Hands-on
The Heart of Science Education

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The Hands-on Science Network

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Foreword

Hands-on. The Heart of Science Education

Recognizing the importance of Science to the development of the Society and of Humankind, constant efforts are being actively made worldwide and for many many centuries by researchers and scientists, teachers and educators, parents and the society in general to improve Science Education and increase Science Literacy at all levels of our societies. Different approaches in different lines of sought are explored. All with both positive and negative aspects and outcomes. Regardless of the addressee, the active commitment of the learner is always fundamental to a successful education. Hands-on activities inherently involves active critical reasoning and interaction with the learning object placing the student in the center of the learning process. The student/learner will act (certainly at different depth levels and pace) in fact as a researcher that will work trying to solve the questions/problems raised, creating in a meaningful way their own new knowledge. Definitely HANDS-ON should/is at the very heart of Science Education.

The book herein aims to contribute to the improvement of Science Education in our schools and to an effective implementation of a sound widespread scientific literacy at all levels of society. Its chapters reunite a variety of diverse works presented in this line of thought at the 13th International Conference on Hands-on Science held in Brno, Czech Republic, July 18 to 22, 2016.

Vila Verde, Portugal, June 27, 2016.

Manuel Filipe Pereira da Cunha Martins Costa
Editor in chief

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FOREWORD

CONTENTS

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HSCi Physical Science Learning Opportunities at Natural History Dioramas

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Abstract. Traditional view of science museums is that they present a static image of science, a fixed body. Visitors to museums come with pre-existing knowledge and frequently interpret that which they see but particular through using their Owen understanding referring to the labels and other interpretative means not only through the information provided by get museums. Such understanding is based on everyday beliefs. Listening to visitors in natural history museums reveals that few comments are made about science in action but focus on identifying the specimens and commenting on the attributes of the animals. However, physical science is much in evident in these animals although not focused on by natural histoiry museums. I report here the effects of a hands on workshop provided for two 11 year old boys and separately to 8 year old primary children at natural history museums in the south of England. The specimens are displayed don an authentic context in natural history dioramas. The two dioramas focused upon was one of an African Savannah scene with a water hole and at the edge of a forest and a compilation exhibit of primates on rocks and trees. The children were asked to view the main diorama and point out any science that they could recognise. They participated in hands on workshop focusing on forces, balance and stability. The leaners returned to the dioramas and were aske d to again any science concepts they could see illustrated by the animal. After the cue provided by the hands on workshop they recognised a number of physical science concepts illustrated by the position in which the animals had been posed. Science in school for them had not been taught in a context.

Keywords. Museum, science, diorama.

1. Introduction

Numerous studies claim that the lack of interest in scientific and technological matters lies in how the related contents are presented to the students [1]. Typically, traditional teaching is focused on master classes with the only support, in the best of cases, of closed and highly structured laboratory practices. Even for those students with an optimal profile, academic performance can be impaired by this merely conceptual teaching approach, standing far away from the ideal academic use of the scientific method [2,3,4].

In contrast to these traditional methods, there are several educational options, which have proven more beneficial and have thus gained increasing importance in recent years. Among them, the so-called Project-Based Learning (PBL) [5] can be outlined, applied for instance to experimental learning objectives. In our subjects of Physics of the first courses of Engineering University Degrees this technique has been used, proposing the students a semester challenge of designing, constructing, and documenting a hands-on activity that illustrates a concept, a law or an application related to the subject theoretical contents. The objective envisaged is to place the students in a non-academic situation outside the classroom, facing the resolution of a practical problem that will enable them to acquire the related transversal skills of our Engineering University Degrees, since the successful achievement of a final project of this type requires, among others, autonomous skills related to team organization, information search, discussion, experimental development and documentation.

The most outstanding results are afterwards gathered and shown in our web of reference [6], that can be used in our daily practice to support teaching, as a training tool for novel and senior teachers or as an open source of information for informal learning. This paper presents the main results and evaluations of the process of creating the contents of this website, representing the result of cooperative and collaborative work of students and teachers, unique in this category to the best of our knowledge. Many primary school teachers and museum educators are not confident in teaching physical science and the nature of science. Thus, it is not surprising that primary teachers feel uncomfortable with physical science. However, understanding is not only acquired classroom; it can be kern in a variety of places [1]. Furthermore, we now understand learning occurs in other places and with other people as well as school and teachers. The context is an important factor in learning and recognise that family members, peers, the media are an influence on recognising and experiencing everyday science [2]. The youngest of children observe think, investigate and are intuitive scientists [3]. Learning is a constructive gradual accumulation as more is learnt [4-5].

2. Field trips

In the latter part of the 20th century onwards, there has developed a growing awareness that learning does not solely occur inside the school building. In the case of science particularly in the core of developing and understanding of the nature and content of science which is, in formal education, traditionally taught in classrooms and in many instances laboratories. But learning out of school in a variety of venues is a valuable aspect of learning both of and about science [1]. Traditionally science out of school has meant a variety of sites such as field centre, museums, science centres, zoo, and botanic gardens. Which are all venues where interactions that may lead to the construction learning [6]. Such experiences are frequently individual ones. However, the socio cultural aspect of learning became reignited as an important element of the learning process at the latter part of the twentieth century, particularly the work of Vygotsky.

3. Learning everyday about Science

Children do not begin their formal school careers knowing nothing of science, whatever age they begin this formal learning journey, which varies from country to country. Children of different ages and thus different stages of cognitive understanding interpret phenomena differently. Their ‘common sense’ ideas are modified as they acquire new experiences and make their own observations as well as accommodating into their mental model information and explanations received by them. Thus, the same question asked to say 63 years old, 6 years old and 10 years old is likely to be answered differently [7].

4. Developing biological awareness

Biologists understand that the starting point for science is observation, [8]. The child’s *personal, spontaneous* science which they develop for themselves develops further through a *partnership* with someone or thing, and then though the more *formal* or *designed experiences in school*. If you observe for example, a 2-year-old child sitting on a stationary swing gradually work out; if there were no ken to push him realise he has to generate their movement themself! These young learners intuitively observe and investigate and make correlation.

Biological awareness and interpretation however, is unlike other aspects. In this world of children in which they are constructing their knowledge and interpreting the world in their terms, indeed constructing a ‘children’s science’; as opposed to what they later encounter as ‘school science’, which again may lead onto further understanding through teaching and experience and reflection of the learner, are not ‘misconceptions’ as defined by teachers well versed in the school and scientists science, veers to understanding 'scientists science’ [9], referred to by some researchers as ‘naive theories, or alternative conceptions [10].

5. Interaction - minds on with exhibits

Visits which contain a focus on activities designed to be performed during a visit at exhibits, as well as school based activities before and after a visit, can be an integral part of the learning [11-12] as many museum educator know.

The social context in which the dioramas are viewed, the age of the learner and the motive for the visit all influence the way in which visitors respond to the dioramas. Visitors expect to see representations of the living world in natural history museums.

A genre of identifying the interaction of visitors with exhibits in outside of formal school institutions has been developed following on the visitor’s studies work of the mid twentieth century. In particular there were studies of tracking and timing visitors to find at which exhibits they expresses interest [13] and analysing the conversational content. Tunnicliffe [14] analysed conversation of both school groups and families at animal exhibits, live, animatronics and classic natural history museum taxidermic specimens. Ash [15] identified dialogic inquiry occurring in dialogues of families at dioramas.

Emergence of inquiry science from a child's earliest years stresses the importance of play [16]. The stage of inquiry science is being directed through guided science to 'Open' or 'Authentic 'science with the learner determining the plan, the action and the interpretation of outcomes. Inquiry science approach declares the partnership between adult and child in the learning process. It is salutary to bear in mind in such two way or three way dialogues, that for the children their ideas their personal interpretation are their attempt to make sense. Their comments should be regarded as alternative conceptions to the accepted wisdom. In fact, as Osborne, Bell and Gilbert [9] pointed out, these ideas are children's science which is developed into school science in the formal education system. Such school science may develop, in some learners, into scientist's science. We refer to the child's early ideas and explanations as "My Science'. As educators we are required to assist the learner in their journey to the established science.

One-way to help learners construct further understanding is to 'throw back a questions to them [17]. Indeed, such is an aspect of argumentation, which develops further the inquiry approach by seeking for the person making a claim, such as statement, "That is a lion", or asking if it is, being asked what is their evidence for such a claim?. What is it about what they are viewing that leads them to that conclusion? In other words they have to justify their claim.

Learners must have the confidence and expectation, to ask questions and not be inhibited in giving their response such as justification of their naming of a biological organism. However, the adults with children, or adult, also need to understand the scaffolding process of learning from their not being declarative but questioning to develop the child's thinking. This is a role, many adult and teachers find difficult.

Schools and family visits whose spontaneous conversations has been analysed [18]. Whilst, the expectation of such a visit inks that museums' specimens are static, unless they are animatronics, which adds a different dimension to observations [19] because the models have a cycle of movement, which inks repeated and repeated.

This research found that visitors comment about the behaviors of the animals. However, not as many comments were heard as those generated at zoo animals which were often moving. The pose in which the taxidermist had positioned the taxidermic specimens enabled visitors to comment about the physics ideas and behaviors such as movement, feeding and fighting.

Children brought to a museum under the auspices of a school outing are essentially conscripts [20] and, although there may be free choice 'learning' [21], some of the visit is focused on a topic, which is chosen by the teacher and aligns with the curriculum of the class. The varied foci depend on phase of visit [22]. Families usually have a different rationale for a visit.

Our work is concerned with the identification of that which children notice spontaneously of physics in action in natural history dioramas and developing relevant activities which can develop their understanding of basic physics.

It is our professional opinion that observing natural history dioramas provides learners with opportunities to identify various aspects of biological science captured in the moment of time; portrayed in a given diorama as behaviour, taxonomy, adaptation to the habitat including anatomical specialisations and coloration.

Other science phenomena such as earth science in the geology of the habitat or the weather portray science such as forces are in evidenced and examples of physics concepts in action. Very basic ideas such as shape, size, colours, patterns and forces and balance can be observed. Floating and sinking, flight is other physics phenomena observable if animals are exhibited in a planned position, which shows such actions. Sound and light are important to living things for survival. Animals have observable adaptations, which utilise the occurrence of light and sound to their environment. However, learning strategies to focus attention of manifestation of physics in biology as observable in the dioramas, involves the educators knowing the foundation knowledge that the children possess.

6. Method

We decided to elicit primary children's understanding of physics and whether these learners could identify physics phenomena in action in animals at a natural history museum in the south of England which focuses on African and Indian dioramas. We collect and then transcribed transcripts dialogues in workshops and at the dioramas were collected and analysed through a read re-read iterative process, which categories of comments emerged. Simple counts were made of responses. These workshops led to children being able to identify the basic physics in action.

7. The research venue: the Galleries of Powell Cotton Museum

Gallery 1 is displaying the animals of north and West Africa and India. Today, this is the first gallery visitors see on entering the museum but it was actually the last gallery built by Percy Powell-Cotton himself, being competed in 1939 the year before his death. The large diorama to the left is known as 'The Watering Hole' represents many species from across northern Nigeria and Chad. The central diorama showcases the amazing diversity of Africa's primates and the different landscapes they live in. The diorama to the back right of the gallery depicts animals from the Indian state of Madya Pradesh (which translates as 'Central Province'). The final diorama, to the right of the gallery, incorporates a variety of landscapes and animal habitats. The far left represents the more lush woodlands around the Mkuze River, in northern KwaZulu-Natal, South Africa. The central part of the diorama, formed of a high rocky crag, represents the Ethiopian Highlands, an area where land levels rarely fall below 1500 meters. The Mountain Nyala displayed here, are only found in this region and have become a rare and endangered species. Finally, the desert habitat at the front of the case showcases the diversity of species found in the Sahara desert (Powell Cotton Museum Gallery 1. Retrieved from [23]).

Gallery 3 was the second gallery to be built, added on to the 'Pavilion' in 1909. The dioramas in this gallery focus on species from equatorial Africa and the plains at the edge of these forested areas. The central diorama represents a lion and a buffalo, locked in battle. The large diorama of animals from equatorial Africa include one of the most impressive specimens is the large bull elephant to the left of the case. In the same case is a truly rare sight – a group of Northern White rhino (*Ceratotherium simum cottoni)* (see Figure 2). (Powell-Cotton Museum Gallery 3. Retrieved from [24]).

8. Recognising Physics in action at dioramas

People rely on the content of their mental models to name or identify what they are observing. This work following described here is a preliminary attempt to find if children can identify in the natural history dioramas any manifestation of physical science in action. Of particular interest is the topic of forces, which learners have difficulty in separating for the idea of motion. Balance and centers of mass in action may be observed, particular in arboreal animals, such as the primates in the primate dioramas at Powell Cotton museum (Fig 1). Light, sound as well as movements and adaptations to the environment in which the featured organism naturally inhabits can also be identified.

Figure 1. Gallery 1 of the Powell Cotton Natural History Museum. Copyright Nikhilesh Havel. Reproduced courtesy of the Trustees of the Powell-Cotton Museum

Observing natural history dioramas spontaneously and then cued, provide opportunities to identify physics in action, albeit at 'a moment frozen in time' as Reiss and Tunnicliffe [25] describe in a Museum of Scotland diorama shows a pair of wolves frozen in their chase of a wild boar in a Caledonian pine forest.

Most animals, when alive, can make some observable movement and most possess the power of locomotion - being able to move from place to place. Balance and centres of mass are phenomena which can be observed in natural history dioramas, as well as structures to bear the mass of the animals, eyes, appendages, particularly legs in land living animals such as the rhino (as shown in Figure 2), and inquiring when the legs of these animals are much bigger in diameter than arid those of the antelopes or indeed the giraffe. Such serrations can lead to surface volume ration understanding and the needs associated with being warm blooded and main gaining body temperature. Observations the most effective position for the legs can be developed into the position of legal on the torso in quadrupeds and then in bipeds and the issue of how animal maintain an upright stance when for example, begin to drink.

Figure 2. Gallery 3 of Powell Cotton Natural History Museum. 'The African Jungle' diorama. Copyright Nikhilesh Havel. Reproduced courtesy of the Trustees of the Powell-Cotton Museum

The Table 1 is a summary of some of the physics concepts that are illustrated in the dioramas of Powell Cotton. For example, gravity and forces in balance of animals and the position of the legs especially when the neck is bent toward a water source. Linking biology with physics for maple, ether are members of the two toed hoofed animals, ungulates (Artiodactyl) their weight is two toes, the third and fourth, which form the hooves. The one toed, or odd toed, ungulates, (perissodactyls), have their weight carried through the by the one hoof. The various physics principles, which are manifest in the animals, are listed below. They can be identified in looking at any animals, live or mussed, but are particularly effective to notice, in a natural bestiary diorama where the animal are exhibited inaction in a realistic context.

