between the distance of galaxies and the expansion of the universe,
- ✓ read with understanding articles related to the age and evolution of the universe.

Unsatisfactory conditions for the implementation of teaching can be a serious problem in the implementation of these proposals. In order to make progress in science literacy, it is necessary to ensure the balance of the curriculum for individual educational areas and to increase the number of teaching hours for science subjects. The effort to educate and educate in elementary school students who can apply in the labor market and motivate them to further study at vocational (technical) schools can be achieved only by offering adequate representation of all types of subjects.

The method of active cognition of students dominates in the design of innovated subject contents. With the radical reduction of the hourly subsidy for science subjects within the framework of the reform in 2008 and the often weak equipment of school vocational classrooms in schools, experiments that do not lose their attractiveness and at the same time fulfill their purpose dominate. In view of this, it would be necessary to improve the equipment of schools with means (aids and technology) for science experiments, including the means of a computer-aided laboratory.

All the proposed changes are difficult to implement without dividing the large classes into groups. Every effective method of work requires intensive communication between the teacher and the student and the students with each other. Researching, discovering and experimenting with ICT tools all the time with the whole class is technically impossible, often dangerous!

In the whole process of education, the greatest burden lies on the shoulders of the teacher. The attitudes of teachers show that they feel a very precarious background not only from their students and their parents, but especially from the weak support from the state. Those who remain in education want to focus mainly on direct teaching.

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Chapter 4

Concept of Astronomy Education Program – **Bulgarian case**

Here, we will briefly summarise the current situation and ASTRONOMY curriculum in the Bulgarian schools, as well as the extracurricular activities available only in parts of the country and conducted mostly outside of the schools.

1 General information

1.1 School Curriculum

In the lower secondary education (grades 5, 6) – no separate physics/astronomy subject. Instead all natural sciences are taught in one 'Humans and nature' class, where there is some physics and astronomy in the curriculum in grade 5, and some physics, but NO astronomy in the curriculum for grade 6.

In grade 7 and onwards, students have a subject called "Physics and Astronomy", but while there is some astronomy in the curriculum for grade 7, there is no astronomy in the curriculum for grade 8. For all above curricula (grades 5 to 8) there are no practical activities in astronomy included.

What is more, for the lower grades teachers in most cases are not physicists.

1.2 Extracurricular classes

There are extracurricular activities in astronomy for students which are not compulsory and depend on both the willingness of the students (and their parents) to join and the availability in the town or region of such classes. These activities are for children from grade 5 onwards who are interested in astronomy, and are mostly organized outside of the schools (in the "People's observatories" and planetaria). The teachers have at least a bachelor degree in physics and astronomy. The activities cover substantially more topics and offer additional (practical) activities – observations, reading a sky map, learning constellations, etc.

2 Educational standards

2.1 For secondary schools:

<u>Grade 5</u>:

Subject: Humans and nature, Knowledge area: From the atom to the Cosmos

Knowledge and capabilities the students should have at the end of the course (regarding astronomy):

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- Describe in simple terms and models the motions of the planets and their satellites due to gravitational forces, as well as phenomena due to Earth's and Moon's motions (seasons, Lunar phases, eclipses)
- Give examples for space satellites/probes, space explorations and their importance
- Distinguish the Solar system planets and group them based on given properties
- Recognize the North star (Polaris) and some of the most popular constellations
- Recognize the Solar system as part of our Galaxy – one of the many galaxies in the Universe

Educational content: Earth and Cosmos. Includes:

- Earth and the Solar system
- The world of stars

Expected results. Students should be able to:

- Explain the changes of the seasons, phases of the Moon, lunar and solar eclipses (with/due to the motions of the Earth and the Moon)
- Recognize the orbital motions of the planets and their satellites as consequence of the operation of gravitational forces
- Compare/distinguish rocky and gaseous planets based on specific characteristics
- Name important events from the space exploration history (space satellites, probes and stations)
- Recognize the Great and Lesser Bear constellations and the North Star.
- Describe the Sun as a star belonging to the Milky Way, and the Universe as consisting of many galaxies

New terms introduced in the class: gravitation, constellation, galaxy, Universe (introduced in primary school terms: planet, star, day, night, satellite, Sun, seasons, calendar, sunrise sunset)

There are no practical exercises!

