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Extra Curricular Activities in TELEKI Gymnasium

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Abstract

Education plays a crucial role in the development of a society. It is very important for everyone to realize that we entrust our future to the young people who leave today's education system, and it depends on us, teachers, how we motivate, teach, inspire and guide them on their way [1].
The number of classes in Physics were reduced strongly in Hungary during the last decades. The huge question that every Physics teacher has been contemplating for years is: how interested and talented students can be motivated under these circumstances. I believe extra-curricular activities may play a crucial role. Of course, the teacher's personality also determines the way students develop, but it also requires incredible consistency and the students' willingness to accept. Teachers play a pivotal role in education. They not only impart knowledge but also inspire, mentor, and guide students.
In this paper I would like to share some good practices of extracurricular activities, which have already been tested, that can be used to enhance students' interest and motivation in STEM education (Mathematics, Physics, Chemistry, Biology) [2].
The following activities will be presented below:

- *extra-curricular activities: how we prepared for the advanced Physics graduation exam, doing experiments and calculations*
- *non – formal measurements at the Budapest University of Technology and Economics related to Nobel prizes, which help us to popularize modern Physics,*
- *study visits at the Training Reactor of the Budapest University of Technology and Economics and Paks Nuclear Power Plant,*
- *Physics performances (atoms and their structure, chain reaction, music and physics, thermal experiments) presented at our school and at the Researchers' Night [3].*

My experience supports that even a small success can turn an entire community into different direction and, if appropriate, steer it in a technical direction and make it fall in love with Physics and Chemistry.

Keywords: *experiments, study visits, physics show, performances, non-formal education*

1. Introduction

Based on my previous research and comparing many new reviewed papers written by different researchers it has become clear to me that education of natural sciences, especially in the primary and secondary schools, is still in crisis in many parts of the world [4; 5; 6].
The latest Survey of Adult Skills made in 2023 completed with the participation of 31 countries (where the participants' age was between 16-65 years) highlights a mixed global picture of literacy, numeracy and adaptive problem solving proficiency [7]. Unfortunately, the literacy and numeracy proficiency in our country is also continuously decreasing.
Bases on the analysed survey and my own experience during oral discussions at Physics conferences, one can conclude that Hungary is in the last ten out of 31 countries. Therefore, to achieve a higher position, we teachers should act urgently, and do step by step some extra activities, put more effort, work.

2. Aim of the Project

The primary goal of this project is to enhance students' engagement and motivation in STEM education — particularly in Physics — through extracurricular activities. Given the reduction in Physics classes in Hungary, it is essential to provide alternative learning opportunities that spark curiosity and deepen understanding.
This project aims to:
Foster students' interest in Physics and related sciences through hands-on experiments, study visits, and interactive demonstrations.

Provide non-formal educational experiences that complement classroom learning and offer real-world applications of scientific concepts.
Support student's preparation for advanced Physics graduation by integrating theoretical knowledge with practical experimentation.
Strengthen collaboration between secondary education and higher education institutions, offering students exposure to cutting-edge research and industry applications.
Inspire students to pursue careers in STEM fields by demonstrating the relevance and excitement of Physics through engaging activities.
By implementing these initiatives, the project seeks to create a dynamic learning environment where students can develop a passion for science, gain practical skills, and build a strong foundation for future academic and professional pursuits.

3. Methodology

The project employs a hands-on, experiential learning approach through extracurricular activities that complement traditional Physics education. Methods include organizing interactive experiments, study visits to research institutions, and performances involving phenomena in Physics to engage students in real-world applications of scientific concepts. Collaboration with universities and industry professionals further enhances learning by providing access to advanced research and practical demonstrations.

4. Preparation for the High School Advanced Physics Graduation (Experiments and Calculations)

The high school graduation reform that came into effect in 2024 requires that the Physics examinee should connect his/her basic Physics knowledge with phenomena experienced in everyday life, and also with the operation of technical devices of modern age and with their everyday use. That is why during the oral exams the students have to perform specific hands-on experiments when talking about the given law or physical process. Due to the small number of Physics classes/week, even students attending the special Physics education program need additional non-formal educational activities in the afternoon.
Thanks to the specializations, the students carry out experiments, we discuss measurement errors and their relationship to everyday life.
During the afternoon activities we performed a variety of measurements. Last time we determined the density of solid and liquid substances and we dealt with the measurement of equipotential lines of an electric field in electrolyte. Students got involved in the activities with pleasure, they focused on increasing their knowledge, and developing their competencies [8].