PHYSICS IDEAS	ANIMALS
Camouflage	Bongo (stripes)
Stripes	Mongoose
Countershading	Nylah
Pattern / sunlight	Giraffe
Colour blending	Antelope
Flight (forces)	Butterflies
	Vulture, wings, talons beak, force
Aerodynamics Lift Bernoulli effect	Kingfishers
Centre of gravity / spreading load	
Hooves splayed (Even-toed ungulates	Addax (white antelope)
Balance Thin legs- light animal	Gerenuk (on 2 legs)
	Donkey split hoof) wider surface area sand
Position of legs	Quadrupeds
Heat loss	Fur

Table 1. The physics concepts illustrated in Galley 1 with the relevant animal identified in the 'Water Hole' diorama

9. Two pilot studies

Such action labels leads into pilot studies conducted at Powell Cotton museum in England to explore the spontaneous recognition of physical science in action in the diorama; whether this could be increased by trigger workshops to refresh primary school children of science concepts they had studied.

Two pilot studies were undertaken, one with two 11 year old boys who had studied science at their state school and were frequent visitors to this museum/. The other group was 15 mixed gender and ability 8-year-old children, half of whom had visited the museums previously and half who had not. Museums in the United Kingdom run courses for parties of school children, as do zoos and botanical gardens. The majority of such are linked to the topics required to be studied in state schools of the relevant national curriculum of the country of residence.

The two boys were invited, each had a researcher with them, to look at the main African diorama (and tell us, “Looking at the dream, what is it about". Their responses contained some inferences made using their observations and previous knowledge. Of with some inferences. Boy 2 replied*, 'Desert. Wild variety of animals doing all kinds of things. A giraffe reaching to eat. Different species of animals. Different zebra animals, doing different things as a group*'. This boy was interested in that, '*This diorama puts together animals in the same space…the diorama is like it combines different animals in arrangement for the visitor.'*

His response to "Where are the things you notice?' was about the effect of the dioramas. He commented " The movement of the animals,...is like you have *a you tube video and you have press pause.* All the actions have put together and this scene shows all the movements. They are represented as being alive. They animals are pleased perfectly to demonstrate that we have mention in the activity". Whereas Boy 2 replied, '*Leaves and animals and it really seems I am there and this makes the difference (to learning science at school)*. The responses to what were the animals doing were factual and descriptive and focused on the species and other exhibits. Interest was expressed by Boy 1 in the movement of animals portrayed but with sensitive interpretation of positions, he highlighted that one antelope that was looking back over he shoulder, *'….as if she's lost something send she looks round to spot it. The antelope's attitude is like a tourist's attitude in a new place when confused.'.*

10. Workshop in middle of visit

In another room the boys were introduced to the 'equipment' for a workshop, namely modeling clay and some small sticks (cocktail sticks) to represent legs. They were asked to make animal that could stand upright stably with 4 legs. One boy immediately made a horizontal rectangle shape and fixed 4 legs one at each corner of the body. The other boy decided to make a 4-legged animal with a vertical cylindrical body. This was resistant to standing up! He eventually decided to reorient his 'body' so he had rectangular one lying horizontally. Then he fixed the kegs together in the middle of the underside of the 'body'. Eventually, he decided to try positioning the legs at corners and was pleased that this produced a stable model. The boys were invited to stand their 'animal' on a pike of card which acted as a 'wobble' board and to investigate for how long their animal stood as they recued more and more backward and forward movements of the broad. They found that by having the legs not coming down vertically from the body but at an obtuse angle, slanted, the model animals were more stable. The boys were asked to add neck and head on their 'body' and then show how the 'giraffe -like model animal could drink. By simulating an exhibit in the 'Water Hole' diorama (see Figure 1) they found that the animal tippled over until they had made the area between the legs wider and shallower. They remembered they had learnt about forces in school science but said it had not related to anything in their everyday world, like animal movement.

On returning to the diorama the boys used these inherent science ideas balance, stability and center of gravity to their interpretation of the diorama. Boy 1 reported that, *'The giraffe starts bending her legs to get her head closer to the ground. I can see stability in the animals. The legs support the position of the head. Each part of the body supports because and for example one leg of the giraffe cannot work with the other legs'.* He noticed the information provided by the body of the animal and explained that the spreading of legs increasing the surface area underneath a spreading their weight at their legs and nobody standing on one leg.

Boy1 modeled with himself how an animal altered the position of its legs in odder to bend down to drink and not overbalance. He was intrigued identifying animals, which were bending down. Boy 2 also noted that the buffalo had wide legs and the antelopes thin stick-like legs and postulated that animals with big ears, such as the bongo, could hear better and needed to because it was dark in the rain forest.

They had also been asked to balance on one leg as a starting activity and were intrigued, particular looking at the 'Water Hole' dioramas in Gallery 1. The boys accomplished this task by observing how the animals sitting on branches and how they balanced by walking along the branch. Moreover, the study shows that children can identify science in action in animals. Thus, in addition to the usual workshops of biodiversity and conservation,

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basic physical science has its place in natural history museum education.

11. 8 year olds activities in the gallery

Peer group responds to dioramas and effects of a series of simple workshop activities with the 8-year-old children resulted in a greater awareness of the wince in action in the dioramas.

The activities tried were:

- Making 4-legged animals from modeling clay and looking at balance and stability.
- Matching colours of cards to colours in the animals. (Designed for early years).
- Identifying basic mathematical shapes. (Designed for early years).
- Walking the line on tip toe (Balance).

	ANIMALS		
	Boys group	**Girls group**	**Mixed group**
a	Giraffe tongue	Gelada baboon Gorilla's mouth	
b	Baboon	Gorilla's eyes	
c	Donkey, Addax, Orcas gazelle	Western Lowland Orillia	Gazelle, Ass, Oryx
d	Swayne's Hartebeest Roan Antelope Beetle	Porcupine, Mona Monkey Bush pig, Addax, Talapoin, Guenok, Zebra, Gorilla's teeth	Sunni, Leechwe, Wildebeest, Giraffe

Table 2. A sample of the responses of 3x 3 groups of 8-year-old primary pupils to the colour matching activity: a) pink; b) red; c) beige; d) brown

Finally, the museum educator had constructed a long 'line' out of thick paper and inch wide, which was adhered to the floor. Children were asked to walk along it normally, finding they had to put one foot in front of the other to stay on the line, and then on tip toe and keep their balance. Children found that when walking on tiptoe they needed to use their arms in order to maintain their balance.

However, we have found that offering workshops in professional development on physical science and animals can interest teachers and provides them with more confidence to tackle such types as forces with their classes and look for applications. Hence looking at animals in zoos and museums is a different way of assisting children to understand some aspects of physical science in action.

The lesson that emerged from these preliminary workshops that is primary science is not taught within a meaningful context in primary schools. Once primed after a viewing by activities the children on a second viewing were able to identify science in action.

12. Conclusion

Physical science principles are implicit in watching the living world and these life sized representations of a moment in time, whether a faithful representation of a known scene or a conceptual construction diorama illustrating biogeographic principles. School science, in the primary school at least, is not taught within a familiar context for children and they do not use school-learnt knowledge in interpreting in this case natural history dioramas until they have been cued into the science concept with some 'hand-on' activities.

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Polymorphic Science Practice to the Training of the Science Teacher

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Abstract. In this work a teaching approach appropriate for the training of the Science teacher is presented. The approach is within a context of constructionism with special attention given to the well-known general problem that teachers have, i.e. to transform their knowledge on pedagogy and/or on the subject matter to appropriate school practice. The work focuses mainly on the notion of Polymorphic practice work in Science and Technology, a notion I introduced some time ago. Here, this notion is presented in a more general way, together with indications on its use, with specific examples and results from implementing it at different levels of educations.

Keywords. Constructionism, cross-thematic teaching approach, interdisciplinary teaching approach, polymorphic practice in science, science teacher training.

1. Introduction

This work focuses mainly on the notion of Polymorphic practice work in Science and Technology, which, in its conceptual form, I introduced at 1998 [1]. Polymorphic practice (measurements, experimentation...) in Science and Technology includes a common psycho-motive activity (doing measurements, experimentation...), which consequently is morphed into different levels depending on the (previous) cognitive attainment and/or the mentality of the learners (school students, trainee teachers…).

It has the advantage that this psychomotive activity (a Hands-on activity in general) may be applied directly in schools to be used as starting point for subsequent teaching activities that depend on the students profile and the type/level of the school. Polymorphic practice in Science and Technology resembles multilevel teaching i.e. teaching pursuing more than one sector and levels of learning. However the difference in the teaching levels is not only on the didactics but also on the subject matter and the attainment levels.

The need for polymorphic practice teaching arises usually in the training of teachers to the subjects they are going to teach where there is a requirement: a) to teach in an advanced level for the teachers themselves, and, b) to teach, by examples or otherwise, in a level more accessible for the pupils at school.

Here a more elaborated framework on the use of Polymorphic practice in Science and Technology to the training of Science and Technology teachers is presented with indications on how to select appropriate Hands-on activities using accepted theories of learning and teaching approaches. Examples of such activities, incorporated in courses of education – training for a variety of learners and under different modes of delivery, with indications on their efficiency are also presented.

2. Issues considered and accepted working hypotheses

The design of efficient examples within the context of Polymorphic practice in Science and Technology depends on a variety of parameters. The issues taken into account and the accepted hypotheses of work affecting selections during the design of relevant course modules within the frame of Polymorphic practice in Science and Technology are:

1) Learning demands active participation from the learner in order to construct or reconstruct the knowledge that the teaching aims to. In Piaget's constructivism, focusing on how children keep or reconstruct their knowledge on the world, learning is triggered when 'cognitive dissonance' occurs and requires time for deliberation and retrospection. Following 'constructio-nism', introduced by Papert [2], in which the focus is on how learning (facts, processes…) is achieved, the use of means, tools, etc. to make actual constructions enhances learning at all levels. Constructionism extends the context of Vygotski (learning through interaction with other persons) and Bakhtin (retrospection i.e. interact one with him/her -self) into 'interacting' (testing, changing, modifying…) things in

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the environment, made by themselves or by other people. According to Papert these 'interactions' increase the construction of new knowledge and the skills of self-directed learning. Within this line, the teaching approaches should include the construction of an object ('self-made equipment') to be used as an instrument of observation and/or experimentation.

2) Science and Technology (S&T) literacy of the population at large is a pre-requisite to the contemporary knowledge based societies in order to keep their living standards and prosperity. In the quest for a more efficient S&T teaching it was found that research findings for an efficient S&T teaching were not transferred to schools. The situation is worse in S&T where, on top to the difficulties of the general teacher, the S&T teacher faces also the problem of including, in an appropriate form, observations and experiments, a task demanding special skill and dexterities. It seems that, despite the good (theoretical) knowledge the teacher may posses on subject matter and on issues of pedagogy, most school teachers continue to teach the way they themselves were taught [3] and various measures have been proposed against this difficulty (see an overview in [4], [5]). I think that the impact of these measures can be enhanced if the teaching of the S&T teacher is based on the teaching approaches taught in the training courses, i.e. the ones desirable to be seen also in the classroom. Within these lines the use of self-made equipment: a) it is advantageous to the development of skills and dexterities of experimentation; b) they should be simple and within the abilities of the learners (trainee teachers or school students); c) the teaching to trainee teachers should be delivered using techniques advocated as beneficial for school-teaching.

3) Observations of natural phenomena, experimentation and measurements are fundamental constituents of any course in S&T. They require specific dexterities and may be used to promote cognitive skills in higher levels. Using observations from everyday life is advantageous and promotes an attitude of connecting Science to everyday life [6]. It implies that the themes should be related to phenomena observed in everyday life.

4) In general education, where the main focus is on a conceptual understanding of the models used to explain natural phenomena, the use [7] of self-made equipment in experimentation enhances the self-esteem of the learner (trainee teachers, school students, general public…) and, if they are also used for measurements, they help towards a better understanding of the principles ('physical laws') involved in the operation of relevant measuring instruments. Otherwise, the use of sophisticated complex equipment may give accurate measurements but removes creativity converting experimentation to a process of demonstration in which the student observes the results of an apparatus he-she does not understand. This, combined with the general attitude to get the results of the experiments instead of inquiring a situation of a Natural phenomenon, hinders, at least in general Science, the understanding of the phenomenon under study. Even in the education of S&T specialists, where sophisticated-modern equipment is indispensable, an understanding of the principles used to construct the equipment is necessary in order to assess its reliability and operational conditions and this task is facilitated, if there is previous related experience with self-made equipment.

5) Inherent to S&T measurements are the notions of sensitivity, accuracy, errors of measurement (systematic or random) and their treatment, etc. The use of self-made equipment may help to understand these nations, especially if learners compare their measurements made with their own constructions. The comparison of their arrangement to test a phenomenon to other arrangements that use a different approach may facilitate to understand the notion of unbiased tests.

Within the context of the previous sections we developed teaching activities using the notion of Polymorphic practice covering a wide range of S&T subjects. Some examples with comments on how they were used in teaching – training courses are presented in this section. Details about these Hands-on activities and some more examples may be found at [7], [8], [9].

3. An example: Bernoulli's law in fluid dynamics

When a fluid flows in a pipe, the pressure, P, the velocity, v, of the fluid and the height h, at any point of the pipe are connected as in Eq.1, known as Bernoulli's law (called also Bernoulli's principle) [10].

$$P - P_{atm} + \frac{\rho v^2}{2} + g\rho h = constant$$

Equation 1. Bernoulli's law. ρ=density, v=speed of the flow, g=acceleration of gravity, h=height

Eq. 1 is valid if the flow is laminar (steady and non-turbulent) and if the fluid is without viscosity and if the variations of the density of the fluid are negligible. These conditions are satisfied adequately enough for water. They are also adequately satisfied for air if there are no significant density changes and if the speed of the airflow is not too high (i.e. less than 100km/h; note that when the velocity of a wind exceeds 120km/h (or 65 knots) it is classified as a wind of force 12 in the Beaufort scale). Eq.1 implies that along a horizontal pipe (h constant) through which a fluid is passing, the pressure, P, is less in places where the velocity, v, is higher, i.e. where the pipe's section is smaller (flow rate is constant as the density of the fluid was assumed constant).

