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INQUIRY-BASED HANDS-ON PHYSICS ACTIVITIES FOR ELEMENTARY SCHOOL AND PRESCHOOL STUDENTS: AN ENJOYABLE INSTRUCTION

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Abstract. *Authors' experience in mentoring research projects of high-school students, instructing of science courses at summer academic programs, and directing of other informal educational activities, was instrumental in bringing creative hands-on Physics experiments into preschool and elementary school. Practice of the kind proved to be both instructive for and enjoyable by the youngest students in Israel, Mexico and Ukraine. Low budget experiments with the most ordinary materials and commonly used devices serving for the apparatus, allowed students to fully perceive that the laws of Physics act not only "inside" sophisticated instruments, but rather rule the nature. However simple the equipment, it produced impressive, often amazingly counter-intuitive effects that young students enjoyed and were eager to research/explain. Hands-on approach let every student participate in the experiments and even do own inquiry. Strongly positive feedback and bright students' insights essentially helped to further improve and develop suggested activities.*
Keywords: *inquiry-based science education, hands-on Physics experiments, informal teaching&learning of science.*

Introduction. Inquiry-based science education widely practiced in the USA for more than 20 years since its inclusion into the *National Science Education Standards* [1], is now a topic of the day in the countries of European Union. Other educational systems, Ukrainian in particular, is being essentially re-oriented towards early introduction of inquiry-based approach towards teaching and learning.

Success of this innovative didactical method sufficiently, if not decisively, depends on the right choice of the specific topics of educational research. If they are attractive (or better excitedly intriguing) to the students, may be investigated in reasonable time and imply for the creative personal involvement, then the positive outcome of students' inquiry is guaranteed.

Specifics of regular school classes do not leave much time for educational research. Also, school teachers' pre-service training hardly provides for their satisfactory preparedness to involve the class into an exciting research. Hence research universities should contribute both into the in-service training of school teachers, and into direct practicing of inquiry-based classes and extra-curricular educational activities.

Early exposure of students to the wonders of scientific research not only favours development of their creativity and positive attitude. It will also help them look forward to taking science courses at high school, entering universities, and pursuing research carrier on graduation. Literally no age is too young for the exciting scientific inquiry.

Back to the future: from Junior Academy of Science to kindergarten hands-on activities

Being all university professors, for years the authors have been practicing high school educational students' research mostly through mentoring and judging projects of the Junior Academy of Science (in Ukraine and in the USA). Some of the authors' experiences also include instructing science courses at summer academic programs (USA) and organizing/leading of the high school students' organizations that promote science (Mexico).

Based on this background, a few international educational practices were performed for the preschool and elementary school students, reviewed below (arranged by the countries of practicing).

Israel

Those experiences have naturally led us to suggesting research educational activities to the much younger students. As an example, hands-on Physics experiments for kindergarten children were practiced by one of the authors during his university lecturing visit to Israel in 2003. Those activities were organized and hosted by former high school Physics teacher Valery

Shpolyansky and Svetlana Shpolyansky in Givatayim in the informal settings with the kids' parents present, and were quite a success.

Some very involving experiments, mostly Physics toys and Physics tricks were practiced, including incredible visual and audial illusions. Moderate number of participants and unlimited timing allowed everybody to do experiments personally, to vary their conditions and to produce a wide range of amazing effects.

Mexico

Another noticeable example of very young students doing (and enjoying) creative hands-on Physics experiments was organized as a master class for the members of the *Misioneros de la Ciencia* (Missionaries of Science) project [2] in the year of 2011. It took place in one of the Mexico City grammar schools, with the students of *CECyT Carlos Vallejo Márquez* (all members of *Misioneros* projects) learning how to present and assisting. Characteristically, an initiative to invite practitioners of hands-on Physics activities to grammar school belonged to the local teacher co-operating with the *Misioneros*.

Authors involved in this visit were at the time doing in-service training of Physics teachers at the *National Polytechnic Institute* (IPN) in Mexico, focused on practicing of inquiry-based teaching and learning. Some hands-on equipment from training seminars was used during the school visit. Experiences shared by the trainees, mostly the seasoned school teachers, were helpful with the younger kids. In particular, cultural and educational backgrounds of the students were taken into account and used to increase their involvement.

A considerable (more than 40) number of students in one class made it easier to establish team spirit of joint research effort, a sort of creative competition and a general positive attitude to the activity. Incredible enthusiasm of the very young kids to perform hands-on inquiry was noteworthy. Nearby school playground made it convenient to do some impressive outdoors experiments (e.g. on elastic/inelastic collisions of rubber balls) which is typically somewhat problematic in class settings.

Ukraine

For years, involvement of the authors into practicing inquiry-based projects and activities with preschool and elementary school students was mostly limited to the occasional organized meeting with students and their parents at the *Nights of Science* and other mass science-promotional university programs of the sort.

Meanwhile, regular mentoring and judging of the projects of the Junior Academy of Sciences, teaching classes of the Junior Karazin University, and other extra-curricular programs for middle and high school students accumulated experience of dealing with the involving inquiry-based hands-on Physics activities.

In the school year of 2015-2016 a totally different approach was the case: dozens of visits were performed to the schools of the city of Kharkiv and smaller towns and villages of the Kharkiv area. Although majorly focused on the professional orientation of the high school graduates, many of those visits involved younger students as well. Hands-on research experiments were performed either in the class (10-25 students attending), in the 'doubled' class (two classes at the desks, up to 30-35 students participating, often of a significantly different age), or in the school hall with an elevated scene, convenient for demonstrations performed by or with the help of the local students (up to a hundred students present at a time).

Topics of suggested activities included all the basic chapters of school Physics, ranging from Mechanics and Gas Laws to Electricity and Optics, with an emphasis on the impressive phenomena and effects. Widely used were ideas and experiences of *The Heureka Project* of the Charles University in Prague, Czech Republic, the community of 'teachers and friends of physics whose goal is to make physics more attractive and closer to student's lives' [3], and of the *Hands-on Science Network*, which 'stands for promoting the development of science education and scientific literacy' [4].

Generally very positive feedback from all the age groups should be noticed, regardless of the older students' majors (history, language, biology-chemistry, phys-math, etc.) although younger students were noticeably more enthusiastic and personally involved.

Specially should be mentioned a kindergarten hands-on Physics presentation for children aged 4-5, the ones literally eager to touch and probe every experimental device with their own hands.

The program culminated in hosting at V.Karazin Kharkiv National University of more than a thousand grammar school children (grades 1-5), organized during the two-week school summer camps as a series of 45-60 min activities for groups of 30-75 students. Two more visits to the schools of neighboring town Chuguev were naturally imbedded in between the presentations at KhNU (around 60 and 100 students of the grades 1-3 actively participating). For summer campers about 20 counter-intuitive experiments with regular kids' toys, stationary, water, and the likes [5-8] were chosen and practiced with variations prompted by the students' feedback. Those visits were highly appreciated both by the students and their teachers. Again, the youngest (first grade) students proved to be the most persistent, enthusiastic and inexhaustible in doing hands-on Physics. Minimum, if any, science learning background did not impede students following the logics of the activities. Even though formulas and calculations were out of the format, some calculative estimations were naturally performed by the children of every participating age group.

Conclusions. 'Never late to learn' should be added by 'never early to do research', suggests our experience of bringing hands-on inquiry-based Physics experiments to the preschool and grammar school. To provide for a successful activity of the sort, a thorough choice of suggested experiments should be made, and their timing must be accurately planned.

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