THREE STAGES OF THE STUDENTS' RESEARCH SKILLS DEVELOPMENT AT ECYGDA LABORATORY

N. Kazachkova[1], D. Kazachkova[2]

[1]Scientific Physics and Technology Centre (SPTC) Ministry of Education and Science in Ukraine at the Department of Physics and Technology in Karazin Kharkiv National University, Kharkiv, Ukraine, nataliyakazachkova@gmail.com

[2]Educational Centre of Youth Gifts Development (ECYGDA) at the Department of Physics and Technology in Karazin Kharkiv National University, Kharkiv, Ukraine, darya.sign@gmail.com

ABSTRACT

The work is dedicated to the good practice examples and some difficulties of extracurricular physics trainings for the secondary school students aged from 7 to 16. There are three stages how students' experimental skills are developed. To teach students how to make simple research, extracurricular courses have been organised at the Educational Centre of Youth Gifts Development (ECYGDA) which is situated at the Department of Physics and Technology at the premises of Karazin Kharkiv National University. During such training students gain special profound knowledge of physics and seriously improve their experimental skills by doing self-made experimental projects using recycled materials, simple household objects, ordinary toys by means of real tools.

INTRODUCTION

The problem of students' experimental skills developing during informal physics education has been mentioned in the works of some Ukrainian and European authors [1], [2], [3], [4]. It is well known that physics is an experimental science so the goal of the physics teaching does not refer only to remembering the main formulas, it means not only reciting and enumerating basic laws of physics but also stimulating interest in experimental work [4], [5]. However, during the last decade bringing up the use of modern computer technologies, an application of up-to-date computer programmes, modeling of physical processes by means of computer onone hand and the lack of financial support for Ukrainian education on the other hand resulted in the displacement of real physics experiments from the lessons at 80% of Ukrainian schools. Moreover, at ordinary secondary schools in Ukraine physics experiments during the lessons or beyond are usually carried out with pre-assembled equipment. Moreover, in most schools the experiments are run using pre-assembled instructions [6]. Those activities are definitely valuable and justified. But students who are interested in physics, technology or engineering as their future career should also have the opportunity to carry out projects they have planned, thought up and elaborated themselves. For that reason the Centre (ECYGDA) which offers special support for realising those projects has been created. Besides, the primary and secondary school students (from 7-16) are encouraged to take part in local and international annual Conferences, Competitions and Tournaments for secondary school children, their parents and university students with their experimental projects where they can "touch science" and find out about very serious topics in an entertaining way. ECYGDA's motto is "Teach to Research with Pleasure!"

ECYGDA LABORATORY

ECYGDA Laboratory was created in 2004 as an institute of additional physics education. There are different types of informal learning facilities like science museums and exhibitions, field trips, science centres and entertaining shows established throughout Ukraine [6]. In these institutes, school students usually participate in one-day excursion or lectures, which are still informal in comparison to school instruction.

Our Centre has agreements with 23 Kharkiv Secondary schools, where we regularly demonstrate Physics Theme Shows, which have the common name Paradox Show connected with a content of the Official School Physics Curriculum. During those shows the lecturers are able to select and choose the students who have capabilities for experimental work and invite them to join the regular trainings on Saturdays at ECYGDA. These selected primary and secondary school students have regular (once a week) short theoretical lectures (45 or 60 min), held by university teachers accompanied by practical training (90 min) under the leadership of university teachers or students. In addition, all our students have a special English course (two hours a week), where they learn physics and maths in English. It is a very important point of their preparation as future scientists. It is considered that there are three stages of experimental skills development.