Every U-shaped tube has one open end within a section of the pipe (pressure within the tube) with the other end outside the pipe (atmospheric pressure). When there is no airflow through the tubes, the liquid legs are level. With airflow through the tubes, a pressure difference appears which can be measured from the difference of the heights of the liquid in the U-shaped legs. For water-flow, the pressure gauges are replaced by equal size holes on the top of the pipe and measurements of the height reached by the water coming out of them in the absence and in the presence of water flow, the differences indicating the pressure changes. Plotting the points [pressure difference vs. 1/d4] in a linear scale graph may check Bernoulli's law – they should fall on a downwards-straight line (see example in [8]). This topic on Bernoulli's law was chosen to explain notions in Hydrodynamics where school students and most teachers show difficulties of understanding. It was used as a test case for explaining difficult subjects, at least conceptually.

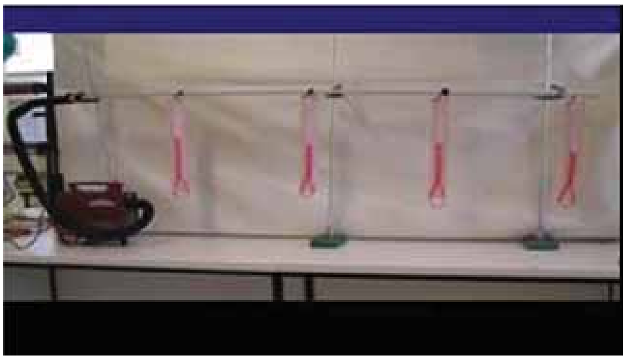
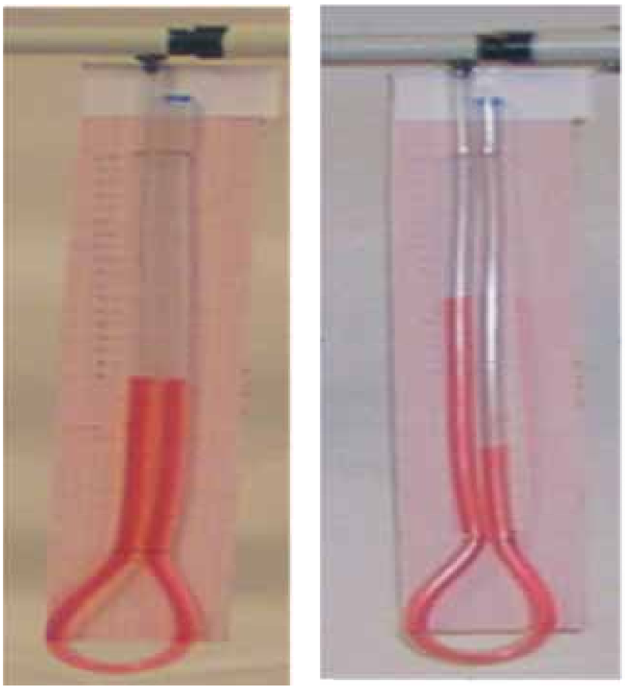


Figure 1. Experimental construction



without air flow **with air flow**

Figure 2. Pressure gauges

This may be tested with the construction shown in Figure 1. Plastic pipe segments (like the ones used in drainage or low voltage wire channelling) with different diameters are joined in one long pipe with varying cross-sections. Air - water tightness is achieved with plastic band (insulating band of electricians) and silicon gel.

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A vacuum cleaner was used to produce airflow through the tubes (in- and out- flow), while for water-flow one end of the pipe is connected to a water pump (a tank suffices if it is wide enough to have negligible pressure changes during the measurements). For airflow, pressure differences inside the tube are measured with the U-shaped flexible transparent plastic tubes (used by masons to level cement floors) containing coloured water (see Figure 2).

The topic, including the construction by the learners, has been taught to primary school teacher-students, to primary and secondary school trainee-teachers and to school students, using mentor type guidance, mostly with Project Based Learning (Problem- and Inquiry–Based Learning were also used at the beginning of every course - see an explanation of the teaching approaches in [11], [12]). The sequence of teaching activities for this course is as follows:

a) Introduction, in which related instances of the topic are located and discussed. These instances may be from everyday life, from learners' own experience, from prepared by the teacher demonstrations, video etc. The discussion seeks possible explanations from the students.

b) A Problem Based Learning task, in which the learners are asked to make the construction, either as described earlier or to construct their own equipment. Discussion includes ways for simpler and more sound – reliable construction.

c) An Inquiry Based Learning task, in which time is allowed for the learners to use the equipment under various conditions and plan their tests. Discussion includes fair (unbiased) tests, measurements' accuracy and sensitivity, conditions of operation, etc.

d) Learners are asked to say and support their opinion on what will be the pressure changes in the absence and in the presence of in- and out- flow within the tubes, which are always filled with the fluid (air or water).

e) Measurements are taken twice, one with water or air pumped into the pipes the other with the water or air taken out of the pipes and the two sets are compared.

f) The predictions made earlier by the learners are compared to the results obtained. Discussions on the observed discrepancies are made. Usual discrepancies include:

- Wrong sign of the pressure differences, believing that when there is inflow into the pipe the pressure will increase in the lower cross section parts of the pipe but the actual observations are opposite.
- Predicting opposite pressure changes for the in- and out- flow but the actual observations seem similar (slight variations to the magnitude may be attributed to different flow rates, an explanation that may also be tested).

g) A project based self-learning task with possible applications of the phenomenon, for example 'flit sprayer' (Figure 3) and similar paint sprayers, 'venturi type fuel injection, airplane speedometer (used previously), techniques used in pump constructions, etc. This task may be extended to cross-thematic studies.

h) Depending on the time available and the response of the learners the teaching may also extend to more advanced topics. This task is appropriate for self-study and interdisciplinary approaches may be used.

Figure 3. Flit sprayer

The discussions and the tools to process the measurements during the teaching activities are adapted to the profile of the learners, i.e. for school students the use of mathematics has to be simple and within the students' abilities, i.e. Equ.1 may be used for (or 'derived') in an in depth analysis in the training of S&T teacher specialists whereas in school teaching it may be replaced by 'the flow produces loss of pressure' a statement that can be derived from observations. If necessary, instead of 'complex' mathematics, other means of process may be used, for example, (scaled) graphs, ruler and protractor.

4. More examples

The procedures presented in the previous section, adapted appropriately, have been also used for other modules of Polymorphic practice in Science and Technology. In this section the construction parts of some more examples with specific points, mainly on the teaching approaches, are presented in brief.

For all of them, more details have been presented in [6], [7], [8], [9], [11], [12]. It is worth to note that some of the constructions may be used to activities covering more than one topic in Primary Science triggering Cross-thematic discussions (see examples in 4.3 and 4.4 below).

4.1 Sun dials

The aim of this activity is: a/to study the changes in day-night times during the year, their relation to earth's movement around the sun and the sequence of seasons in temperate (tepid) latitudes of the Earth's surface, and, b/to understand how time was measured and the concepts of the different reference systems for time (local-political, UTC, sidereal). These issues are considered as difficult to understand and sometimes teachers (in primary schools mainly) are advised to avoid the relation of the sequence of seasons to the movement of Earth around the Sun. This practice includes two Hands-on activities: a/measurement of the geographical coordinates of a location, and, b/construction of a sundial.

For the measurement of the Geographical coordinates, the device needed is a simple vertical rod OA on a flat horizontal surface (see Fig 4). During the day (around noon is the important time period) we mark the end of the shadow of the rod (the s points in Fig 4) together with the time and draw the corresponding line. For demonstration purposes the s-point line is shown curved. In practice it is almost a straight line. The point B of the line that has the smallest distance from the base of the rod, O, determines the local meridian (the direction O to B is the North-South direction). The time the shadow of the rod is along this OB direction is the time of the local noon and determines the Longitude of the place. The corresponding angle φ is equal to the Latitude on the equinoxes see explanation in [7]. The activity is very simple and offers opportunities for teaching processes of data filtering and manipulation. Using some (advanced?) mathematics to make best fits to the line of the points s, accurate within fraction of a degree results may be obtained for the geographical coordinates. However, the results may also be obtained using graphs, ruler and protractor with a precision of the order of 0.5o-1o arcs for the coordinates and of ±1 days for the beginning of seasons. From measurements of the geographical coordinates in two locations with a known distance, the Earth's radius may be obtained in a way similar to the one Eratosthenes used – see [6].

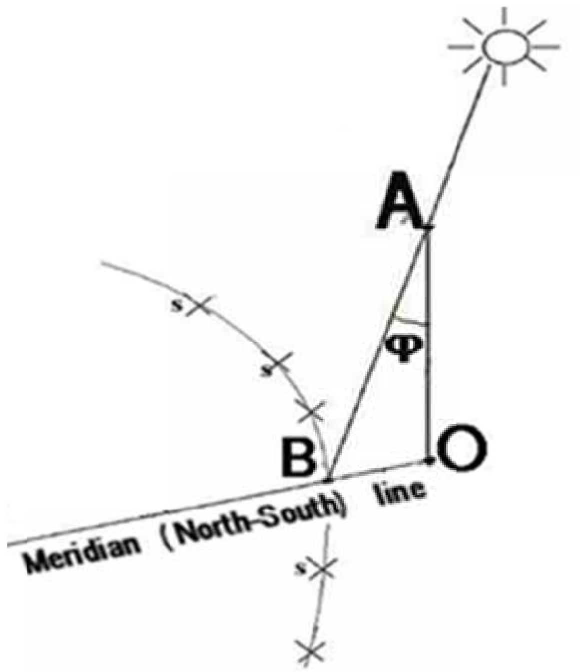

Figure 4. Measuring geographical coordinates

Students are asked to construct a type of sundial of their own choice and selection of materials and to justify their selections. This

Hands-on activity of a sundial construction is focused mainly to the development of self-learning skills. Depending on the learners' response and the available time, further study to time measuring devices may follow.

4.2. Triangulation

This activity provides a visualization of some notions from the geometry of triangles, explains the origin of length units AU [13] and parsec [14] and focus on studying conditions affecting the accuracy of measurements. The activity begins by selecting a base, for example the side of a desk (to measure the distance to the wall opposite) or the lower end of a window (to measure the distance to a point outside the classroom). We mark two points A, and B near the edges of the base and measure their distance, AB=γ. We draw a line on a piece of paper and mark two distant point a and b. We locate the paper with the a point over A and the line along the base. With a ruler we aim from A to a point C of which the distance we plan to measure and draw the line a to C thus obtaining the angle BAC. We repeat for the line B to C to obtain the angle ABC. We draw a scaled image of the triangle ABC using the base AB=g as one edge and the angles at its ends a and B. From this scaled image with a ruler the distance from the base to C is calculated and compared to the actual distance. A discussion on any found discrepancies is initiated. Repeating the measurement and/or using various orientation of the base relative to the line towards C (perpendicular or oblique) best possible conditions of minimizing the error may be inferred. With some more thinking the height of a (nearby) tree may be measuring by using this technique twice one to measure the distance to the tree trunk the second measuring the 'altitude' (angle between a horizontal line towards the tree trunk and a line towards the tree top). This angle is used as parallax of the tree height to be measured with the other angle approximated as being 900. During the discussion the idea of measuring distances within the Solar system (by using as base the distance between two observatories) or to stars (by using as base the Earth's radius around the Sun) are introduced and the origins of AU and parsec are explained. As a project, learners' are asked to construct a (portable) device to measure the distance to nearby objects. In most cases they construct an open 60-degree triangle (set square of 300 and 600 angles) with the edge in the 600 revolving on top of a protractors' image calibrated to give directly the distance. Depending on the learners' profile and the time available a detailed discussion on the random and systematic errors of observation and of the measurements complemented with methods for their treatment is feasible. In Primary school it has been used to discuss natural quantities of different order, e.g. pure numbers as for the angles (they do not change in linear scaled graphs), scalars, etc. the use of linear scale graphs was also introduced as a tool replacing otherwise complex mathematics.

4.3. A Gas thermometer

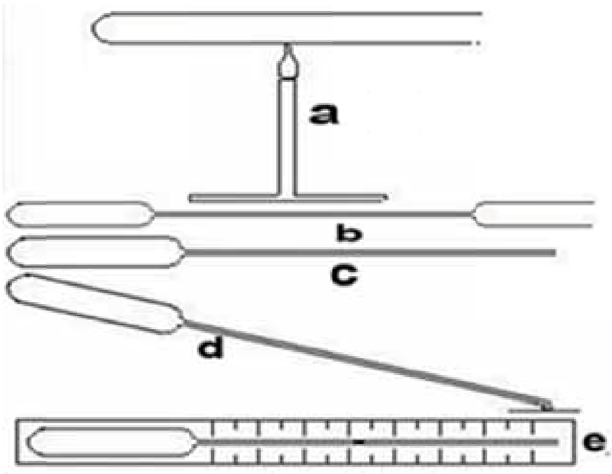

Figure 5. Gas thermometer

The device has been presented in [7] and is portrayed in Figure 5. A test tube made of simple glass (similar to the ones used in chemistry) is heated (a). When the glass is soft enough we elongate the tube with a quick steady straight outward motion (b). We cut (break) the glass near the open end of the test tube (c), the result being a bulb chamber with a thin elongated pipe. A drop of a colourful fluid (e.g. permanganate water solution) inside the narrow part of the tube moves as a reaction to temperature changes of the air in the bulb and may be used to indicate the temperature (d). Fixing the tube to a piece of cardboard and making the calibration completes the construction (e).The activity is a good starting point to study the process of calibration of the measuring instruments in Science and their limitations, e.g. range, accuracy, precision, principle of operation, etc. The (many?) unsuccessful trials to make the device are a good starting point to discuss properties of glass and how to develop a glass handling dexterity, useful to the construction of special glass tubes and bottles replacing specialized and rather expensive glassware used in chemistry. Operating the device under different conditions, a visualization of the gas laws may be achieved.

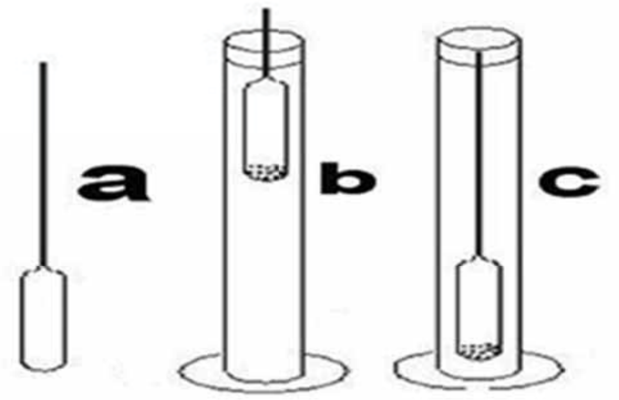

Figure 6. A hydrometer

The same device may be used also as a hydrometer (see Figure 6). The tubes contain thin shot or fine sand in appropriate quantities to have, when immersed into water, the results of shown in Figure 6(b) (to measure densities of liquids lighter than water) and in Figure 6(c) (to measure densities of liquids heavier than water). The calibration process is a good starting point to discuss the various ways of titration of solutions, etc.