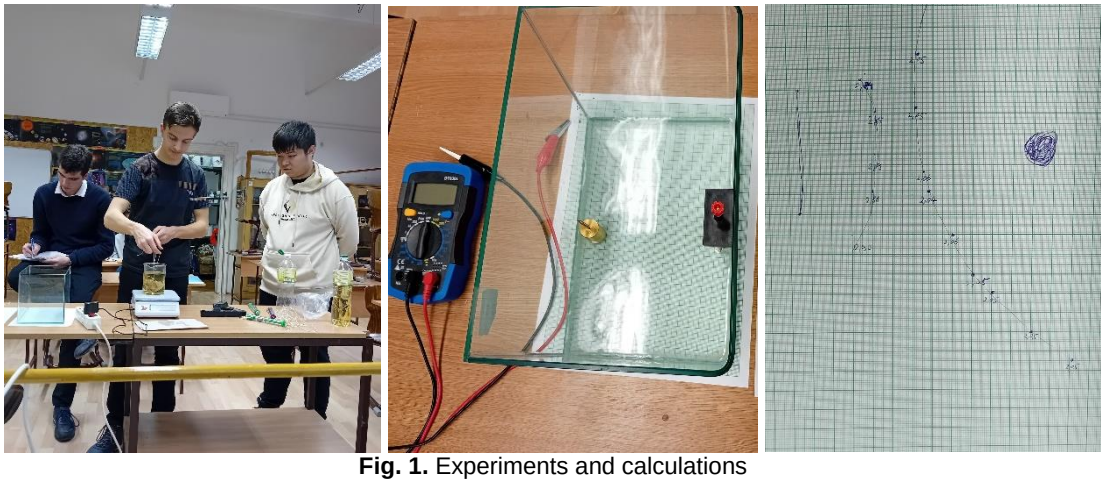

Fig. 1. Experiments and calculations

5. Non–formal Activities (Experiments and Calculations Done at University)

Authors of several contemporary publications agree that different learners learn in different ways. Some of the learners learn from textbooks, webpages, or tutorial video channels, others join extracurricular activities, or take part in one of the Researchers' Night's activities offered for students.

It seems that it is really difficult to make a clear distinction between formal and informal learning as there is often overlap between the two [9].

Pedagogical value of the program: description of formal-nonformal-informal learning

It is well known that the three concepts of formal-nonformal-informal learning were created by Philip H. Coombs in the seventies. Already at that time, they were dealing with the investigation of the crisis of formal education systems (didactically planned, closed system, bound learning). According to Coombs' approach, only a fraction of the learning processes takes place in formal education systems, but there are also other dimensions in which the participants acquire knowledge and skills. In his interpretation, formal education is the same as education in the traditional school system. By non-formal education Coombs means forms of learning that take place outside the school system, but within an organized framework, with a definite purpose, while informal learning takes place in diverse areas - in the family, at the community level - in an informal, non-organized form. The advantage of informal learning is the acquisition of information and the development of skills, during which individual attitudes, values, and skills are formed (or transformed).

Already in his study Coombs emphasizes that in this threefold division above formal education is pushed into the background, the stakeholders do not acquire the defining part of knowledge in this hierarchically structured, closed system. Coombs' approach reveals that the student breaks with the traditional teacher- and education-centric approach. A paradigm shift takes place, the lifelong learning paradigm is strengthened.

The terms formal-nonformal-informal exist in many approaches with different interpretations. Several people have been dealing with the issues ever since, but the "Memorandum on lifelong learning" document published by the European Commission in 2000 represents the real milestone. In European Union documents, informal learning appears together with non-formal, and is constantly present.

Based on the examination of the specialized literature it can be concluded that informal learning is related to various activities, most often to work activities, and is often present in some form even during free time. That is why it is a very topical issue, which poses a kind of challenge to researchers and educators. It would be important to clarify the rules and conditions for the recognition of informal and non-formal learning, but at the same time, creating an informal learning framework in a somewhat organized form represents a challenge.