<u>Grade 6</u>:

Subject: Humans and nature, Knowledge area: From the atom to the Cosmos

No astronomy in the content.

In the Physics section, there is a topic on gravitational force and gravitational acceleration of the Earth, but again with NO practicals.

<u>Grade 7</u>:

Subject: Physics and astronomy

In the Physics section, there is a topic on light and its spectrum.

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From the atom to the Cosmos:

Knowledge and capabilities the students should have at the end of the course (regarding astronomy):

- Group the Solar system planets and small bodies by given criteria.
- Describe in simple terms the different types of galaxies, the structure and evolution of the Universe.

Educational content includes:

- The Solar system and its bodies
- The Sun and the stars – basic composition, sizes, nuclear fusion
- Galaxies – basic information
- General idea about the structure and evolution of the Universe

There are no astronomy practicals in the curriculum!

Grade 8:

Subject: Physics and astronomy

There is no astronomy content.

2.2 Extracurricular topics

- Stellar astronomy. Celestial sphere.
  Includes: Celestial maps; horizon; apparent diurnal motion of the stars; rise, set, culmination of celestial objects; constellations; myths and legends about the constellations; the north sky during the seasons; celestial navigation.
- Earth. The Earth's motion. Time and calendar.
  Includes: Apparent diurnal motion of the Sun – rise, set, direction of the Sun's apparent motion; apparent diurnal motion of the Sun during different seasons – qualitative description; Zodiac constellations, motion of the Sun through the zodiac constellations; equinoxes and solstices – connection with the seasons; Measurement of time – number of days in the months and year; normal and lea years.
- Moon.
  Includes: composition and topography; phases, explanation of the phases.
- Solar system.
  Includes: Planets – names, order, rocky and gaseous planets, satellites – names of some of them; dwarf planets; small bodies in the Solar system – asteroids, comets, meteors and meteorites – general qualitative description.
- Astronomical instrumentation and observational methods.
  Includes: General qualitative description of telescopes; the largest telescopes and observatories.

- The basics of astrophysics. Sun. Stars.
  Includes: Brightness of stars and other celestial objects – general qualitative description.

4.1 Concept from academic point of view

An analysis of the Bulgarian national curriculum and standards for primary and secondary science education indicates that STARS material is prepared in full compliance with the focus of formal science education and can be used to achieve the basic objectives of the equivalent subjects.

Based on analysis of the objectives, it is possible to formulate the following recommendations to extend astronomical education and improve the science knowledge at primary and secondary levels.

Recommendations:

- The following main principles: observation, experimentation, measurement and estimation, and application of scientific knowledge, predicting phenomena and determining causal connections are practically missing from the lessons and need to be included. Other principles are better addressed, e.g. identification and proper use of terms qualitative description of objects, explanation of terms, quantitative description.
- Improvement of theory formation in science education. It not only enables the students to build up knowledge and apply already learned skills, but also takes theorizing into account as well as the development of process-related skills. This is important, because students need both components to develop their competences and scientific skills.
- Emphasize on inquiry-based learning and similar forms of active learning whenever possible. These activities allow students to raise questions, plan experiments and inquiries, gather information, analyze, interpret and explain data and phenomena, verbalize their thinking, present their outcomes, and share them with others. These steps support thinking processes and foster further cognitive development. In this way, students learn to reflect on their research process and view it from a different perspective. This is supported by the exchange with the classmates.
- Supplementing suggestions and concrete implementation examples. This allows and helps teachers to adapt the material to the interests and abilities of the students individually. This cannot be achieved with very brief examples in the curriculum and individual illustrative materials. Therefore, the recommendation can be given to teachers with a number of suggestions and implementation examples. In addition, it could motivate and support teachers who teach outside their subject area to teach specific scientific topics.
- Students should be given more time to investigate scientific topics. It is important that students have sufficient time to discover the scientific questions, to study them in detail through the different phases of a research process, and to understand underlying principles. Thus, a flexible teaching time is desirable, which can be adapted to the learning processes of the students.
- Use more widely the active teaching methods like excursions to science centres, observatories and planetarium. Observing individual science phenomena and processes outside the school is crucial to knowing that school education is useful in terms of understanding phenomena and

processes, thus leading to the integration and interconnection of the various parts of the curriculum into a comprehensive scientific literacy.