4.4. A Weighing-machine

The device has been presented in [7] and is portrayed in Figure 7. It is made with materials (rod and hooks) used to hang slide curtains in house windows. During the calibration process, different aspects on the mechanical moments may be clarified. The construction, if done with diligence, may be very accurate. It may also be used in other apparatus, for example to construct “An amperometer” useful to the visualization of electromagnetic forces.

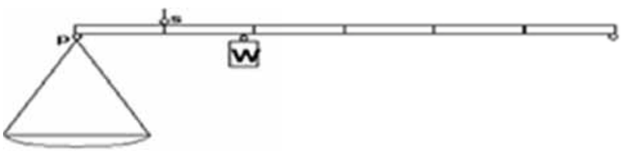

Figure 7. A weighing-machine

An iron washer fixed on the balance rod and a coil around an iron bolt has replaced the plate on which the weight to measure is placed. Connecting the coil serially to an electric circuit, the current induces an electromagnetic force, which holds the washer to the bolt. The electromagnetic force is obtained by moving the weight along the rod. Changing the point supporting the rod, different ranges may be selected. The operation of this device under various construction parameters, e.g. amperage, number of coil turns, the coil core (i.e. the bolt inside the coil), etc. may help to a better understanding of electromagnets, a topic considered as difficult by many, school-students and teachers. Mastering this issue, it seems a relatively easy task to construct an electric motor, see a demonstration in [8] topic ‘An Electric Motor’.

4.5. Etc.

More Hands-on Polymorphic activities have been developed, for example: measuring the gravity constant [1]; numerical overview of refraction [1]; geometrical optics [8]; Visualization of vector addition [15]; a variable lens [8]; mechanical resonance [8]; an electric motor [8], hands-on applications in other fields, e.g. (educational) robotics or otherwise – see later on, etc.

5. Some comments

The activities described earlier and (other similar) have been used in the teaching of S&T courses to school students from pre-school to higher secondary education (‘Lyceum’). They have also been used in the teaching of S&T and of S&T Didactics course to students in the Department for Primary Education of The University of Crete (undergraduate student-teachers for Primary education and trainee-further education teachers in primary and in secondary education). In these teachings, the students have realized the activities as assigned projects. In all these cases, students have responded with very positive comments [7]. In assessing the courses, students’ more frequent expressions indicate: a) acquirement or enhancement of a positive attitude towards S&T; b) an increased self-esteem (confidence on their capacities); c) the course was difficult.

The first two responses came from school-students and from teacher-students. That was an important outcome as S&T is considered as a difficult or a complicated field addressed to specialists. The third observation came almost exclusively from teacher students. Instead, school students expressed the opinion that it was a very interesting course that was related to real life activities. Teacher-students opinion on the difficulty of the course was very often accompanied by statements that, despite, or because, its difficulty they enjoyed the course, they would recommend it to other students and they would enrol in a similar type course. These comments, however, were from teacher students who completed the course while the perceived difficulty seemed to be the reason for the significant drop-out rates observed during the first teachings.

As presented in [11], [16] Polymorphic teaching is an effective approach to the teaching of S&T especially for primary education schoolteachers and students. Teacher-students and teacher-trainees finishing the course, in their concluding task, very often implement construction activities that have polymorphic characteristics and relate to activities from their life, a noteworthy outcome indicating a successful course. Examples of such activities include:

- Creation of a dehumidifier that could be used to keep on display and under standard regulated conditions old books of the University's Library (Figure 8) [17].
- Artefacts that could be used in activities and operation of a 'smart house' produced in courses on robotics [18].

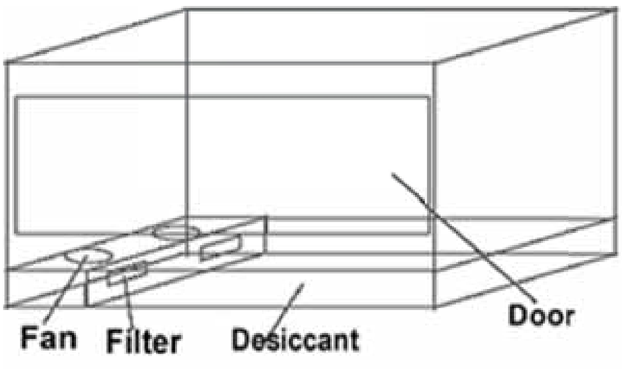

Figure 8. A dehumidifier

The effectiveness of polymorphic teaching activities some guidelines are useful to observe (see also [19]):

- The polymorphic practice should relate to a, preferably interesting to the student, activity from his/her environment,
- The complexity and the difficulty of the construction should be neither trivial nor beyond the student's capacity – the Vygotski's zone of proximal development is a useful criterion,
- Students should they themselves participate actively to the construction process – if working in groups (recommended for school-students) active participation of all the students should be ensured,
- Students should be encouraged to continue and praised for their outcomes – it helps boosting their self-esteem [20],
- Teaching guidance should be in the form of mentoring – the teacher should act together with the students as a member of the group who is also worried on how to solve emerging problems.

Using the above guidelines more strictly towards a personalized teaching almost eliminated the dropout observed at first teachings, although it increased somewhat the load to the teacher.

Due mainly to the adopted teaching approach, the courses are organized in modules with simple tasks that can be easily undertaken by (adult) students making the courses candidates suitable for open/distant education teaching, an idea explored in [9].

These courses can be transferred (with minor adaptations) to the school classroom, an advantage when teacher-students have not completely mastered the philosophy of the course, e.g. in training courses where there are time limitations – they may simply imitate the teaching they were exposed to.

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[9] http://www.clab.edc.uoc.gr/aestit. See link Outcomes [visited 13-May-2016].

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[visited 24-May-2016]).

[14] One parsec was defined as the distance from Sun of a star for which 1 AU subtend (i.e. has a parallax of) one arc second. It was introduced as a convenient unit to quote distances of stars from raw ‘triangulation’ data. In 2012 the parsec was defined as 648000/π Astronomical Units or about 3.085677581×1016 m (~3.26 light-years) (values from Encyclopedia Britannica, http://www.britannica.com [visited 24-May-2016]).

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[20] This is a critical issue as most of the learners (school-students and teacher-students and teacher-trainees) are usually inexperienced in workshop construction activities. The development of self-esteem (i.e. confidence on their competence), especially to the general teacher in primary education whom the profile is mainly within Humanities, is a very important as it will help him/her to endeavor more easily to such activities in the classroom. For school-students it may help to provide a positive attitude towards S&T preventing the widespread belief that S&T is difficult, complex or for specialists. It is characteristic that when a group of primary school students (ages 11-12) were asked to check their results on the measurement of geographical coordinates by looking at a World Atlas book, their comment was ‘they have found the same with us’.

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On-line Problem Based Learning Physics Projects

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Abstract. In the framework of the Physics subjects in the Degrees of Engineering at the University of Vigo, some of the transversal skills (creativity, maturity, teamwork, experimental resolution of challenges, ...) are developed through a Project-Based Learning (PBL) approach. As a result, students perform their own experimental setups and prepare the corresponding accompanying documentation. The most outstanding results obtained are afterwards gathered in a web of reference, which can be used as future teaching support, as a training tool for novel and senior teachers, or as an open source of information for informal learning. This paper presents the main results and the evaluation of the process of creating the contents of this website.

Keywords. Project-Based Learning (PBL), hands-on activity, physics, learning by doing, engineering.

1. Introduction

Numerous studies claim that the lack of interest in scientific and technological matters lies in how the related contents are presented to the students [1]. Typically, traditional teaching is focused on master classes with the only support, in the best of cases, of closed and highly structured laboratory practices. Even for those students with an optimal profile, academic performance can be impaired by this merely conceptual teaching approach, standing far away from the ideal academic use of the scientific method [2-3-4].

In contrast to these traditional methods, there are several educational options, which have proven more beneficial and have thus gained increasing importance in recent years. Among them, the so-called Project-Based Learning (PBL) [5] can be outlined, applied for instance to experimental learning objectives. In our subjects of Physics of the first courses of Engineering University Degrees this technique has been used, proposing the students a semester challenge of designing, constructing, and documenting a hands-on activity that illustrates a concept, a law or an application related to the subject theoretical contents. The objective envisaged is to place the students in a non-academic situation outside the classroom, facing the resolution of a practical problem that will enable them to acquire the related transversal skills of our Engineering University Degrees, since the successful achievement of a final project of this type requires, among others, autonomous skills related to team organization, information search, discussion, experimental development and documentation.

The most outstanding results are afterwards gathered and shown in our web of reference [6], that can be used in our daily practice to support teaching, as a training tool for novel and senior teachers or as an open source of information for informal learning. This paper presents the main results and evaluations of the process of creating the contents of this website, representing the result of cooperative and collaborative work of students and teachers, unique in this category to the best of our knowledge.

2. PBL Physics Projects

Since the academic course 2010-2011, our students are proposed a formative approach consisting in the resolution of an experimental challenge, organized in small groups (Figure 1). The process begins with the choice of the activity from a list of available options, all of them affordable and proven. These options each year are defined a priori by the teachers choosing either, for example, from literature [7], a website [8] or a set of selected educative journal papers [9]. The goal is the practical implementation of a device or mechanism related to the theoretical and practical contents of the subject, using either simple materials readily used in daily life, or laboratory equipment if necessary. The process must be documented as well with a slide show presentation program presentation including a fundamental introduction, historical references, objectives, materials and steps followed in the development of the setup. In addition, the students record a homemade video, provide information on the foundations, assembly, operation, several keywords to help further searches, and also complementary references - videos, interactive simulations, books, websites, ... -.

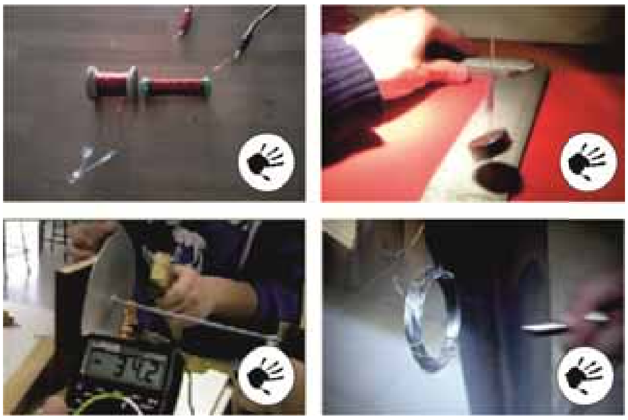

Figure 1. As an example, several electrical induction activities

Some surveys have been conducted to obtain information on the students valuation of the performed work, and also their perception regarding the effectiveness of this approach in achieving the desired competences. Most of the responses, in a range varying from 50% to 70%, indicate that students consider that this challenge allows them to interrelate previously acquired concepts by proposing and developing creative practical solutions. This is achieved using previously acquired theoretical knowledge applied to different phenomena and situations of daily life. Also this promotes cooperative work, communication skills, organization, planning and acceptance of responsibility. It moreover highlights the multilingual reality of teaching. Besides, it allows to get acquainted with the necessary information sources to achieve a permanent and continuous updating of their formation, being thus fully aware of the need for lifelong training and quality improvement. And finally, this is obtained emphasizing the dynamic values of scientific thought, showing a flexible, open and ethical attitude towards different opinions or situations.

3. On-line information

Part of the obtained material is used to update a web page (Figure 2) that provides a reference base of hands-on activities documented online, that can be used as a tool for learning physics. The web, managed and edited by the teachers, is free access and of accessible navigation. It is published in three languages (Galician, Spanish and English), and designed with W3C standards, both in HTML, XHTML and CSS2, so it can be easily viewed in any browser (Mozilla, Opera, Netscape, Explorer, Safari, etc.) and on any platform (PC, tablet or smartphone). Nearly 200 projects / experimental activities are currently displayed, including sufficient information in different formats easily downloadable in PDF format for later reference.

Figure 2. Homepage of clickonphysics.es

The speach used in the web entries is rigorous but also clear and easily understandable, since it is based on the information generated by the students during their semester work. The website is aimed primarily at students and teachers of first courses in scientific and technological careers, but also can be used in primary, secondary, or high school levels, and additionally to anyone interested in learning physics through doing physics.

The website is also used as support material for hands-on science training courses for novel and senior teachers, at university and pre-university levels [10]. The possibility of posting external user comments is also included, with 1300 contributions so far, many of them with embedded links related with themes of Biology, Chemistry and Geology. These posts are related with the physical concepts of the projects, and have been partly produced by teachers involved in hands-on science training programs (Figure 3) providing added value to the work of our students.

Specific project information may be accessed from the top featured links through dynamic banners on the home page, or alternatively using a search functionality by topic present in each project.

Figure 3. Hands-on activities in teacher´s courses

The webpage sections devoted to popularization, utility, catalogue and links present ideas that may be used either inside or outside the classroom, as well as examples of our published works, or other information sources from other universities, museums, research centres, networks, projects etc.

One of the main objectives of the contents of this page is to underline and emphasize the cultural and historical value of Physics (Figure 4). At the same time, it is intended to stimulate curiosity seeking to involve the general public in concepts, laws and principles of Physics. The final aim is to induce, if possible, the creation of new knowledge by self-examination through performing activities focused to address and resolve problems with a physical basis.

Figure 4. Several historical quotes in the web

The experimental activities are classified in the six main thematic blocks of Classical Physics (electromagnetism, fluids, mechanics, waves, optics and thermodynamics). They can be used in the classroom as a tool for self-learning or extracurricular activities. On this basis, new transversal disciplinary categories can be created, and as an example there are currently three additional ones, namely challenges, highlights and and unfinished projects. These categories include, respectively, activities that can are proposed to be solved in an individual contest among all students, twelve specifically selected activities or activities that must be completed.

Motivational talks are scheduled for students and teachers of pre-university learning institutions to advertise the website and promote hands-on science education [11-12]. These talks are designed to engage and motivate students towards a personal commitment to widen their scientific curriculum, using easily accessible materials in real hands-on demonstrations. In general terms, the talks are designed to provide a learning experience through fun and entertainment and, in some particular cases, they are also intended to promote discussion of concepts related to energy, magnetism, electricity or optics, aiming to combine informal and formal learning.

Figure 5. Talks at high-schools

The talks usually begin with a presentation that provides the context for learning, and a set of activities that help to visualize, understand and connect their knowledge. During the presentation, relations between this alternative approach and the student formal curriculum are established. Hands-on activities easily attract interest, facilitate learning, and are immediate and easy to replicate. These talks also aim to help teachers progress in their daily work, since they can introduce these new methods of interaction between the formal subject contents and the students.