The first stage is for primary school pupils aged 7-11. At our theoretical training we proposed them 13 interactive physics theme lectures which have been elaborated by the teachers of the Centre. All of them have been adopted to the primary school pupils to be understandable for children of that age range. Every Saturday at the premises of the Centre one of the lectures (dur. 45 min) is presented to our visitors. The topics are interesting for children: Physics in Toys, Wonderful Mechanic, Travelling in Sound Land, Physics in the Kitchen, Light and Colours, Paradoxes of Magnetic Field, Wonders of Electricity etc. At the beginning visitors become acquainted with simple principles and laws of physics and then they are able to do simple experiments themselves. After 5 months of training they choose the topic and prepare their own simple research projects. They usually report about their first "scientific results" at the annual University Conference "Junior Scientific Start-Up" in May. At the first stage they usually do simple experiments which are demonstrated and explained to the audience at the Conference. This new approach is a successful attempt to show that it is possible to change pupils' and secondary school students' views about physics with a relatively short but explicit methods (Fig.1.).

Fig.1. Simple research project Sound Waves at the first stage

The second stage is for students aged 11 to 14 who are selected by methods mentioned above from Kharkiv schools and lyceums. They are also involved in regular extracurricular (once a week on Saturdays) short theoretical lectures (45 min) and more serious practical training (90 min). During such experimental training students are taught to operate with simple tools like handsaw, boring mill, perforator, Vernier callipers, tester. They design and help to produce some exhibits for the Physics Exhibition [6] or for the events which are organised in their schools (Week of Physics, Science Picnic, Night of Science) under the leadership of university students and university research engineers from the Department of Physics and Technology. They gain a lot from such kind of practical trainings and their experimental skills are seriously improved by doing self-made experimental projects using recycled materials, simple household objects or ordinary toys (Fig.2.).

Fig.2. Working with real tools and the example of hands-on Heron Fountain from the plastic boxes as a second stage project

The third stage is research skills development (see Fig.3.). The prevailing lack of interest in physics matters among adolescents aged 13 to 17 is obvious and common not only for Ukraine but also for all developed countries [7]. It most notably manifests itself in the steady decline in the number of students at Physics Departments in all Ukrainian universities. ECYGDA with its location at Karazin University, combined with the possibilities associated to this fact – use of the machine laboratories and the electronics repair laboratories at the Department of Physics and Technology, subject-specific support by scientists, lease of equipment has got lots of advantages not only in Kharkiv Region, but also in Ukraine.

Every year the Centre staff works with 5-6 groups of students. There are 6-8 students in each group. They are divided according to their age range or secondary school forms. We also take into consideration their theoretical knowledge in physics and mathematics. Before they start, they have to pass specially prepared short tests in Physics and Math (for the students aged 13-16). It helps us to divide them into the appropriate and convenient teaching groups. There were 10 research projects in years 2014-2015. The best ones are the following:

– Simple experiments with sounds (first stage research project) reported in English by Daria Slobodina (11) and Aleksandra Barkova (10);

– Heron's Fountain (second stage research project) made of ordinary kitchen plastic containers, a non-typical pattern designed and produced by Anton Rusynnyk (12);

– Creation of the experimental set-up and demonstration of a "soap film liquid motor" which was done by students Maksym Peretyaha and Vitaliy Yurko aged 14. All those projects were done at ECYGDA Laboratory where students have the opportunity to obtain an insight into scientific method of investigation, to conduct their own research projects, to promote their activities and demonstrate some of their key competences in science and technology and communication in the foreign language at the different local and international conferences. Usually among them are ICYS (International Conference of Young Scientist), QUANTA Competition, IYPT (International Young Physics Tournament), annual Conferences of Junior Karazin University, Ukrainian Science Festivals, Science Picnics, Research Nights and some other events.

Fig.3. Experimental skills development at the third stage

The third stage projects are usually much more serious and can be compared with real Diplomas at University. The example is "Liquid film motor" [8]. In recent years scientists have become interested in the physics of liquid films. Study of those films is a part of the interesting physics section called "Physics of Surface". When the films are subjected to the action of various chemical, thermal, structural or electrical factors, they display interesting dynamical phenomena. Investigation of soap films and bubbles is very impressive topic in a lot of student research projects. A soap film should be formed on a flat frame. Place the film in an electric field parallel to the film surface and pass an electric current through the film. The film starts rotating in its plane (it can be seen in Fig.4. below). The phenomenon have been investigated and explained.