- Include astronomy topics and or examples in the curriculum in each grade. This will ensure the continuity of the learning process.
- Use astronomy examples wherever possible in related sciences to illustrate theoretical content, e.g. regarding optics, gravitation, etc. in physics classes, conic sections in mathematics classes, etc. This will not only strengthen astronomy knowledge but will also show the interconnections between different natural sciences and science and technology.
- Include astronomy knowledge in the National external evaluation after grade 7, which would add incentive for both teachers and students to work better and harder on obtaining that knowledge.

4.2 Concept from teachers' point of view

For better student achievement, there should be more hours for teaching and consolidating knowledge. The classes in physics and astronomy from 7-10 grade are 216 in total (in 7th grade - 1.5 hours, in 9th grade - 2.5 hours and in 10th grade - 2 hours). Total: 6 hours * 36 school weeks = 216 hours. Yes, if they choose the subject of physics and astronomy after 10th grade they have more hours, but in order to choose it until 10th grade it is good for students to see not only the theoretical part and tasks, but also the experimental and applied side of the subject. Usually, due to flu and cold weather related vacations, when teachers cannot hand over the material, we restructure from these classes. Therefore, it is necessary to provide enough hours for new knowledge, problem solving and exercise, laboratory work and observation. In most schools, the subject of Man and Nature, where the foundations of the natural sciences are laid, is taught by teachers of biology and chemistry. As a recommendation, I would address the need for an earlier start of astronomy education and additional qualification of teachers, teaching the subject. With the help of this game approach and more hours of astronomy, both for teaching and for solving practical tasks and observations, students will acquire long-term knowledge and skills in a non-standard way for the subject.

Chapter 4

Concept of Astronomy Education Program – **Czech case**

As we listed examples of good practice, prepared Methodical material for teachers, Training Program for Teachers and mainly identified obstacles that complicated wider implementation of the STARS in primary schools, we can formulate a Concept of Astronomy Education Program. The main sources during creation of Concept of Astronomy Education Program are: "*What a primary school pupil should know from physics, chemistry and natural science: design of evaluation criteria for science education at primary school*" (Kolářová, 1998), "*Astronomical teaching*" (Kéhar, Randa, 2018) and basic idea, that "*Primary school pupils should be able to recognize and explain (at a level appropriate to age) all astronomical phenomena observable with the naked eye.*"

4.1 Concept from academic point of view

An analysis of the Czech national curriculum for primary science education indicates that STARS material is prepared in full compliance with the focus of formal primary science education and can be used to achieve the basic objectives of equivalent subjects.

Based on analysis of the objectives, it is possible to formulate the following program to extend astronomical education on primary level.

Legend of letters before the dash: F as Physics, part 11 Earth and Universe. Number after the dot is just the order. Legend of letters after the dash: A – identification and proper use of terms; B – qualitative description of objects, systems and phenomena and their classification; C – explanation of terms; D – predicting phenomena and determining causal connections; E – observation, experimentation, measurement and estimation; F – quantitative description; G – application of scientific knowledge.

F11.00-A: Terms: Solar System, Sun, Moon, Planet, Dwarf Planet, Comet, Meteoroid; Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune; Lunar Phase, Full Moon, New Moon, First Quarter and Last Quarter, Solar Eclipse, Lunar Eclipse, star, constellation, Polaris.