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4. Summary and conclusions

The practical implementation of hands-on projects in the field of Physics of our Degrees of Engineering of the University of Vigo has been presented. The described and recognized creative and educational components are a cornerstone of this approach, providing the students new alternative opportunities to actively engage in the acquisition of skills. The results provided by anonymous surveys on the students have so far provided positive feedback. The information gathered in the reference website is complete and useful in various contexts, and meant to encourage further exploration of anyone interested in the results of cooperative and collaborative work between students and teachers, unique of its kind in our knowledge. The web shows at the same time our teaching work to our students (comprising past, present and future) and as an extension to the society in general. To our knowledge, this tool can be exported and adapted to many other subjects and degrees in various technology and science domains.

5. Acknowledgements

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Physics through All Senses: Popularization of Physics by Using an Interactive Show

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Abstract. The paper describes a long-term project called Physics through All Senses which is organized by the Department of Physics Education (Faculty of Mathematics and Physics in Prague). In the first part of the paper we describe the project in detail – it is a 90-minute-long performance aimed at secondary school students that consists of experiments inspired by human senses. This performance is not devised as a lecture with exact theoretical background, but as an interactive show engaging students into it. The second part of the paper is focused on examples of concrete experiments which we use during the performance.

Keywords. Interactive show, experiments, secondary school, informal teaching.

1. Introduction

Students of all ages are often keen on innovations and technical development and physics as a school subject offers ways how to understand them. It looks like an ideal state – unfortunately, it does not work. In the Czech Republic, physics belongs to the least favourite subjects for upper secondary school students aged between 15 and 19.

For this reason, every way which strives to improve students' perception of physics and to make it more attractive is welcomed. This authors' conviction was at the beginning of the project Physics through All Senses.

2. Creation and goals

Interactive show Physics through All Senses was created as a part of a more extensive PR project prepared by the Faculty of Mathematics and Physics (Charles University in Prague) in summer 2012. The general goal of the whole project was to bring physics closer to secondary school students, to present it as attractive and intelligible and to point out the possibility of studying physics on our faculty.

Since its beginning, the project has been under the control of doctoral students at our department, i.e. the Department of Physics Education. Actually, we also kept track of other goals than those mentioned above.

At first, our ambitious goal was to involve the students of bachelor's and master's study programmes at our department in the project. While these students are preparing for their career of future teachers, the participation in the performance could serve them as a training of some important skills – appropriate communication with students, explaining physics phenomena, performing experiments etc.

Further, we aimed at strengthening the relationships with the community of secondary school teachers and at exchanging experiences with them – it seems that some experiments we perform are perceived as inspiring for teachers (according to their oral feedback that we continuously receive).

3. The design of the performance and its development

The performance is primarily intended for secondary school students aged between 16 and 18 (occasionally we perform also for younger audience). It lasts about 90 minutes and it takes place in the school which invites us. Its design requires two performers to carry out each show.

All our equipment is transportable by train or by bus (which naturally excludes heavier apparatuses) and therefore we are able to present the show at any secondary school in the Czech Republic.

The show is composed mainly from demonstration experiments which often require participation of the audience.

The first scenario of the performance was prepared in June 2012 and contained about 25 physics experiments divided into groups according to human senses (thus giving the show its name); in addition, we have added a few "fictional" senses like the sixth sense or the sense of technology. In time, based on our experience, the set of experiments was continuously updated, so that these days their number is still about 25 but only half of them have “survived” since the first scenario.

4. Selected experiments

As mentioned above, in the choice of experiments we are limited by the fact that we need the equipment to be transportable by two persons without a car. On the other hand, it motivates us to include low-cost experiments as well which could be performed also later by teachers that have watched the show.

In this part, we shortly describe a few experiments which we consider to be the most attractive or most beneficial for students.

4.1. Micro-world

We use the digital USB microscope to distinguish between subtractive (RGB) and additive (CMYK) colour mixing. While we demonstrate the first on the example of pixels of liquid crystal displays (Figure 1), for illustration of CMYK colour model we study a coloured text printed by an inkjet printer.

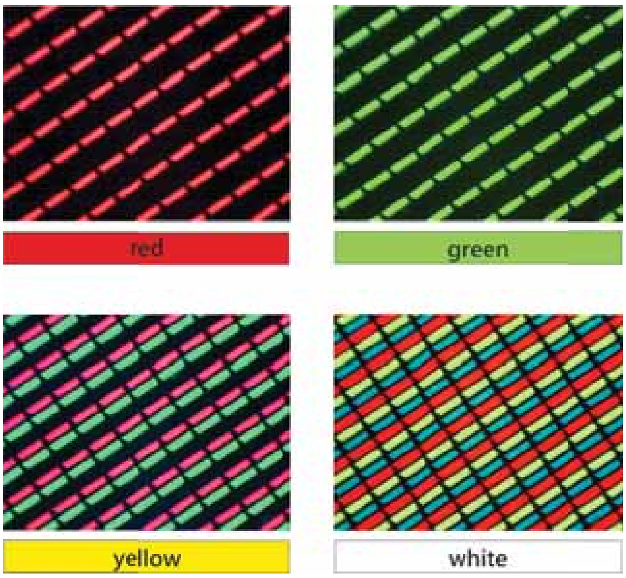

Figure 1. Pixels creating four different colour shades

4.2. Kitchen vacuum pump

As an introduction to the understanding of atmospheric pressure, we use a kitchen vacuum pump which enables in its body a decrease in pressure at ca. 30 % of the initial value. We place a glass of beer with foam head or a sweet with whipped cream inside the open container and then we start to vacuum the air. The foam or cream inside increase its volume (Figure 2) thanks to the expansion of the air enclosed in the air bubbles.

Figure 2. A student trying to open the container with lower pressure

4.3. Magdeburg suction cups

This exhibition is a reconstruction of a famous historical experiment known as “Magdeburg hemispheres”. In 1654, German physicist Otto von Guericke performed this experiment to confirm the existence of atmospheric pressure. In our version, instead of hemispheres we use suction cups designed to carry glass plates and students (in the role of horses) are supposed to split them off (Figure 3). The suction cups we use have a declared maximal load of 50 kg.

Figure 3. Students trying to split off the suction cups

4.4. Fakir’s bed

Brave students can stand on a fakir’s bed created of nearly one thousand of pins distributed on the A4-sized plate without their shoes.

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Although the experiment is safe for participants, sometimes instead of a volunteer we use an inflated balloon. Even if we press the balloon with a considerable force, it does not pop, only deforms into funny shapes (Figure 4).

Figure 4. The fakir's bed and a balloon lying on it

4.5. Tube music

In the field of music we offer a very unconventional musical instrument created of five plastic plumbing tubes with different precisely measured lengths. Hitting one end of the tube with a palm produces a tone given by a frequency of standing vibrations of air column in the tube. In our performance, students play three prepared Czech folk songs using these tubes (Figure 5).

4.6. Magic with induction heater

Although the induction heater is only a kitchen appliance, it has a wide use in demonstrations focused on electromagnetic induction.

In our performance, we show the contactless water heating in the pot above the plate of the heater or heating of a pot separated from the plate with a book. Using an aluminium foil we demonstrate that this foil refuses to remain on the plate of the operating heater (Lenz's law) and if it is forced to remain there, it starts to burn due to the occurrence of eddy currents.

Finally, we use the coil in the heater as a transformer, more precisely as a primary winding – the secondary winding is created with a coiled wire with a bulb which starts to shine near the heater.

Figure 5. Students playing plastic tubes

Figure 6. Burning an aluminium foil caused by eddy currents above the plate of heater

4.7. Do not try this with water!

In this experiment we use a transparent, electrically non-conductive liquid called NOVEC 1230 which is primarily used as professional extinguishing medium (chemically $C_6F_{12}O$). Its electrical non-conductivity predetermines this substance to be used in situations where water or other liquids could damage or even destroy extinguished objects – e.g. electronical devices, exhibits in galleries etc. In our performance, we sink a mobile phone into NOVEC (Figure 7) to demonstrate the existence of dielectric liquid (and our trust in physics…).

5. Feedback

We have not systematically collected feedback yet, but judging from the immediate reactions of both the students and the teachers, the show is perceived very positively. Obviously, there is a demand for similar events, teachers very often ask us for some recommendation or invite us for a few years consecutively. We consider this a great success that in some regions schools share their experience with our show, thus spreading the information about our activities.

Figure 7. Mobile phone sunk in NOVEC 1230

6. Conclusion

Since the beginning in autumn 2012 more than 6,000 students have seen the show. If you are interested in other experiments we present during the performance or want to know more about the project, please contact with us by e-mail vera.koudelkova@mff.cuni.cz.

Importance of Activities in Science Education

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Abstract. In 21st century scientific and technological advances shape education that many students receive. Students have to be familiar with science and technology to consider about the life phenomena and to make informed decisions about personal and social issues. Understanding of science is also very important in both school and the workplace.

Turkey made great onset, especially with the proclamation of the republic in 1923, which has a high percentage of young people among its population. Turkey has an established educational system and raise successful students who were accepted by well-known, prestigious universities in every academic year. However, educators in Turkey should take into account of the rankings in national and international exams. In science education; field trips, making experiments, using various applications, applying to project competitions and exhibitions, bringing computer to classes, watching animations and videos, preparing posters, making presentations and also making joint projects with other institutions are the indispensable activities that must be performed in all science courses. Importance of activities in science education should not be ignored.

Keywords. Science, education, technology, high school education, activity, science course activities.

1. Introduction

1.1. About Turkey

Turkey made great onset, especially with the proclamation of the republic in 1923, which has a high percentage of young people among its population. Turkey has an established educational system and raise successful students who were accepted by well-known, prestigious universities in every academic year. Whereas, elective courses in recent years under the name of religious lessons are preferred in high ratio due to the conservative structure of the public. The greater a country's young population, greater the advantage it has, especially if the government gives chance to young people to have education according to their interests and desires. Great leader Atatürk said, "The main reality of life is science" and expressed the importance of science once again. Whereas the elective course which are offered nowadays make a controversial issue with the statement of Atatürk in one of the most important factor that a country must support; education! Considering that the science is associated with the development level of a country, in Turkey we should take into account of the rankings in Pisa Test. Unfortunately, Turkey is not one of the top countries (Fig 1) [1-2].

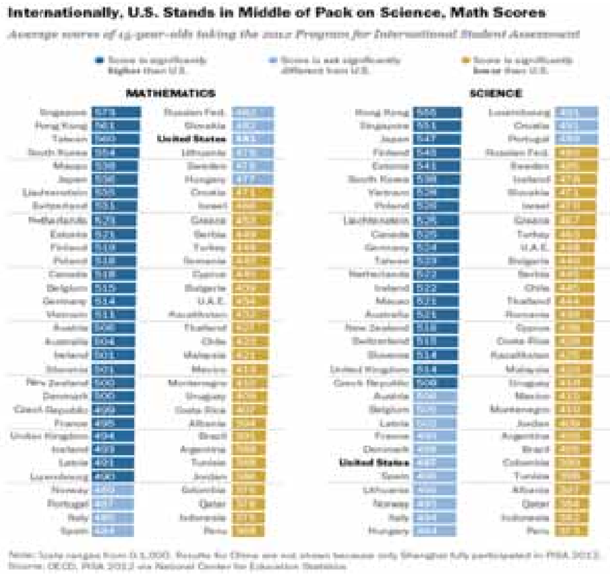

Figure 1. Scores of PISA Test

In science education, field trips, experiments and course activities should be performed in all science courses.

1.1.1. Education System in Turkey

Education in Turkey is governed by a national system, which was established in 1923 accordance with the Atatürk's Reforms. Compulsory education lasts 12 years (4+4+4 system is applied in whole country). Primary and secondary education is financed by the government and free of charge in public schools. Secondary or high school education is mandatory and required in order to progress to universities but it is optional to continue if the student does not apply to any university. In primary education, science courses are taught with activities and experiments and in high school science course is divided into three different courses (physics, chemistry and biology) with a variety of activities and experiments. In 9th and 10th grade classes, basic science subjects are being told, in 11th and 12th grade classes advanced science courses are given to students. Orientation according to the student's interest therefore takes place in 11th grade.

1.1.2. Stages of the Education System in Turkey

- Pre-School Education: Optional education up to 6 years of age.
- Primary Education: Compulsory and free basic education for eight years (5 years elementary + 3 years secondary), 6-14 years of age.
- Secondary Education: 4 years of High School, 15-17/18 years of age. Some schools might have an additional year of language study.
- Higher Education: 4 years of University, or 2 years at Higher Vocational Schools. Some schools have an additional year of language study. Master's study lasts 2 years; PhD lasts 3-5 years [3].

2. Various Activities in Science Education

Scientific aspects of hobbies, personal interests, technology and supporting experiments and activities involve a great impact on learning process of students. Using new materials, instruments or devices affect the personal development in a positive way. Due to these reasons, Ministry of Education in Turkey viewed all the lesson contents and added various activities that should be performed by students individually or cooperatively. Besides the given, specific activities teachers should have consider various different techniques and activities that they can apply in their lectures [4].

2.1. Technology Usage in Education

Developing technology and the presence of Internet both have provided access to all areas of life in a much easier way and makes a great ease in education and teaching fields.

Taking into account of the evolving technology, teachers can say that teaching techniques are now more pleasurable and more convenient when they take a course on the basis of science and also in interdisciplinary activities. Models, animations, mobile phone applications, videos, and 3D printers help us to create, imagine new activities that can be easily performed in class environment. By the way, new teaching techniques have emerged. Imagination of the students take an active role in learning process because sometimes they gain the role of their teachers and explain what they have learned to their peers in class. Students also understand in a quick way due to responding different learning opportunities and they even prepare presentations, models, and projects and present them in class.

This year one of 12th grade students in my chemistry class studied molecular geometry by using 3D printers and performed a great job. He designed how to represent bond, atoms and different angles in molecules and printed important, well-known molecules in a 3D way (Fig 2). Students in my class understand the molecular geometry by using these printed molecules. They easily see why molecules can have different angle values.

Figure 2. Study of molecular geometry using 3D printers

Another important science activity in my class is the interdisciplinary study of Computational Science and Chemistry courses which course contents were enriched by the students' performances. Students can make connections between different course contents in which basic information like the periodic table

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was studied. Although periodic table seems easy to understand, it is difficult to keep in mind all the information that it contains about elements. However, students altered the concept, created a new periodic table by learning to use different programs. The periodic table is obtained by utilising QR code application and turned into a fun game (Figure 3).

