The popularization of space exploration amongst high school students

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***Abstract*—Space industry made possible for us to explore our universe by leaving the atmosphere of the Earth. It gives us great opportunities and challenges. Recruitment and motivation of the students can not be started too early, and of course we also need some appropriate methods to keep up their interest. Many people believe, that the best time to pass through the most knowledge to the students could be the secondary school age. At this age, students already have the basic knowledge in physics and mathematics that makes them able to understand more complex problems. In space research there are many areas, topics (e.g. astronomical facts, space exploration history, the ongoing projects in space research, future research plans and challenges) that are of great interest, and which are excellent for raising the interest and motivation of high school students for science courses. After a short overview of the topics and some existing programs, we will present a self-made program for secondary school students that promotes the space research for them. The tasks also fit the subject of physics, mathematics and geography. This unconventional class is interactive by involving and activating students. We have already presented the program in three different classes in a secondary school in Budapest with great success. We share experiences and analysis about the results with the audience.**

Keywords— Education, Space research, Storyline method

I. Introduction

We need space researchers! The school is one of the most suitable places where teachers can motivate students in this direction. Numerous space agencies and foundations try to make people aware of importance of space exploration. For example, the NASA and the ESA pay a great deal of attention to the popularization of STEM and the space exploration both in school lessons and free time activities on their webpage.

Physics teachers also try to find new ways individually in popularizing space science and space exploration among secondary school students. Some good examples worth mentioning, such as M. Pető [1][2] who built line tracking, firefighting, life-saving robots and minisatellites and participated in CanSat competitions with her students. A. Komáromi [3][4] demonstrated some space applications in teaching thermodynamics and modeled a heat shield, which has also been shown in the Science of Stage Europe festival (a regular biannual event with a motto: "From teachers for teachers”). Cs. Fülöp and Zs. Horváth [5] carried out an out-of-school project with their students on the topic of the brightness of stars. Or Zs. Horváth [6] designed a lesson about exoplanets and the habitable zones of stars.

Our self-made program has been inspired by all of the above.

II. The Storyline Method

The didactical path of our project is based on the Storyline method which was developed by Steve Bell and Sallie Harkness in Scotland [7][8]. The point of this approach is that there are no lessons, the children can learn with fun but guided to develop the ability to solve more complex problems and to communicate with each other in a better way. The speciality of this method is that the teachers create a background story for the course which is based on the subject of the class and the students solve the exercises in that given situation. Storyline is a teaching method involving students to help learning a subject matter. It is basically a series of questions leading through the storyline. Students create characters for the story thus adding their feelings and attitudes to it. This will make them interested in the learning subject. Their interest motivates them to do research on the subject and thus internalize the learning process. They are encouraged to apply their analytical skills and creativity for the storyline. This method is relevant to one important statement of Marisa Michelini, who is a significant expert of the PER (Physics Education Research) “that it is necessary to create knowledge of a subject which is not static and definitive, but in progressive and continuous evolution” [9]. Based on this we have created our special physics lesson.

The backstory of our project was the popular post-apocalyptic theme. The year is 2800 and 80 % of humanity gone extinct. The Earth became inhabitable due to several natural disasters. The students are the last space researchers in the world with the task to find a new livable planet. They are the members of Post-Apocalyptic Space Agency (PASA).

III. Participants, Pre- and Post-test

Our project was performed in the Balassi Bálint Secondary Grammar School in three different classes with a total of 75 students between the ages of 12-17. From the three classes that were participating in the project two of them were learning physics on a basic level (9th and 10th grades) and one group (the 7th grade) hadn't specialized yet.

The lesson started with a survey. Here some demographic data were collected and some questions (pre-test) about space exploration were asked from students. The questions were:

1) Which 3 words come to mind about space exploration?
2) What sciences do you think are related to space exploration?
3) What difficulties might astronauts encounter during the long journey?
4) What is a multi-stage rocket?

At the end of the program they filled out the same survey (post-test) which they got at the beginning of the lesson, so we could measure and evaluate the effect of the program. The Table I shows the exact time table of this special physics lesson.

IV. The project (PASA)

After the survey (pre-test) the class was divided into 5 groups. Every group could select a theme in keeping with their interest from the predefined ones. These themes fitted to either physics and mathematics or any other space-related topic. It was clearly perceived that the formation of the groups was the easiest for the youngest students. After the description of the task the students became greatly excited; moreover, they laughed at the fact that they were the last hopes of humanity.