Most terms appear in the last year of primary school and only in some textbooks (e.g. Fraus publishing company). In the curriculum for primary education, only the terms star and planet (related to astronomy) occur in the (mandatory) outputs of the subject of physics. There is a comparison of the essential properties of the Earth with other bodies in the solar system in the subject geography. Other terms occur in physics in the curriculum (this section is only recommended):

• properties of light - solar and lunar eclipses;

• solar system - its main components; lunar phase;

• stars - their composition.

F11.01-A: To say what kind of bodies consists of the Solar System (Sun, planets, dwarf planets, their moons, comets, minor planets and meteoroids).

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See F11.00-A.

F11.02-A: To enumerate planets in order of their distance from the Sun.

Enumerating planets in the correct order of their distance from the Sun is already included in the curriculum for the first stage of primary education.

F11.03-B: To illustrate the annual movement of the planet around the Sun. (Use a lamp and an apple, ball to show the Earth's movement around the Sun. Show how the Earth will travel in a quarter, in a half-year, in a year. Show how the Earth will rotate in 12 hours, 24 hours, 1 week.)

Illustrating annual movement of the planet around the Sun is already included in the curriculum for the first stage of primary education.

F11.04-B,F: Describe the difference between the sun, planets, dwarf planets and comets. Use the tables to find and compare some parameters of the Sun, planets, dwarf planets and comets. (Choose bodies from the Solar System bodies that shine by their own light. Find in the tables masses of all planets and say which one has the greatest mass. What has the greater mass: a planet or a comet?)

Describe differences of Solar system bodies is output of physics (just comparison of Sun and planets). Quantitative comparison of parameters is not part of curriculum and real teaching. Some textbooks (e.g. from Fraus publishing company) cover these requirements.

F11.05-C: To explain why comets are observable after several years only. (Halley‘s comet is visible every 76 years. Why cannot we see it every year?)

It is not part of the curriculum for primary education, it is part of some textbooks. Questions about observation of comets usually come to the public's attention at a time when some comet is close to Earth. This finding is related to the small size of the comet, a significant change in distance from the Earth and the Sun, and the changing appearance of the comet (tails). All this knowledge is available to the teacher and he/she is therefore able to formulate an appropriate explanation.

F11.06-A: To define the force that keeps planets, their moons, and comets in orbit around the Sun. (Why does not the Moon fly away from Earth? Which force keeps it close to Earth? Which force keeps the Earth and other planets at the Sun?)

It is a part of curriculum for primary education in the outputs in physics. Knowledge is only qualitative. Elementary school pupils can only reach the quantitative level within the extended activities or during the Astronomical Olympiad.

F11.07-C: To demonstrate the changing of the seasons in the northern and southern hemisphere as a result of Earth's axial tilt relative to the ecliptic plane, the hemisphere faces the Sun. (The globe is the Earth and a lamp is the Sun. Set them to the position when winter is in the northern hemisphere.)

Already included in the curriculum for the first stage of primary education.

F11.08-C: To explain why the Moon and the Sunshine.

Already included in the curriculum for the second stage of primary education, physics, and usually seventh grade.

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F11.09-C,F: To compare the apparent sizes of the Sun and the Moon. (Explain why the apparent sizes of the Moon and the Sun are approximately the same, although the diameters of the Moon and the Sun, as shown in the tables, differ substantially.)

Included in the curriculum related with Solar and Lunar eclipses.

F11.10-B: To compare possibilities of man's stay on different planets and on the Sun, or on other stars. (Can humans visit the Moon, Mars, Venus, Sun, star? Explain your answer.)

It is not usually described in the textbooks for all planets, just selectable. It is possible to derive it from basic features of these bodies. It is part of the first stage of primary education.

F11.11-B: To describe the main differences between planet and star. (Imagine that you are an astronaut approaching a distant body in the universe. How do you know if this body is a planet or a star?)

It is included in the outputs of curriculum for primary education.

F11.12-B: In the solar system image use arrows to indicate the direction of the gravitational force of the Sun on the planet and its moon, the comet.

The term gravitational force is included in curriculum and textbooks (see F11.06-A), but it is not expected to apply it as written in this point.