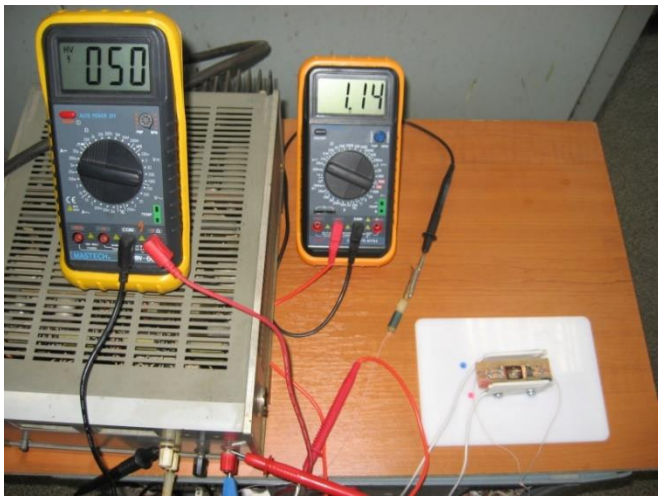

Fig.4. Elaborated liquid film motor measurements

CONCLUSIONS

Five self-made devices have been designed and created during 2014-2015 years in the Laboratory. During the extracurricular theoretical and experimental trainings mentioned above students have the opportunity to obtain an insight into the real research methods of investigation, to conduct their own research projects and demonstrate some of their KCs (for example basic competences in science and technology and communication in a foreign language) at the different local and international conferences (Bronze medal at International Conference of Young Scientists, April 2015, Izmir, Turkey). Teaching methods proposed by the authors are not contrary to the existing Ukrainian teaching techniques, they can be considered as an effective supplementation to traditional methods and forms of physics teaching. For more than 10 years of the Centre's existence 98% of the students entered in Kharkiv and some other Ukrainian Universities and became good students and successful scientists both in Ukraine and in some European countries. We are proud of our ex-students who are now working in Germany, Canada, the USA, the Netherlands and Poland.

REFERENCES

1. Peternev V.: Simple experiments made in Vocational School. GIREP-EPEC Conference Proceedings 2007 (Selected Contributions), Opatija, Croatia, pp. 209-214, 2008.
2. Sjoberg S. and Schreiner C.: How Do Students Perceive Science and Technology? Science in School **1**, 66-68, 2006.
3. Trna, J.: Motivation and Hands-on Experiments, in: Proceedings of the International Conference Hands-on Science in a Changing Education. HSci2005. Rethymno: University of Crete, pp. 169-174, 2005.
4. Kazachkova, N.: Students research work is one of the innovative methods of physics teaching, in: International Conference Physics Teacher Education Beyond 2000 and PTTIS, The Book of Abstracts, eds. Kazachkova N., Yanson Y., Kryukov Y., Khodko A., p. 205, Barcelona-Spain, 2000.
5. Priemer, B.: Open Ended Experiments about Wind Energy, in: GIREP Conference 2006, "Modelling in Physics and Physics Education", eds.: E. v. d. Berg, D. v. d. Berg T. Ellermeijer, Amsterdam, Book of Abstracts, p. 77, Ljubljana: GIREP, 2006.
6. Kazachkova N.: Creation the first in Ukraine touch-exhibition of physics paradoxes as an innovative way of physics popularization, in: GIREP-EPEC Conference Frontiers of Physics Education, Opatija, Croatia, Book of Abstracts, pp. 150-151, 2007.
7. http://www.esfz.physik.unierlangen.de
8. http://www.iypt.org
9. Dvorak L.: Labs outside labs miniprojects at a spring camp for future physics teachers. European Journal of Physics **28**, 95-104, 2007.