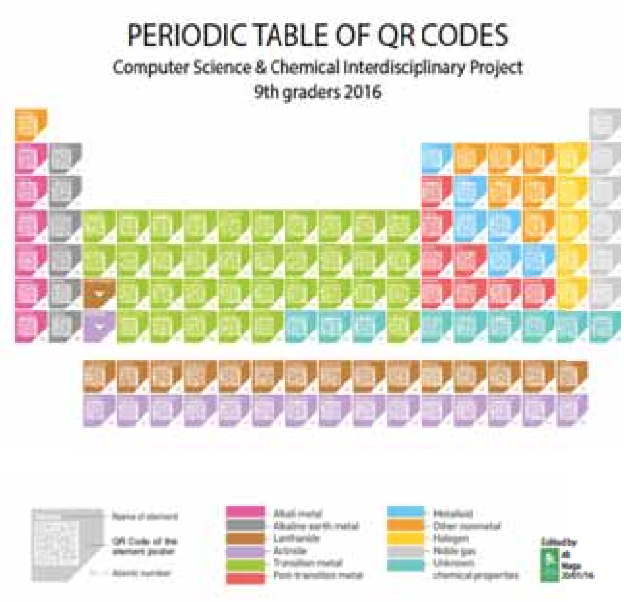

Figure 3. QR Code Application on Periodic Table

Students prepare posters about acids and bases and present them in class to their peers. Videos were prepared about daily life subjects like antacids, which they can relate to usage of acids and bases in daily life and uploaded to their' blog pages (Figure 4). These pages offer them a great chance to list all the activities in chronological order, usually with the ability for visitors to have idea about the student's educational work.

Another activity that can be done in class is related to cell phone application called 4D Elements. Students can easily download the cell phone applications and using the application lesson plan is taught in both enjoyable and effective way (Fig 5). With the application my students can recall the symbol of various elements and observe how the elements can combine with each other to make an ionic or a covalent bond. Moreover, they have the chance to see the structure and appearance of the obtained ionic or covalent compounds.

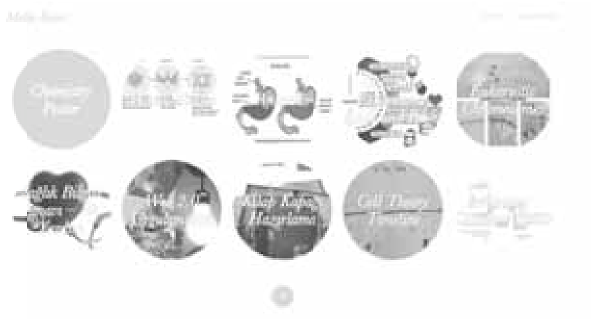

Figure 4. View of the Blog Page of a Student [5]

Figure 5. Application of 4D Elements Using Tablets or Cell-Phones

Experiments are performed to predict phenomena. Experimental research is important to society, it helps us to improve our everyday lives. Moreover, conducting experiments under laboratory under school conditions with students help to teachers to gain experience.

One of the main strengths of experimental research is that it can often determine a cause and effect relationship between two variables. By performing experiments, students can analyse the variables that should be studied during the experiment. Another strength of experimental research is the ability to assign participants to different conditions through random assignments.

Furthermore, experimental research can often answer the causality questions that are left unclear by correlational studies. Because experimental studies are relied on controlled, artificial environments and are implement to understand the real world situations [6].

Usage of probes and instruments (Fig 6), are easy to use by the students and provide high quality experiment environment. Many sensors can be used across several subject areas and maximize use of technology. Teachers need to use probes or instruments to evaluate curriculum materials for experiments of activities that students carry out. Effective science teachers evaluate the knowledge of their students based on how science concepts are organized and represented by them. Teachers prefer to use both qualitative and quantitative assessment techniques, which, should be applied, in primary, secondary schools and in universities. Scientific instrument make the learning process more attractive [7].

Figure 6. Various Probes and Instruments

2.2. Project Based Education System

Figure 7. Project Exhibitions of TÜBİTAK in Turkey

The desire of my 2 students to national and international competitions was spectacular. Paper recycling and wastewater treatment on cleaning the textile dyes were the subjects that my students actually work on. This showed how they are environmentally conscious, informed, and mature. They gave me the chance to look to the future with hope.

Exhibition of projects and the participation of students to these exhibitions have a great impact on students' evolution in science courses (Fig 7). I want to emphasize how important it is. As a teacher who also had worked as a project coordinator for 7 years, I observed that students develop presentation skills, learn how to search information and how to write a project report.

The perspective of the students about scientific work environment and atmosphere changed and exhibitions encouraged them towards new scientific studies. Especially schools adopting the project-based education approach are based on the student's self-development.

Figure 8. Trips to Different Factories

Field trips can reinforce what a teacher has been instructing in class about a subject and help students understand the topic better. Students can collect data, and then can analyse them. Trips give students the chance to build closer bonds with their classmates, experience new environments and enjoy a day away from the classroom. A trip to ice cream factory, trip to wastewater treatment facility or trip to power plants can give variety of information to students and motivate students through increased interest and curiosity (Fig 8). Field trips tend to be special and enjoyable learning experiences. As a result, student-student and student- teacher social interactions increases, curriculum enhances, and involvement in a real world experience makes learning more meaningful and memorable.

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2.3. Partnerships of Schools with Non-educational Institutions

Peruvian university UTEC and advertising agency, FCB Mayo, decided to create an air-purifying billboard. It drew the attention of the public interest (Fig 9). Agency firm continued to perform another project related to obtaining potable drinking water. Firm gained numerous accolades, including Adweek's Isaac Gravity Award and a gold Lion in Outdoor at Cannes. More students started to apply to the university but more importantly, people can get clean drinking water (Fig 10) [8].

Another important joint project is knows as "life paint". Volvo produces a spray due to traffic accidents caused by bicycle users. Product is manufactured specifically for bicycle users and gained great attention. Life paint shows up bright phosphorescent white under headlight beams, and Volvo is touting it as a way to help prevent cycling deaths and injuries (Fig 11) [9].

Figure 9. Campaign of FCB Mayo and UTEC-air-purifying billboard

3. Conclusion

Education in 21st century should be approached from many different angles. Science education should be supported by activities and the usage of technology in the content of science courses has an impact on sustaining students' development.

Field trips, making experiments, using various applications, applying to project competitions and exhibitions, bringing own computer to classes, watching animations and videos, preparing posters, making presentations and also making joint projects with institutions are the indispensable activities.

As a result, due to developing technology and access to Internet, educational systems must be reviewed. Turkey should also renew its education system by looking at the scores of Turkish students in international various tests and develop new point of view. In addition, Turkey should add activities into the curriculum of the science courses and students should learn by conducting and experiencing.

Figure 10. Campaign of FCB Mayo and UTEC-obtaining potable drinking water

Figure 11. Campaign of Volvo-life paint

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Activity Based Science Learning Through Video Programme: a Case Study

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Abstract. In current scenario science education in India is certainly not helping make science popular among the teachers and the taught especially from the level of primary to secondary. There may be number of reasons for this concern but two major causes are quite visible. One is overwhelming emphasis in our education on theoretical aspect, in preference over the practical ones involving solutions of real-life or day to day problems; and second very little or no efforts to relate or link the science taught (especially at school, colleges etc) with the science actually at work in things in real-life or around us. Science communication efforts are being useful to fulfill the gap areas which are created by formal way of science learning especially to link science with real life situations.

Keeping in view the gap areas and to promote activity based science learning at the level of upper primary to secondary, 52-episodes television serial “KHUDBUDH” (where “khud” means self and “budh” means intellect) were produced, telecast through national channel of the country continuously for the period of one year and shared at social media platform to cover large section of students and teachers.

As a part of science communications strategy in producing serial participatory model were followed where children of different schools were giving task to perform science activities. In each episode three to four activities and anchoring were performed by children, method of science was understood, curiosity was generated and excitements and fun moments were captured.

This paper looks at methodology involved in producing activity based science serial, dissemination strategies, its impact and response etc. We find that students through participatory approach were generally more favorably and had better understanding of method of science which is required to inculcate habits of linking science to real life situations.

Keywords. Activity based science learning, hands on experiments, Vigyan Prasar,informal education, science communication, low cost science experiments.

1. Introduction

In the India, a country with diversity, the need of science communication is strongly felt from last few decades. In current scenario science education is not progressing the way it should be. There may be number of reasons for this concern but two major causes are quite visible. One is overwhelming emphasis in our education on theoretical aspect, in preference over the practical ones involving solutions of real-life or day to day problems; and second very little or no efforts to relate or link the science taught (especially at school, colleges etc) with the science actually at work in things in real-life or around us.

This situation is arises because there is very few school across the country up to secondary level engages student for practical classes. The mandate of these schools is only to complete the syllabus well within the time. With this results students have only familiarize the terminology of the subject and find difficult to relate the concept with their surroundings. Resulting, students find difficult in their decision making later on.

Science communication efforts are being useful to fulfill the gap areas which are created by formal way of science learning especially to link science with real life situations.

The science communication is an important tool for the communicating science to all stakeholders in the society. Presently, engagement model of science communication is being widely used for making communication more effectively. Earlier, lots of work has been done by adopting deficit model of communication.

Keeping in view the gap areas and to promote activity based science learning at the level of upper primary to secondary, 52-episodes television serial “KHUDBUDH” (where “khud” means self and “budh” means intellect)

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were produced, telecast through national channel of the country continuously for the period of one year and shared at social media platform to cover large section of students and teachers [1,2]. This serial was produced by Vigyan Prasar (VP) - an autonomous organization under Department of Science and Technology [2,3]. Objectives of VP are to take up large-scale science popularization tasks/ activities, to promote and propagate scientific and rational outlook, to act as a resource-cum-facility centre for SandT communication.

The main objective of the producing of the serial were to promote activity based science communication, to familiarize the concept of method of science to students since their childhood, to develop a interesting, innovative, knowledgeable resource material.

Berk (2009) in his chapter multimedia teaching with video clips: TV, movies, YouTube, and mtvU in the college classroom, explained the various advantages of learning through the video clips that its useful for the attention of students, enhance the concentration, generate interests, develop creative sense of anticipation, imagination build up, increase memory, stimulate flow of ideas, foster deep learning, opportunity for freedom of expression, make learning fun, mood set up, decrease tension [4].

Hands on activity, is an interesting way to explain the scientific experiments in simple fun learning way. Video programmes on the hands on activity are beneficial for making its impact many times and among different audiences. The upload of the video programmes on the YouTube and social media help the viewer to watch the programme as per his/her suitable time.

Hussain and Akhtar (2013) published a paper [5] on impact of hands on activities on students' achievements as case study and conclude that the inclusion of hands-on activities showed a significant effect on students' science achievement.

These different approach and modes were used in making the serial. Here its idea of the bubbling curiosity!! The Show adopted a unique format, a travelogue that was shot in schools and communities all over the country. The Team travelled to different schools, in villages and towns and plays science with children. It encouraged the children to put on their thinking caps. In the whole shooting of the programme, the science was not confined to Text books or definitions, but a game of reasoning, rational thinking, experimentation and think-along.

Figure 1. Packaging of 52 episodes science serial "KHUDBUDH"

Each episode was thematic and present features shot with different schools. At each location 20 children participated in the creative endeavour. It was a fun experiment, a Science toy or an activity. The children had fun and as they enjoyed, they started think. They were encouraged to think along, Why? and How? and sure enough, they were able to figure out things for themselves. No definitions, calculations, formulae, names of Scientists or Principles but the Concepts of Science!

Khudbud was steered by a passionate team of Science Communicators at Beacon Television and partnered with experts from Vigyan Prasar, Homi Bhabha Centre for Science Education, Navnirmiti and IUCAA, Pune. It was an experiment in learning that celebrates Childhood and the strength of an education system that is based on Creativity.

The programme based on actual experiments performed with students of various schools from all over India. The tools and techniques used in the experiments were simple and easy to understand. The language for production is Hindi which is the most widely spoken language in India.

The children were doing experiments, the children were anchoring the show and hence shows become more and more interesting, curiosity generator among the children. This paper looks at methodology involved in producing activity based science serial, dissemination strategies, its impact and response etc.

2. Methodology

To familiarize activity based science learning and its related advantages to students, Vigyan Prasar took an initiative to produced a 52-episodes television serial “KHUDBUDH”. During the conceptualization of programme, it was decided that science serial should be produced by involving students, in other words participations model of science communication may tried. For doing these some task may be given to students with instructions. Students do perform the activity in team and try to understand the concept of science from them. On the other hand, their creativity, immediate reactions, time taken to understand the concept, finally their understating about method of science may be captured in video format. These exercises may be done in different schools located in different regions of the country with different sets of activities and telecasted through national channel so that others could repeat the activities for better understanding of science.

The script genesis with popular science angle, shooting and editing, rough cut of the programme, telecast of programme and receipt of feedback by viewers, youtube upload of programme and analysis of youtube analytics are the part of methodology of this research.

2.1. Script genesis, Model adopted and Format

After deciding the activities, pre -research was carried out, to make scripts more knowledge full and entertaining. The script genesis was the main part of the production of this programme because this required efforts of imagination and thinking. The content flow and blend of information with entertainment was major challenge to produce a serial. The experts from media, scientists, science writers were engaged to prepare a draft-line for each episode. Based on this draft-line scripts were prepared for each episodes. The science part and its simplicity in explanation were checked up by experts at various levels and rounds of discussion. The care was well taken about occurrence of monotony, bombardment of information, dullness by use of same visuals/information again and again in the video programme.

2.2. Strategy for selection of science activities and flow of content

All these topics/activities were chosen irrespective of syllabus of a particular class and were presented in innovative and interesting ways, that text book can’t. The topics in text book of a particular class need some understanding from previous classes but though this serial "*KHUDBUDH*" subject were introduced through the basics. The some examples from the episodes are highlighted here:-

In the episode related to light, activities on: i) a radiant energy that moves in a straight line and is ‘invisible’ in itself; ii) bending of Light-Refraction; iii) what does white light contain? colours of light; iv) color mixing – painting with light; v) laser- special type of light were chosen. These activities were supported with different tasks to understand the phenomenon. The task were, Why is it so difficult to drop the coin in the bowl? Why does it keep falling outside?

Children were encouraged to place a pencil in a glass of water and see how it bends. They were asked to connect this phenomenon to the dropping the coin in the bowl challenge. At the end with the anchored voice over on Refraction of Light, and phenomenon were explained.