For every group the first exercise was the literature research where the students got the materials about their topics. These documents (Fig.1) contained questions to help them understand the topic, as well as a brief introduction to the exercise. Of course, they could use every aid they could find including their mobile phones with internet access. Thereafter they had to present their findings to the class. There were no limitations about the topics, they had a free hand with the content of their presentations.

TABLE I

Time schedule	
Time	***Activity***
5 min	Pre-test
5 min	Description of the task and select groups
15 min	Groupwork
15 min	Presentations
5 min	Post-test

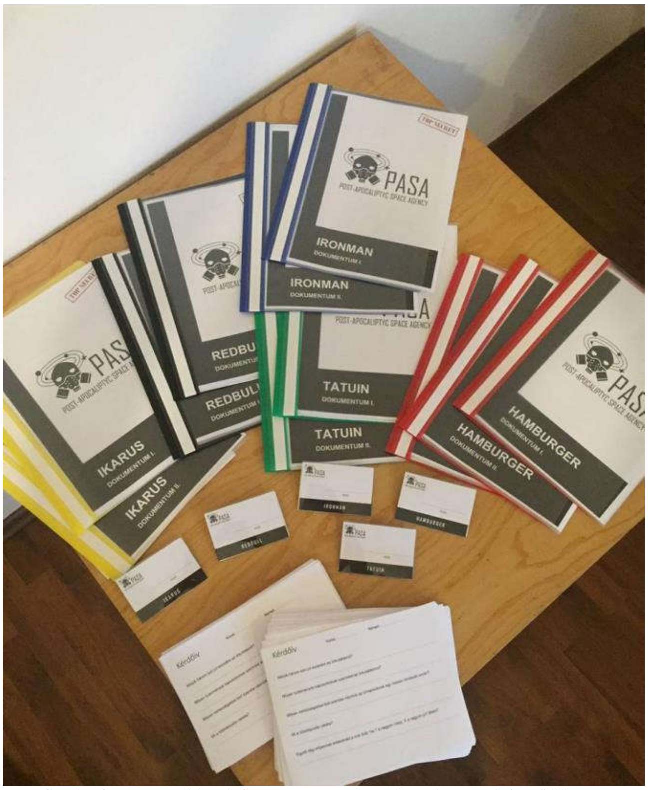

Fig. 1 The starter kit of the PASA project: handouts of the different groups, badges, pre- and post-tests.

The groups of students were built around the following predefined topics: The first group, named Tatuin, was based on geographic knowledge. In this section the students could read about the aurora borealis and the environmental conditions of Earth. The Ikarus and Redbull groups dealt with questions in connection with mathematics and physics. They could learn about how solar cells work, the evolution of rockets and a story about Elon Musk's Tesla in space. The Ironman and Hamburger groups relied on the children's creativity. These groups were created so that the children who were not interested in STEM could also join the program. These topics were about articles related to the preservation of mental and physical health in space or how food is different in a space environment. In general, the experience was that every student was able to choose a group they liked so they could be an active participant in the lesson.

The special physics lesson had a starter kit. The starter kit contained handouts for the research groups. The handouts included articles, exercises and questions. Every student got a blank badge on which they could write their names. These materials were emblazoned with the Post-Apocalyptic Space Agency brand (Fig.1).

For example, the IKARUS group got two documents. In Document-I the students could read about the history and evolution of solar cells, and the difference between the photovoltaic effect and the photo-electric effect was defined and highlighted here. Document-I finished with three questions referring to the energy support of the satellites, the operation and history of solar cells used onboard on satellites.

The students could find the answer for the first question in the handout, but it did not contain the remaining answers. Therefore, they had to use the internet to answer these questions.

Document-II contained an exercise from NASA's website. The students could learn about the efficiency of the solar cells and they could use their mathematics knowledge, especially their geometry knowledge. They got 3 different geometric shapes for the solar cells and they had to calculate the areas, the perimeters and the efficiencies of the solar cells (Fig.2).

In general, this group was popular for students who liked mathematics and physics. They solved the exercises very well and quickly. Our goal with this group was to show how mathematics is used in space research and to develop their web search habits.

