AMAZING SCIENCE

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This article is mainly about the technique of project-based training in science education. The method is based on the concept of individualizing the students' creative abilities. A student must bring all of his/her knowledge to develop an investigation and prepare further on a presentation using PPT or a poster. The student must use written and spoken language, art and graphics, background study and history of a subject, mathematics, learn about scientific thinking and processes, develop organizational skills, and conjure up some serious curiosity about its topic. In fact, curiosity, the conversion of that curiosity into a problem statement, and finding ways to overcome a chain of obstacles is what science is all about.

Fig. 1. By putting together puzzles the child has to use its creative mind.

Fig. 2. Lecture conducted by a FermiLab engineer.

You may ask: why did we choose the project method? The answer will be: due to its effectiveness and naturalness. Starting in the early childhood, we implement a couple of vital projects. We begin to perceive the world around us; we learn how to crawl and walk and how to speak. All this is done by copying and repetition. And all these heroic and ingenious things are done without fear of failure. Children are remarkably persistent and quick in forming their intellect i.e. - the ability to obtain information and use it. The child's mind knows no boundaries; it is inquisitive and consistent, continuing the instinct of self-preservation. Later on, they are learning to turn the pages of illustrated children's books, then – to be a quick reader, and then – put together puzzles. Here the intelligence is often failing, demanding the creative mind, which appears miraculously, without any tension, as by itself.

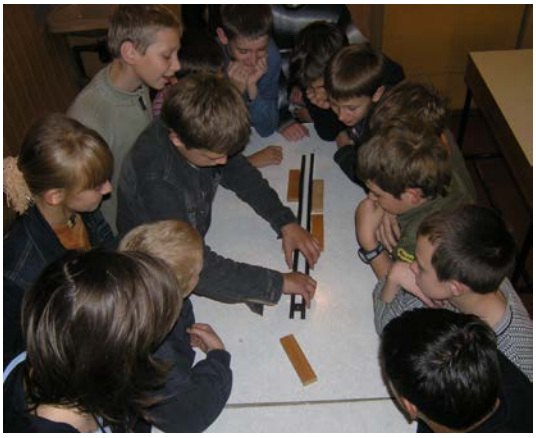

Fig. 3. A small investigation during the break.

The engagement in a large number of projects requires a number of scientific advisors. These requirements have been successfully met by establishing a scientific organization named “Quasar” (*the key idea*) that united the students’ efforts of different age groups, who were engaged in science. “Quasar” has become a powerful organizational and intellectual amplifier where students’ creative beginnings and makings in different spheres of science can develop in full at the earliest age.

The Youth Scientific Society (YSS) “Quasar” is an officially registered non-state, non-profit organization. It unites high school students, university students and young scientists with the main aim to promote the youth scientific interests and to support gifted schoolchildren.

Fig. 4. 18-23 of April 2008 YSS “QUASAR” organized the ICYS-08 in Chernivtsi, Ukraine.

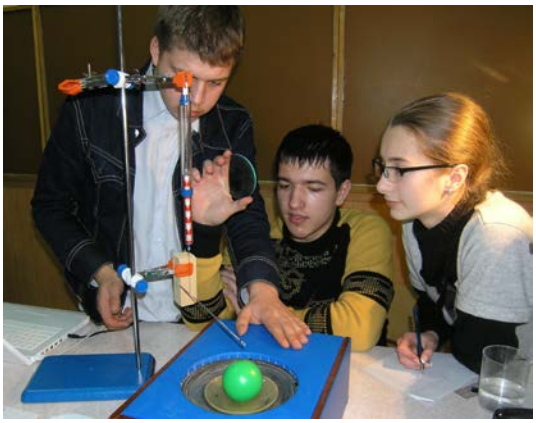

Fig. 5. Team work. Discovery of a new effect.

Since 1992 the "Quasar’s" 229 high school students have participated in 103 conferences, Olympiads and competitions, have carried out 130 scientific projects in the fields of physics, mathematics, astrophysics, computer science and ecology. To the present day, they have been awarded 97 diplomas, two gold medals, four silver and seven bronze medals at various national and international scientific conferences, tournaments, fairs and Olympiads.