6. Concrete Informal or Non-formal School Activity Done Yearly at the Institute of Physics of Budapest University of Technology and Economics

The Institute of Physics yearly organizes many interesting non-formal learning, extracurricular activities for students from secondary schools. All activities are focused on students, who are about to make their career choice.

These activities, which are called “Nobel Prize-winning experiments for high school students" [10], are usually announced in early September. These yearly activities were launched in 2013, and the main idea came from Prof. Dr. András Halbritter, Physicist. He considers that it is very important for the country to supply new scientists in the fields of natural sciences and technology.

When we registered our students to this whole afternoon activity, we could choose the small group measurements from the following list, according to the level of knowledge and interest of the pupils:

- Atomic nanowires
- Holography
- Superconductivity
- Ultrashort laser pulses
- Liquid crystals in polarized light - from LCD displays to malaria diagnosis
- From the photo effect to lasers and to quantum communication
- Control a nuclear reactor!
- Semiconductor technology from the first transistor to the smartphone
- Measurements with a Michelson interferometer

Each group of students completed one measurement. The most favourite two measurements were Holography and Superconductivity.

During the Superconductivity measurement each group of students was able to experiment with high-temperature superconductors. The essence of the experiment was to measure the resistance of the superconducting wire as a function of the temperature of the wire. A small superconducting sample together with a platinum wire thermometer was immerged into the liquid nitrogen tank, and measuring instruments were connected to them to measure the resistance of the sample and the temperature. The interface of the measuring device was connected to a computer, data analysis was made using

the computer. All extracurricular measurement sessions provided a great opportunity for each group of students to do more serious experiments, to get familiar with collaboration work, to develop their different skills, and to enjoy the activities, to learn Physics by doing.

Fig. 2. Superconductivity

7. Study Visits

Our first visit to Training Reactor of the Budapest University of Technology and Economics (BME)

With view to the close cooperation between TELEKI Gymnasium and BME, we can visit BME's Training Reactor every year. The operation of the Training Reactor was started in 1971, and it has 100 kW nominal thermal power. If we looked into the reactor core a few minutes after the reactor was stopped, we could see the bluish glow of the Cherenkov radiation. Cherenkov radiation is visible only in a few reactors in Europe, therefore the Budapest Training Reactor is quite a unique place.
We visit this place yearly with a group of 15 students over the age of 16 (because of radiation protection regulations). My students are very enthusiastic and excited to see these blue lights every year above the reactor core.
The Institute of Nuclear Techniques (NTI) of the Budapest University of Technology and Economics (BME) is the centre of the Hungarian nuclear higher education. The university courses provided by the Institute cover a broad range of nuclear techniques related to nuclear power plants, radiation protection, fusion and medical physics.
The staff members have different types of qualifications as Independent Technical Experts in the Nuclear Field from the Hungarian Chamber of Engineers, such as reactor physics, thermal-hydraulics, mechanical engineering, chemical engineering, radiation protection, proliferation resistance and transport of radioactive and nuclear material.
BME Training Reactor is also at the disposal of the participants with its whole instrumentation and along with the educators and researchers having several decades of educational experience.
When we arrive at the reactor, first everyone takes a cloak and puts on a shoe protector over their shoes and passes through a radiation detector gate. We do everything for our own safety and in compliance with the rules of radiation protection.
Before starting the tour, we listen to a theoretical presentation (we learn the principle of the reactor's operation and see with our own eyes the fuel rods placed in the assemblies). During the tour, we visit the reactor's control centre, the commander, and from the very top of the reactor, we also have few glances inside the reactor's internal structure, the core.
Thanks to the radiation shielding of the 5-meter water column we also see the heating elements, the assemblies placed under the 5 m water column, and the place where the samples which will be irradiated arrive through the pipe mail.
During the latest tour, we were free to ask questions and received detailed answers. During the visit we also saw the starting and receiving location of the pipe mail, as well as a low background measurement location of the HpGe (high-purity germanium) detector.
The view of the Cerenkov radiation and the whole visit was very impressive and useful. We were happy and grateful to be there, and we expressed our thanks to BME NTI for the possibility of the visit.