Similarly, the core communication on Lungs included;

- Oxygen: The breath of Life
- The pathway of air
- What do we breathe out
- Our Amazing Lungs. Test your Lung Power.
- Surface Area of the lungs
- Lung Model
- Why is Smoking injurious to health. Pledge: No Smoke

To explain the above concepts through activities a scene was created as follows:

The four anchors are sitting and taking deep breaths. One person shows thumbs up, asking for readiness. The others nod to say yes. The first one gestures with hand to breathe in…all take in a deep breath. The first one then indicates Go with a swift movement of his hand. All four start humming. They are testing their lung capacity. As the breath starts running out their voices soften. One stops… breathless.

The 2nd one too, breathless… the third one and then the one who holds longest breath and stops. They marvel at her lung capacity and discuss how they were feeling when they played this game.

Go on to introduce the topic. Our breath…Our lungs…the amazing machine…the basis of our life and energy is what we will explore today. They promise a lot of fun, games and learning in the self way and start.

Children are all excited. We chat with them on breathing. Everybody is asked to sit still. Do nothing. No movement. No sound.

They are asked to now think about what all they are doing and have not been able to stop! Pause to think. Our question is what all are you doing even when you are not doing anything?

They will be encouraged to interact, Blood flowing, Heart pumping, Pulse moving and Breathing!!!

So what does that mean? There are things inside our body that just happen without our conscious control!

We will now play the game of holding breath with the children. Each one of them has to start at Go and honestly raise hand when they run out of breath. A general round of claps for the children who held longest breath.

Interaction on what they experienced. When they ran out of breath…they also could not emit a sound. So, what have you learnt? Think.

Next… the child who held the breath going for the longest time will be asked to come up again and this time repeat the exercise in front of the children. The children will be asked to observe his/her shoulders as she breaks for breath.

Then starts the Selection for Challenge Round Children were asked to come in front of camera and answer questions.

- *Why do we breathe?*
- *Where does the breath enter from?*
- *Where does the breath go?*
- *Can you think of a way of measuring the amount of air taken in with each breath?*
- *What would you need for that?*
- *Could you do that with a balloon?*

Children were encouraged to think! Not all children were asked the same question. They were selected on the basis of answers and participation?

Before entering the challenge each child was given a straw and thread and guided to make the straw and thread toy. This was a fun activity and was looked pretty on camera too.

Physics	**inertia, sound, gravity and levitation, balance, friction, circular motion, shadows, magnets, static electricity, surface tension, boiling and freezing, materials, float or sink, simple machines, pressure – density, motion – conservation of momentum, mirrors, light – reflection, refraction, laser, flight – up and down**
Ecology	**trees, leaves/photosynthesis, water cycle and conservation, soil, ponds, biodiversity, reduce-reuse-recycle**
Earth Sciences	**wind energy, heat energy, earthquakes/ tsunami**
Human Body	**blood and heart, skeletal system, lungs, eyes and sight**
Chemistry	**acids and bases, chemistry in day to day life**
Astronomy	**sun, our solar system- nano**
Material Property	**candles, rubber bands, postcards, balloon, matchbox, salt**
Conceptual	**chor police, triangles, survival (camouflage, etc), wind up special**

Table 1. Topics covered in episodes

2.3. Shooting and Editing

Shooting planning and shooting with all measures were adopted, voice over and anchoring, editing with inclusion of graphics and animations (if needed), subtitles are performed with justification and media knowledge. The shooting was executed in many schools including both government and non-government schools. Government schools were chosen more in numbers for shooting. Schools situated in rural areas were more in numbers in participation as compared to the urban schools. As per the designed scripts activities were given to the team of students and their performance were captured and answers were also drawn from them. The choice for the colours of dresses and background colours, timing of shoot like day time or night time, quality of camera were the important jobs to be performed by the producer and director of the video programme.

2.4. Editing

After shoot, voice over, anchoring the video programmeme is on editing table. The inclusion of graphics and finishing touch were given to the programme. The draft of each episode was shown to the experts before finalization, to verify the content and its flow, accuracy, quality and visuals.

Subject	Nº of episodes
Physics	20
Ecology	7
Earth Sciences	3
Chemistry	4
Astronomy	2
Material Property	12
Conceptual	4

Table 2. Subject wise distribution

2.5 Telecast of the video programme

After the production, 52 serial science serial was telecasted weekly through countries national channel "Doordarshan-National" during for the period of one year.

A wide publicity was also done through advertisement in science magazines, television, social media and through website.

Even after knowing that the television rating points (TRP) is not the scientific way of evaluating the programme, it was noted down. The impact also analyzed through letters, feedbacks by emails, phone calls and request of re-telecast of the serial. On the basis of the viewer demand the same was uploaded on You Tube platform.

Figure 2. Still image from the programme

2.6. Sharing resource material on YouTube platform

After completing the telecasting through television episodes of serial were uploaded at Vigyan Prasar's YouTube.M/S Beacon Television- an agency engaged for this work also uploaded on its YouTube page and same was shared with Vigyan Prasar. Further impact of the serial was analysed on the basis of response from viewers from India and abroad.

3. Results and Analysis

The responses from the viewers were received through dedicated email Id, letters, detailed analysis of YouTube, phone, sms etc.

Total 1500+ emails, 560 letters and more than 2000 phones calls were received either for given the answers asked at the end of the programme or for giving the appreciation to Vigyan Prasar for this innovative efforts and many of them requested for the repeat telecast.

This indicates the viewers liked serial very much. Based on their it was full of knowledge and entertainment. Many children wrote that lots of concepts were easily understood while playing. They specifically mentioned that science is very interesting.

The average television rating points (TRP) of this programme were obtained between 3 to 3.5 in general. It is estimated that approximate 35 lakhs of people watch each episode of the serial. The YouTube analytic report also serve as an indication of the impact of the programme nationwide and internationally.

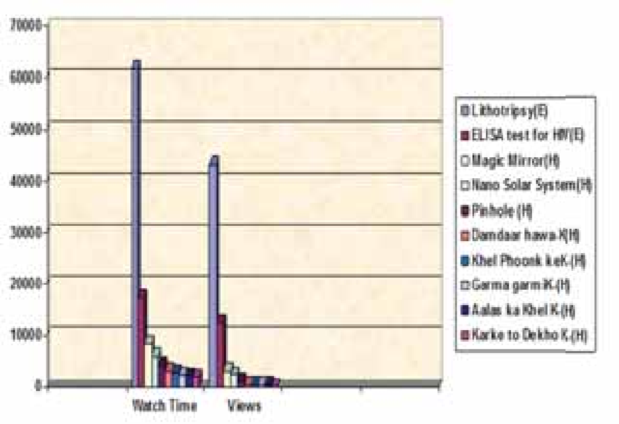


Figure 3. Graph showing total watch time (in minutes) and views on You Tube for top 10 episodes between 3rd February 2012 to 1st march 2016

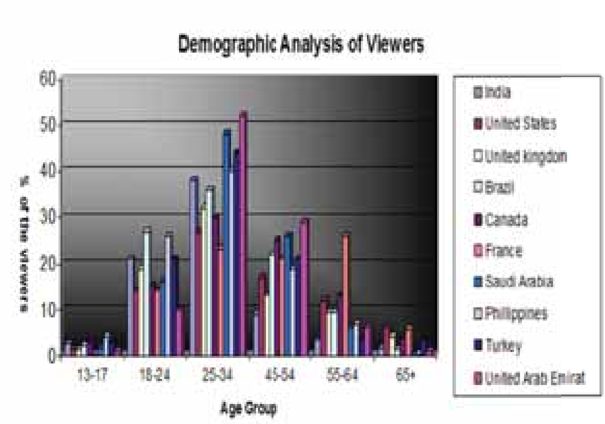


Figure 4. Graph showing Demographic of viewers and % of viewers watched the programme during 3rd February 2012 to 1st march 2016

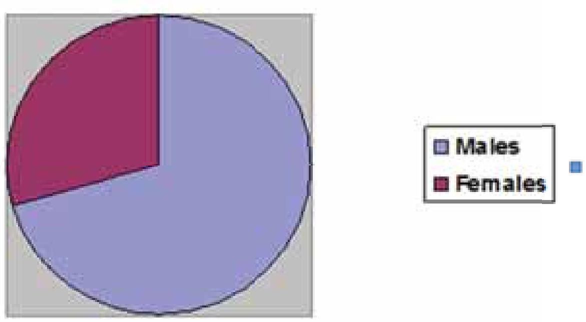
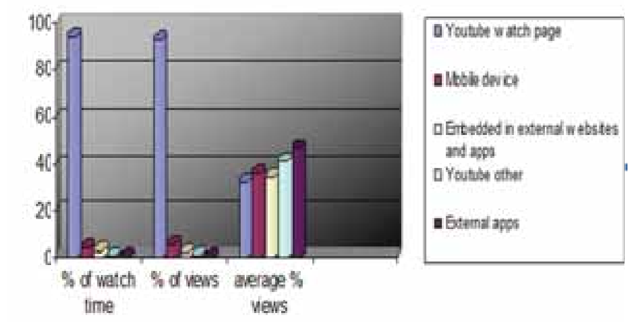


Figure 5. Graph showing Demographic of 70.6% males and 29.4% of females watched the programme during 3rd February 2012 to 1st march 2016



a	b	c	d	e
YouTube Wach page	124826	65236	1:54	32%
Mobile devices	5187	3594	1:26	36%
Embedded in external websites and apps	3298	1249	2:38	34%
Youtube other	168	115	1:27	41%
External apps	6	3	2:05	47%

Table 3. Showing different playback locations and watch time, views details (Ref:- www.youtube.com): a) playback locations; b) watch time in minutes; c) views; d) average views duration; e) average % viewed

4. Discussion

In the research paper published by the Welbourne and Grant (2015), content analysis of 390 videos from 39 youtube channels was conducted [6]. He found that the professionally generated content number wise superior but the user generated content was significantly more popular. If we takes the You Tube platform as a base, the present study describes that the programme was watched 136099 minutes by 74471 viewers. Episodes are available in Hindi and English. The viewer ship is post telecast indicating the search for good science programmes is prevalent in the society. Especially in the country like India where scientific content covered by media is very less (less than 3-4 %). Average 109 likes and 13 dislike shows the programme is well appreciated among viewers especially 18-34 years age group. The results shows that the maximum watch time i.e 124826 minutes is through YouTube search page with maximum views of 65236 which accounts for the 94% of total watch time and 93% of total views respectively. Mobile devices still not so popular for youtube watch for science video programmes as only 5187 minutes(3.9%) watch time and 3594(5.1%) views is observed in the episodes of KHUDBHUD. In comparison with the English programme the Hindi programme is less watched due to searching difficulties. While considering the demographic analysis the Figure 4 suggests that the 26752 views from India,14994 from United States of America then United Kingdome, Brazil, Canada, France, Saudi Arabia, Philippines, Turkey and UAE. This results shows that programme was seen internationally though You Tube platform and average 35 lakhs people per episode watched from India through television.

The magic mirror, nano solar system, pinhole, khudbudh-damdar hawa, khudbudh-khel funk ke, khudbudh-garma garmi, khudbudh-alas kaa khel are some most popular among the uploaded videos on YouTube page. The Khudbudh video programme is becoming popular among the students and teachers as a e-learning tool.

Approach for engaging student for the activities/experiments was well appreciated by viewers because it connected, not only the students who participated but also the students who were viewing the programme.

Serial gave an opportunity to introduce the concept of method of science since beginning. By practicing method of science in all sphere of life scientific attitude may be developed. In this way serial was useful in attempt to inculcate scientific temper in common mass.

This resources material may be utilized as a scientific teaching aids. The schools where there is no laboratory and have very limited resources in terms of faculty and other, this material may be utilized to enrich the resources at local level.

The study undertaken by Roberts (2009) suggests that the e-learning communities need more centralized coordination and governance [7]. Bell and Park (2008) in their chapter the Digital Images and Video for Teaching Science [8] mentioned that the digital images and video has advantage that there is no need of a huge equipment budget. A roomful of computers may be enough for video production. Even with a single computer connected to a projector or television screen and an internet connection the access to variety of resources may be undertaken to help students to learn science concepts.

A Report commissioned by Cisco Systems Inc. to Wainhouse Research, LLC, and authored by Greenberg and Zanetis (2012) suggested that the impact of video may be summarized into 3 main key concepts like interactivity with content, engagement, knowledge transfer and memory [9].

52 episode based activity oriented serial will be a precious knowledge resource. This will be utilized by students from generation to generation and has a potential to be an effective, engaging, and essential tool in every classroom.

5. Conclusion

Video based science communication may be utilized successfully to promote activity based learning. Difficult concepts or process of science may be understood easily by seeing the animations, images etc. If the student find science interesting and attached emotionally with the subject then it can be said that subject now became as a hobby for them. So activity based science learning are useful for: i) hands on; ii) minds on; iii) emotions on for the students besides enhancing curiosity, creativity, imagination and others. This Hands-on approach support the participatory model of communication through engagement.

Such efforts free the boundaries of countries for knowledge dissemination and tied all citizens globally for scientific thinking and awareness on global pandemics like Aquired Immuno Deficiency Syndrome, Tuberculosis and so on.

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Introduction to Scientific Research in Constructed Wetlands' Microcosms

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Abstract. Waterways that run through Caldas da Rainha city, flow into Óbidos lagoon, the greatest lagunar system of the portuguese coast. Nowadays, the local watercourses' poor water quality, contribute to eutrophication of this important wetland. This work, part of a multidisciplinary project submitted to Ilídio Pinho Foundation was performed by students from 2nd and 3rd cycle basic school - EBI Santo Onofre. Students were faced with a real problem in their area, and challenged to search solutions, through experimental research in Constructed Wetlands' microcosms, in order to be aware of the need to "Protect Rivers, Preserve the Lagoon, Promote the Future".

Keywords. Constructed Wetlands (CW), microcosms, (waste) water treatment, *Óbidos* Lagoon, *Cal* river.

1. Introduction

Óbidos Lagoon is located on the western coast of Portugal, between the promontory of Nazaré and the Peniche peninsula, next to Foz do Arelho (Figure 1). Administratively it belongs to the municipalities of Caldas da Rainha (North) and Óbidos (South).

Located perpendicularly to shore, the lagoon is predominantly elongated and oriented NW-SE [1,2,3]. The inlet channel is situated at the central third of the sandy barrier and is poorly developed reflecting its recent artificial opening [1]. This lagoon system fits the wetland definition of the Ramsar Convention. In 1985, this ecosystem was classified as Corine Biotope (C21100067) in an area of 2600 ha and, in the years 1990, was included in a preliminary proposal to the National List of sites under the Habitats Directive, integrating the site Peniche/Óbidos [3,4]. However, despite the recognition of this wetland's importance, the Óbidos lagunar system does not have a protective status yet [3,4,5].