The Society was founded in 1991 and is, actually, a small independent youth academy of sciences. It is a prototype of school with no classes, lessons, grades, examinations and terms of graduation. Members of this school are both students and teachers, they make up an active environment, where their creative beginnings and work in different spheres of science can develop in full at the earliest age possible. The students enter the association at the age of 12 – 14 (Fig. 3) and then are involved in scientific activities through a system of optional courses and seminars. They start by solving simple problems and go on dealing with more and more difficult questions, learn how to design their solutions in the form of scientific work and to give speeches at scientific conferences. The YSS members remain in the society, if they wish, as college students, post-graduate

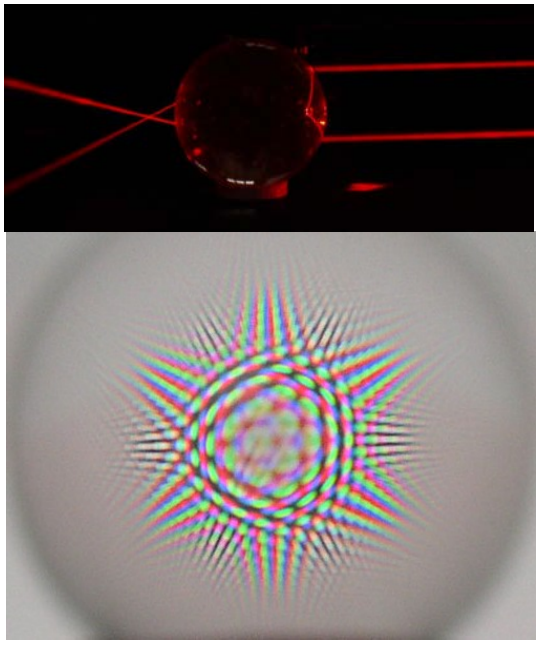

Fig. 6. An unexpected optical effect discovered during a regular investigation of a glass sphere.

students and scientific researchers. They actively help the younger members of the YSS and each other in the fulfillment of scientific work, and gaining extracurricular knowledge. The members of the YSS are studying or working in Ukraine, Russia, the USA, the Netherlands, Great Britain, Switzerland, France, Germany, Denmark, Israel and Canada. When they come home on vacation, they take part in seminars and deliver lectures as part of optional courses.

YSS currently participates in 9 international and 4 Ukrainian national projects, keeps in touch with 17 educational and research organizations, including research institutes, universities, and science magazines.

1999 the Canada Fund supported the YSS "Quasar".

Fig. 7. Discovery of the "Rotating Ball Effect".

18-23 of April 2008 YSS "Quasar" organized the International Conference of Young Scientists ICYS-08 in Chernivtsi, Ukraine (Fig. 4).

Students are able to study during a break and after school on their own, if they are motivated by a genuine interest. In that case, they need a coach rather than a teacher, who can be a peer, a student, a graduate student or a scholar. A small, but real problem can develop into a project lasting several years and the gained experience during this time is often more important than the problem, no matter whether it is solved or not.

In modern science, problems are solved by teams – the project can unite students, knowledge and abilities complement each other. The need for mutual help holds the group together, there is always a leader among them, and the shared interest in this case helps to overcome contradictions and differences of the characters – so that a group gives birth to a team. In the picture (Fig.5) you can see the team that won a prize in a serious contest presenting the project which is a small discovery.

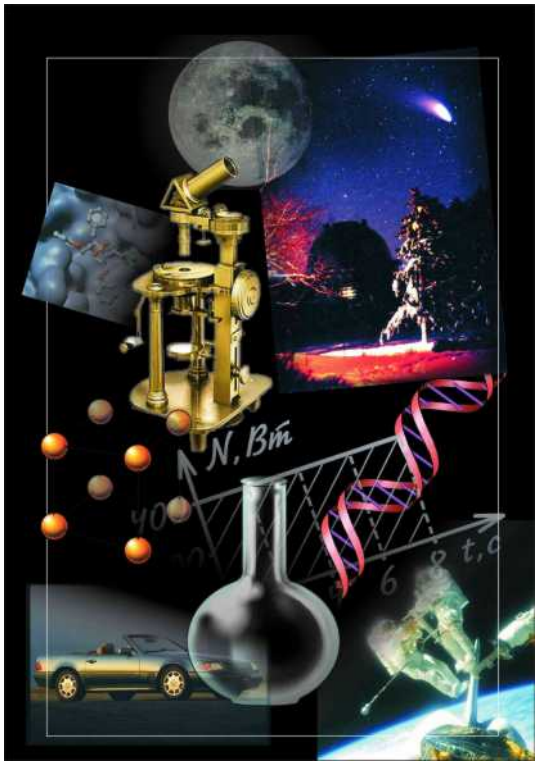

Fig. 8. "Physics-8. A Step to the Next Century"

A discovery can be planned or can occur randomly, but in any case it is a very rare event (Fig. 6). The Linear Vibrotransporter – a problem that was previously formulated and then solved in two steps. The problem of transitive chaos which was demonstrated using a small jumping ball, gave a new modification of

the problem while the ping-pong ball was replaced by a tennis ball (Fig.7). A random error led to the discovery of a new effect. How often have you been witness of a discovery?