F11.13-C: To illustrate by model the alternation of day and night. To represent by model the movement of the Moon around the Earth and its rotation around the axis.

Illustrating alternation of day and night from movement planets around the Sun or Moon around Earth is part of curriculum for primary education.

F11.14-F: Find the required parameters of Earth and Moon in the tables. (Find out how many times the Earth's diameter is greater than the Moon's diameter.)

Finding the parameters of Earth and Moon is not part of the curriculum for primary education, it is also not common for real teaching. Some textbooks (e.g. from Fraus publishing company) cover these requirements.

F11.15-C: To demonstrate relative position of the Sun, Earth and Moon at Full Moon, New Moon, Quarters and Eclipses. (Use a lamp, a ball, and an orange to show the position of the Sun, Earth, and Moon on a Full Moon without an Eclipse and on a Full Moon with a Lunar Eclipse. Can the Solar Eclipse be with the Full Moon?)

It is not included in the curriculum for primary education. Textbooks contain examples of models.

What should be further improved in the above introduced program? There are still missing two main principles: E – observation, experimentation, measurement and estimation and G – application of scientific knowledge. Other principles are covered: A – identification and proper use of terms (5 times); B – qualitative description of objects, systems and phenomena and their classification (6 times); C – explanation of terms (7 times); D – predicting phenomena and determining causal connections (1 time); F – quantitative description (3 times).

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4.2 Concept from teachers' point of view

Shall astronomy teaching in the Czech school system have any effect and sense, it is necessary to achieve several conceptual changes. The following are some of the key ones:

- Extending the required knowledge and skills within RVP (general educational plan). In its current form, the guidance document only requires elementary knowledge without any coherent concept.
- More lessons. The current time dedicated to the teaching of astronomy is highly insufficient and does not allow introducing students to the important topics and new findings in the field. Even though astronomy topics can be encountered in other subjects (physics, biology, geography), it remains only on the margin with no possibility to build up on the obtained knowledge.
- Availability of quality sources of information. When it comes to astronomy, teachers are dependent on the information available in teaching manuals or on the results of their own searches online or in encyclopedias. There are no unified textbooks of astronomy for primary schools, which would contain information on the individual astronomic phenomena together with instructions and activities for practical lessons. It is more than obvious that the STARS Manual offers a quality solution for this issue.
- Teacher education. During their studies, teachers only get basic information on astronomy, they are not given adequate knowledge of this field nor the possibility to study it in greater detail and the topic thus rarely attracts their interest.
- General knowledge of astronomy. Astronomy as one of the branches of physics is a highly progressive field bringing theoretical as well as practical knowledge. It is without any question interconnected with other areas of human knowledge and we cannot help but wonder how much in the shadow it stands.

It would definitely be possible to find other possibilities and ways to point out and try to find solutions to the insufficient teaching of astronomy but these appear to be the most important. The STARS Manual seems to be a good step in the right direction and it has the power to remove at least some of the obstacles lying between students and astronomy and to help move the teaching of this branch of physics a great deal forward.

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Resources:

ARCHER, L., DEWITT, J., OSBORNE, J. DILLON, J., WILLIS, B. a WONG, B. 2010. "Doing" science versus "being" a scientist: Examining 10/11-year-old schoolchildren's constructions of science through the lens of identity. *Science Education*, Vol. 94, No. 4, 07.2010, p. 617-639.

KÉHAR, O., RANDA, M. Astronomická výuka. In *Astronomické vzdělávání a popularizace astronomie 2016*. Plzeň: Západočeská univerzita v Plzni, 2018. p. 60-73. ISBN 978-80-261-0796-5. (The title of the document in English: Astronomical teaching)

KOLÁŘOVÁ, R. a kol. *Co by měl žák základní školy umět z fyziky, chemie a přírodopisu: návrh evaluačních kritérií přírodovědného vzdělávání na základní škole*. Praha: Prometheus, 1998. 87 p. ISBN 80-7196-110-8. (The title of the publication in English: What a primary school pupil should know from physics, chemistry and natural science: design of evaluation criteria for science education at primary school)