8. Our visit to Paks Nuclear Power Plant

The most expected field trip of our students is the visit to the Paks Nuclear Power Plant. This trip is only allowed for those over 16 years of age, therefore students' motivation is very high, they really look forward to be 16 years old. Each year in May a group of 50 students from our school has the

opportunity to participate in this study trip, therefore following the enrolment to school in September students register themselves as quickly as possible for this field trip, and wait until May for their dream to come true.
Usually, our group starts the visit in the Information and Visitors' Centre of MVM Paks Nuclear Power Plant Ltd, where we are welcomed by information officer Zoltán Róbert Tóth and greeted by Dr. Antal Kovács, Director of Communication. During our visit to the Visitor Centre, we learn a lot of interesting facts about different types of radiation, energy production, and types of nuclear power plants.
Then our group gets divided in two parts. All of us visit the same places, but for time saving and security the two groups are going in different ways.
First, we see the control room of the Nuclear Power Plant, where trained operators are busy monitoring the processes in Unit 4. It was interesting to see the huge wall full of buttons and displays, which are located in front of the office desks. After the control room, from the visitor corridor we could see the reactor hall.
We climbed ten stories high to see the twin reactors, and the red covers above them. It was explained that there is a cooling pool where the hot, spent fuel assemblies are placed for 3-5 years, to wait for their radioactivity decreasing ("cooling").
It is incredible how long it takes for these gigantic components to lose most of their initial radioactivity and "cool down", thus their temperature and radioactivity decreases, so that they can be stored in the Interim Spent Assembly Storage Facility (ISSF).
Our next stop was the turbine hall, where we took a short walk around one of the turbine generators. Here, we had to walk in single file, wearing earplugs and goggles, while observing certain elements of the secondary circuit, such as the condenser and various parts of the turbine.
This study visit is always a very good experience which could change student's vision related to energy issues.

Fig. 3. Study visit at Paks Nuclear power plant

9. Stage Performance - Researchers' Night's Activities

Researchers' Night initiative in Europe started in 2005. The project was launched by the European Commission as a Europe-wide educational festival, repeated annually on the last Friday of September. Since 2006 Hungary has joined the program with different colourful activities organised in many educational and research places of the country.
The main aim of the festival is to increase the popularity of natural and technical sciences, to motivate students especially at the age of 10-18 year, who are about to select different options to continue their study and build their career.
The event is organised starting from the afternoon into the night, and higher education institutions, research institutions, research groups and R&D laboratories offer scientific and educational programs for students and for the audience from age of 3 to over 100.
Researchers' Night offers a variety of programs including night lab visits, lectures, experiments, discussions, interactive games, exhibitions, workshops, theatre performances and concerts, night sky study and outdoor escape games. All programs are free for the audience, and many of them do not require previous registration. The great success of the event is well demonstrated by the increased

attendance of the event over the years. One of the Hungarian Researchers' Night activities is very peculiar and unique. It is called: "Following Teacher Öveges footsteps". It is organized especially for the small kids, from the age of 3 years and upwards. Teacher Öveges was a well-known Physics teacher in Hungary in the 50's-70's, who popularised Physics knowledge in the Hungarian TV with very simple hands-on experiments.

This event is hosted at the R&D Centre of Ericsson Hungary, at the Science Park of Budapest, and has been organized by us: Beata Jarosievitz Dr. and my husband, Csaba Sükösd Dr., physicist, since 2012 [10].

We are grateful to Ericsson Hungary for offering this unique possibility in their highly recognised campus to attract and "infect" the young generation with Physics and Science.

The "Following Teacher Öveges footsteps" event of Researchers' Night is a non-formal learning activity. Our aim is to provide the opportunity for non-formal learning with the aim that the children who come to the program can study Physics in a different - but organized – framework and in an innovative way. Without even noticing they start to like natural sciences and fall in love with Physics.

How this event looks like?

This event starts in the early afternoon, when children and their parents and/or teachers from primary and secondary schools are also able to attend the program. Students coming to this event are also invited to use their knowledge, initiative, mind, and to be partners during each 25 – 40 minutes presentations. These presentations are performed by previously selected physics teachers, who are the best, well recognized teachers from our country. Usually their work was already previously recognized by the prestigious award, called Ericsson Prize for teachers of the Ericsson Hungary.

During the event teachers' role is to make very attractive performances, shows, and experiments, together with the audience who usually join their presentation. All these shows can also be followed via online broadcast. The archive created about the presentations can also be used later by school teachers as a good educational resource.