The collaboration within the society coherently fosters student independent research with a greater sense of self-reliance. The effective undertaking of a scientific project requires an exchange of ideas, which is accomplished by the interaction of students in society. To broaden their interaction with likeminded people we participate in a great number of scientific conferences, competitions and Olympiads (further information is attached). *Working groups* are created according to the students' inclinations and function as a part of society, working in physics, mathematics, computer science, astrophysics, ecology, economics, and even sociology and linguistics. The efficiency of the group is restricted only to the availability of scientific advisors and equipment.

Separate elements of this method are used in my lessons, in textbooks and in extra curricula education. My innovative ideas have been incorporated into our last two textbooks in physics (Fig.8) titled "Physics. A Step to the Next Century".

Many “Quasar” members cooperate with us after graduating from high-school. Now we can also receive the consultation from specialists working in famous laboratories (Fig. 2). A number of optional courses on modern scientific problems are taught during vacation sessions. A very interesting exchange of ideas and knowledge is carried out at these meetings, which is a profitable mutual schooling for the participants. The students will benefit from this new learning platform due to their increased capacity to absorb new content and will thus turn information into knowledge quickly and effectively. There is a curious fact. A magnet attracts not only iron objects; it also attracts interest and attention. Students, who surrounded a powerful magnet in the break instead of having lunch or lasting for entertainment, did not know at that moment that all of them would become engineers (Fig. 9). The Quasar activities have been inseparable from the school educational process. Its advantage stems from the *self-organizing structure* allowing for the involvement of a larger number of students leading to a higher quality of projects. As a mark of success we also consider the enthusiasm with which students participate in research endeavours, their dedication to science and the fact that the numerous former Quasar members have become professional researchers at Harvard, Princeton, FermiLab, Leiden, Max Delbruck Institute etc.

Fig. 9. Students, who surrounded a powerful magnet in the break do not know in that moment that all of them will become engineers.

Below we present a selected list of projects that have received awards of a very high degree in different scientific conferences and competitions:

Fig. 10. The “Saharov Readings Conference”. Demonstration of the Linear Transporter Device.

Warsaw, Poland. *“The First Step to the Nobel Prize in Physics”.* International Competition in Research Projects in Physics.

Category Awards: 1995, 2001.

Fig. 11. International Astronomy School.

Category Honorable Mention: 1993 (2 papers); 1996, 1997, 1998, 2002.

Moscow, Russia. "*The Open Russian Scientific Conference of High School Students"* on physics, mathematics, computer science, ecology and chemistry.

1st Diploma: 1996 (Computer Science), 2000 (mathematics).

2nd Diploma: 1994 (Physics), 1996 (physics – two diploma), 1999 (physics)

Team Competition:

1st place: 1994 (mathematics), 1998 (physics)

2nd place: 1995 (physics), 2003 (physics)

"International Conference of Young Scientists, ICYS" on physics, mathematics, computer sciences and ecology.

1st Diploma: 1996 (physics), 1999 (ecology) – golden medal, 2001 (physics)

2nd Diploma: 1999 (physics) – silver medal.

3rd Diploma: 2006 (physics) – bronze medal, 2007 (physics, Computer Science) – bronze medals, 2009, 2012 (physics) – bronze medals.

Special Prise: 2010 (physics - team project, computer science)

Fig. 12. The "Intel-Techno Ukraine" Science Fair.

Crimea. Ukraine. "*International School and competition in Astronomy" (Fig. 11).*

1st and 3rd Diploma: 1999

Moscow. Russia. *"Moscow and Moscow Region Olympiad in Astrophysics and Space Physics"*

1st and 3rd Diploma: 2000

Petersburg. Russia. *"The Saharov's readings"* International Scientific Conference of High School Students in physics, mathematics, computer science, chemistry and biology (Fig. 10).

1st Diploma: 2000 (computer science), 2002, 2005, 2009 (physics)

2nd Diploma: 1995 (physics – two diploma), 1998 (physics).

Kiev, Ukraine. “*Intel-Techno Ukraine”,* Science and Engineering Fair (Fig. 12).

2nd Diploma: 2010 (physics) – team project.