V. Results

The results were formulated based on the development in students; awareness and knowledge between the pre- and post-surveys, as well as the experiences during the class including student presentations.

Some interesting answers from students:

"It was good to practice teamwork and public speaking"

"It's unusual, but interesting. We could do it more often"

"I am not interested in this topic, but it sparked my interest a bit"

As mentioned above, one of the questions in the survey was about how many disciplines related to space exploration the students know. In the diagram, (Fig.3) blue marks the pre-lesson survey and orange indicates the post-lesson survey results.

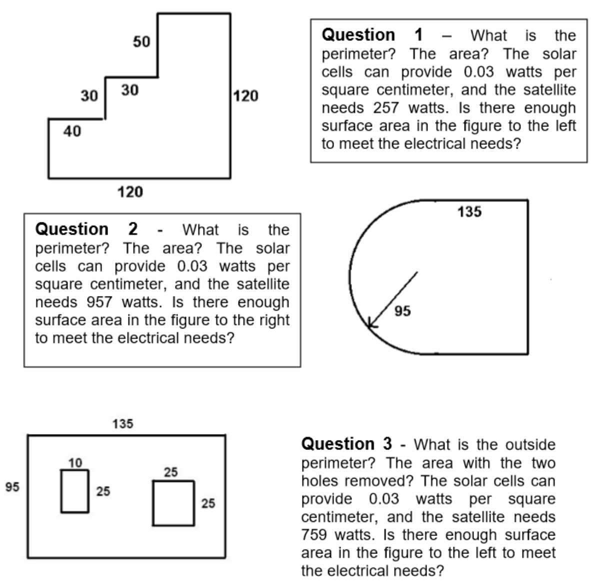

Fig. 2 The different shapes of solar panels (Ikarus group). Source: http://image.gsfc.nasa.gov/poetry

It is worth noting that the last question (What is multi-stage rocket?) was the most difficult one. In the pre-test, 41% didn't answer this question, but after the lesson this number decreased by 52% compared to the previous result.

A question was put to the students in group Hamburger about long-term food storage and preservation in space to see how creative they could be. To my great surprise one of the 15 groups (in the three classes) referred to the fact that we are in 2800, and because of the technological development we should be able to print food by now. So, their solution was to use 3D printed food in space.

For the group Tatuin I had the question: "Why is the sky blue?" The answer could not be found in the Document they got from me; the point was to use the internet to find it. To my surprise none of the student could find the right answer. They found the same web page from the 3 million results, but they did not understand what they read. They copied quotes from famous poets who described the sky in their view. I concluded that the students have serious problems in information processing and finding a relevant answer to a question. We have to find a solution to this problem to stop the spread of hoaxes and fake news among youngsters. Also it is important that the students be made familiar with the English language as early as possible, because much useful and up to date, correct information can be found in English on the Internet.

VI. Summary

To summarize the experience of the students about our unusual class, it was positive, and what we saw was that the children are open-minded about STEM and space exploration in general. If we can present these themes interactively and entertainingly, they will enjoy it and have an interest in it. We have to popularize space exploration in their language and should not be afraid to use new methods to spark interest in them and introduce them to a new, interesting and ever-changing world to get out of the rut even if only for a short time.

We would like to finish with this interesting quote from Larry Niven.

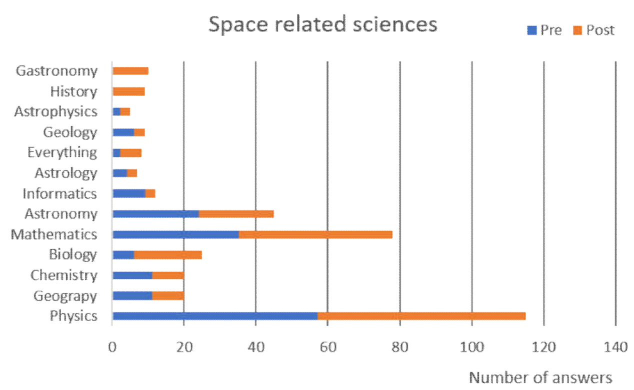

Fig. 3 Diagram of the space related sciences

"The dinosaurs became extinct because they didn't have a space program. And if we become extinct because we don't have a space program, it'll serve us right!"

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