The effect of non-formal learning

According to my experience so far, the "Following Teacher Öveges footsteps" program is very successful, the audience always left the full-house program series with new experiences and information. All those interviewed spoke positively about what they saw, and more and more people are waiting for the next year to come back and see the new on stage presentations with real experiments and some performances again. The feedback is supported by concrete facts. In many occasions the programs continued until midnight with full house, even elementary school children still watched the performances with sparkling eyes, and took part enthusiastically in the interactive experiments. Due to the diverse audience it is not possible to prepare a questionnaire survey to get a real feedback about the event. Therefore, only action research method can be used for evaluation. Analysing the results of the action research, we were happy to conclude that there is a huge demand for the program, for understanding and discussion of physics phenomena based on observation, for inquiry-based learning (IBL). The non-formal learning program is not only a kind of a show, the presented experiments are based on research-based learning.

At this year's event, an old dream of mine came true. This time we were able to stand on stage together with my students and enthusiastic colleagues. We did some experiments following a script I prepared in advance. My physics-loving volunteer students and my enthusiastic teacher colleagues cooperated closely from beginning of September, and we successfully presented our musical show production. Our main theme was based on thermodynamics. Our performance including Physics experiments and songs made the laws of physics easier to understand and remember.

The primary goal of our performance was to explain thermodynamic and to make Physics popular

At the beginning of the performance, our team entered the stage with the opening song of a Hungarian rock-band, which is well-known in Hungary ("The great band is here again….").

Fig. 4. Reserchers' night 2024 (https://fizika.tbg.hu)

After our entrance "Celsius" and "Lord Kelvin" argued a bit, they tried to convince each-other, that there is only one temperature scale – their own of course – no other is needed. Finally, they explained very well the importance of thermal equilibrium, the difference between each temperature scale, and the importance of their use.

Which are the best presentations?

All of them are amazing, all of them attract the kids' and students' attention.

In the new scene, working with new actors, we learned about the importance of linear thermal expansion in practical life, the surface thermal expansion of solids and then the expansion of gases under the influence of heat through experiments and explanations.

Later we showed how an egg can be put into a bottle? The curious audience understood our explanation singing for them the appropriate physics law.

Fig. 5. Isobar process with experiment

Our performance was very successful, it was an unforgettable experience for the students to make a performance in front of 200 people and for many viewers from the front of the online broadcast channel. My students were on the stage in a real spotlight for more than 50 minutes. Feedback from parents, teachers, and several partners was very positive. The shared photos reflect the amazing atmosphere and the feelings that we had during the event: it was really a wonderful night for all participants!

The Researchers' Night event not only contributed to the dissemination of scientific knowledge, but also strengthened the community and social dialogue, emphasizing the positive effects of research and innovation on everyday life.

"Following the Teacher Öveges footsteps" intellectual legacy: many teachers, students and educators still strive to present the wonders of Physics and other scientific fields in a creative, experimental way.

10. Conclusions

Extracurricular activities play a crucial role in maintaining and enhancing students' interest in STEM subjects, especially facing the challenges of reduced Physics class hours. Hands-on experiments,

study visits, and physics performances provide engaging, real-world applications that deepen students' understanding and motivation. Collaboration with universities and industry partners further enriches the learning experience by exposing students to advanced research and practical applications.
The experiences shared in this project demonstrate that even small success can positively influence a learning community, steering students toward technical fields and fostering a lasting passion for science. By continuing to implement and expand such initiatives, educators can create a more engaging and inspiring STEM education environment, ultimately preparing students for future academic and professional success.
Students enrolled in different Physics activities mentioned above gave me very positive feedback about their development, their feelings, attitude to SCIENCE.
The main aim of the activities performed was to increase the popularity of natural and technical sciences, to motivate children and students and to build their key competencies in all learning areas using different teaching methods.
Students involved in the experiments will never forget the studied physics phenomena, laws, while having a lot of fun and enjoying the small group activities or study visits.
Based on the results and on personal interviews we can conclude that my formulated hypotheses has been confirmed: I made Physics topics more fun, understandable and I reinforced the connection between Physics and everyday life. Our students involved in the activities surely became more motivated having participated in unforgettable Extra Curricular Activities.

11. Acknowledgement

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Figures

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