Waterways that run through Caldas da Rainha city, Arnóia, Real and Cal rivers, flow into the Óbidos lagoon [1,2,6]. Nowadays the poor water quality of the local watercourses, contribute to the eutrophication process of this important wetland - proliferation of large quantities of algae, accumulation of organic matter and consequent high oxygen depletion [3,4,5,6].

Figure 1. Óbidos lagoon localization [1]

In this context of notorious lack of investment in the improvement of streams that converge to the lagoon, the main purpose of the Ilídio Pinho project – "*Protect Rivers, Preserve the Lagoon, Promote the Future*" - was to raise awareness among the local community, above all, students and their parents, about the major environmental problem of the region, that will surely affect future generations: progressive deterioration of freshwater ecosystems and its sustainability.

The hypothesis considered to improve the environmental quality of those areas, included experimental research in microcosms [7] of Constructed Wetlands (CW).

Water treatment systems based in plant beds began to be used as a way to treat the wastewater of small communities [8,9]. In these CW kwon in Portugal as “FitoETARs” [9], plants do not play the main role in the organic load removal, but are very important to the structure of the system, because the rhizosphere supports the microorganisms’ community, main actors of the water treatment system [9, 10]. However a full scale “FitoETAR” design, should be preceded by laboratorial tests for selection of suitable plants and substrate, for treatment of water with specific characteristics.

So, one of the main objectives of this work was the construction of microcosms (pilotes, models) to allow the evaluation of different plants (and eventually different rhizospheric biocenoses) in Cal river’ water treatment. This river was selected because of it’s proximity from EBI Santo Onofre.

Figure 2. Sampling point at Cal River (nearby Bricomarché)

The activities carried out by the students are described on a facebook page [11] and some of them are here described and analysed.

2. Sampling of the Cal River’ water

Some field trips to the Cal River were realized to survey their pollution level and selected a section as sampling point. The selected portion (Figure 2) is located near Caldas da Rainha Bricomarché, coordinates: 39° 24 ' 16.1 "N 9° 09 ' 04.4" W.

The choice of this sampling point considered its proximity to the school and the safe access due to its low water flow. Furthermore, it appears that although the water presents an acceptable transparency, smells like sewage and sulphur, an odor probably due to the thermae activity of the city.

3. Experimental plants

The plants used for the construction of “FitoETAR” prototypes, were collected in Tornada marsh. “Paul de Tornada” is a wetland area and is one of the few marsh areas of this western region [5,6]. It’s classified as a Wetland of International Importance under the Ramsar Convention and under Portuguese legislation, Paul de Tornada is a Local Nature Reserve, since 2009 [12]. The three plants selected for microcosms assays were: *Phragmites australis* (reeds), *Juncus maritimus* (rushes) and *Iris pseudacorus* (lilies-of-marshes).

4. Preparation of Microcosms

Figure 3. Preparation of microcosms

The microcosms were prepared in reutilized plastic carboys of 5 liters, according to [10]. The students removed the bottom (base) of 12 carboys and placed a few layers of cheesecloth inside the bottlenecks, openings, with covers in (Figure 3). They add 750 g of Leca (expanded clay), 250 g of gravel (inert materials) to each carboy, and placed one plant of each species in triplicates (Figure 4). Three of the carboys were maintained without plants, as controls.

Each 12 microcosms, received 2 liters of water from the Cal River, at beginning of the experimental period (5 April 2016). The microcosms were placed inside plastic brackets, and all of them remained under similar conditions of temperature and ambient brightness during the five weeks trial period (5 April to 3 May, 2016).

Figure 4. Triplicates and control of *Iris pseudacorus* microcosms

5. Water analysis collected from micro-cosms

Weekly, the students collected water samples from the triplicates of the four microcosms conditions. With 5 ml of water from each of the replicas they made a 15 ml composite sample, for each independent variable (Fig 5). The water collected was used for determination of different parameters: nitrite (NO_3^-), nitrates (NO_4^-), chlorine (Cl_2), carbonate hardness (KH), total hardness (GH) and pH. These analyses were performed with Tropical Aqua Care – 6 in 1 test, a kit for freshwater analysis (Figure 6).

Dipping a test strip in the water samples, the students determined and recorded (Table 1) with the aid of a colour scale supplied with the kit, an estimated content of the six chemical parameters referred above.

	Pa	*Jm*	*Ip*	*Ctl*
NO_3^- (mg/L)	0,5	0	0	2
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
NO_4^- (mg/L)	0	0	0	0
	0	0	10	10
	0	10	10	10
	0	0	0	0
	0	0	0	0
Cl_2 (mg/L)	0,8	0,8	0,8	0,8
	0	0	0	0
	0	0	0,8	0,8
	0	0	0	0
	0,8	0	0,8	0,8
KH	20	20	20	20
	20	20	20	20
	20	20	20	20
	20	20	20	20
	20	20	20	20
GH	8	8	8	16
	16	8	16	16
	8	8	16	16
	8	16	16	16
	16	8	8	16
pH	8	7,6	7,6	7,6
	7,2	8	8	7,2
	7,6	8	8	7,6
	8	7,6	8	8
	8,4	8	8,4	7,6

Note: Nitrite (NO_3^-), nitrates (NO_4^-), chlorine (Cl_2), mg/L; carbonate hardness (KH), total hardness (GH) and pH. Microcosm assays: *Phragmites australis* (*Pa*), *Juncus maritimus* (*Jm*) *Iris pseudacorus* (*Ip*) and control (Ctl). Values refer sequentially to the analysis days: 5, 12, 19, 26 April and 3 May 2016.

Table 1. Six chemical parameters' average content on water samples of microcosm assays

Despite the lack of precision of those analysis, students learned to record and compare the data collected. Subjectivity of these qualitative data (a colour range) when numerically translated, facilitates its comparison. So we can say, for example, that in these tests the water carbonate hardness was not affected by the plants (or the substrate), and pH values fluctuated in all assays, but only between 7,2 -8,4.

Figure 5. Collect water samples from microcosms

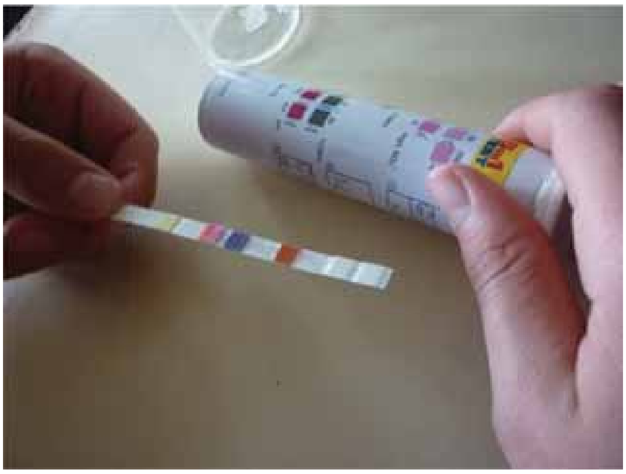

Figure 6. Test kit for water analysis - Tropical Aqua Care – 6 in 1

5.1. Optical microscopy analysis

Some drops of water were also collected directly from the microcosms with Pasteur' pipettes for observation on optical microscope (bright field). The temporary preparations were made with one or two drops of water sample between glass slides (75x25x1mm) and cover slip (24x24mm). These wet microscopic preparations were immediately analysed (Figure 7), and the living creatures observed were record and photographed and filmed with cellular' cameras.

The observed organisms were identified using some guides with images [10,13] and teachers aid, and students were able to distinguish between flagellates, ameboid protozoa and ciliates (Figure 8) and metazoa like rotifers (Figure 9), nematodes (Figure 10) and crustaceans (Figure 11).

Figure 7. Observation of microscopic preparations

Figure 8. Protozoan ciliate (*Paramecium*) in bright field (100x)

These are only some examples of the many photographs and videos that students took during the Science Club activities (Ciência +).

6. Field trip to Óbidos lagoon

In previous visits to Óbidos lagoon the presence of several non-hazardous wastes were observed on the bathing area. Therefore students and their parents were invited to participate on a civic activity to clean the lagoon margins, with the partnership of the Pato Association and local authorities. This hands-on activity triggered the need of behavioural changes with regard to environmental issues. This may stimulate an interventional attitude in young people, so that in the future they will be able to find and developed practical solutions that can be applied and may contribute to aquatic ecosystems sustainability.

Figure 9. Rotifera in bright field (100x)

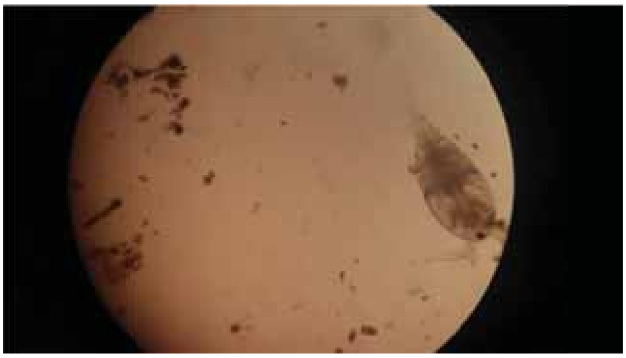

Figure 10. One copepod (Crustacea) in bright field (100x)

Figure 11. Nematoda in bright field (100x)

7. Conclusion

Cognitive skills developed by students in these experimental activities expressed themselves by the enthusiasm with which were weekly performed water analysis.

Students found out that from very simple and common reused materials (water carboys) it is possible to mimic what happens in a real situation, that is, on a wetland. During the weeks of laboratory activities, students showed quite enthusiasm, especially with microscopic observation of organisms like protozoans and metazoans. Starting to dominate an adequate use of optical microscope, they were able to be quiet, showing patience to chase, the rapid moving organisms. Besides the success in keeping them, "seated", the students were be able to [14]:

- perceive what is a controlled trial;
- predict factors that can affect, in these particular case, the value of the variable to be measured;
- distinguish observations, collection of data and its interpretation, in order to draw conclusions;
- confront results with predictions made and realize the limits of validity of the conclusion of each of the tests.

For the teaching staff, the possibility of practical activities without financial resources is a challenge to the imagination either teachers or students. Furthermore, carrying out not common activities, distract more problematic students from inappropriate practices inside classroom. The use of mobile phone to take pictures from microscopy analysis is not only an excellent exercise to concentration and dexterity, as a way to integrate (a difficult instrument to prohibit) for learning objectives and soft skills.

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Computer Hard Disk Drive Transforms into the Bone Conduction Speakers

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Abstract. We have been proposing ways to reuse some computer hard disk drives (HDD) which are no longer used, in science educational materials such as speakers and induction motors. This time we devised a way to make bone conduction speakers reusing scrap HDD. We can imagine the excitement and surprise students experience right at the moment when they hold on bone conduction speaker made of scrap parts and can hear music. We will introduce how to make and use one. Although it is possible to build on simple speaker using only a coil and a magnet, in order to make the bone conduction speaker, we modified the structure so that either an ice cream spoon or a platter is inserted between the magnet and the holder.

Keywords. Bone conduction speaker, hard disk drives, reusing scrap HDD.

1. Introduction

We have been proposing ways to reuse some computer hard disk drives (HDD) which are no longer used, in science educational materials such as speakers and induction motors [1-2].

This time we devised a way to make bone conduction speakers reusing scrap HDD. We can imagine the excitement and surprise students experience right at the moment when they hold on bone conduction speaker made of scrap parts and can hear music.

2. Manufacturing method of bone conduction speakers

Below we will introduce how to make and use one. Since most HDD components have been fixed with Torx screws, we needed two kinds of Torx driver [1]. Figure 1 shows the top cover removed from a HDD. Figure 2 shows the parts which were removed from a 2.5 inch HDD. In this bone conduction speaker, neodymium magnet, the magnet holder, actuator coil, and the platter were used. The arm coil terminals and the cables of an earphone jack were soldered together as shown in figure 3 [1].

Figure 1. Removed cover from 2.5 inch hard disk drive

Figure 2. Removed parts from HDD

As the magnetic polarity is magnetized so that N and S may bisect one side, as shown in figure 4, it is necessary that the coil is set on either N or S pole. Although it is possible to build on simple speaker using only a coil and a magnet [1], in order to make the bone conduction speaker, we modified the structure so that either an ice cream spoon or a platter is inserted between the magnet and the holder.

The bone conduction speaker we created is shown in Figure 5. Because of the magnetic suction power between the magnet and the holder, neither the platter nor the coil comes off easily. It is also easy to make the vibrations of the platter or the spoon larger by inserting an elastic item such as a rubber band between them.

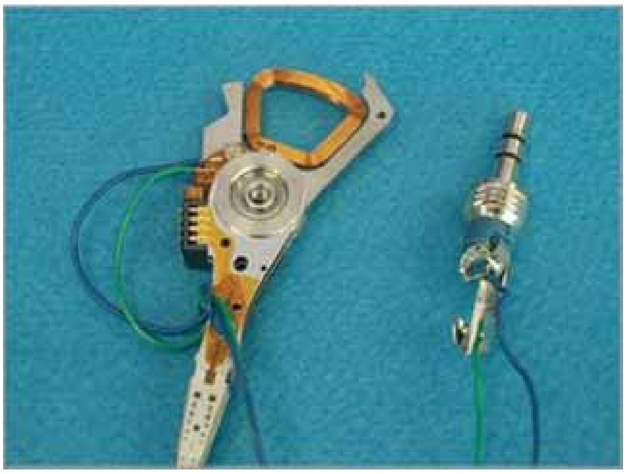

Figure 3. The coil terminals and the cables of an earphone jack are soldered together

Figure 4. The poles of the magnet (North/left-South/right) bisect one side

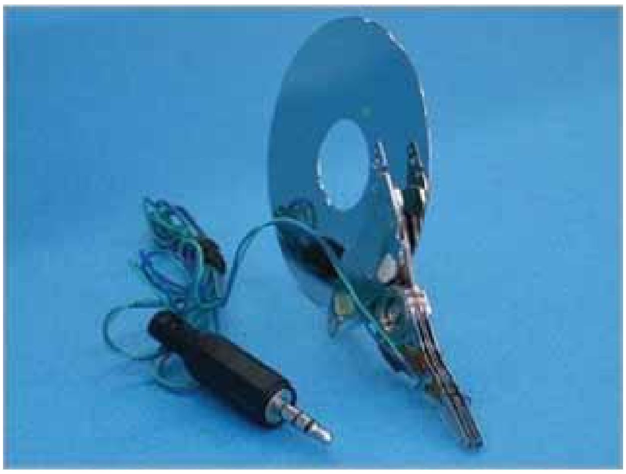

Figure 5. An example of the bone conduction speaker

3. How to use bone conduction speakers

When student holds the platter or the spoon between their teeth, the vibrations directly reach the auditory ossicles of the person without vibrating the air and the tympanic membrane. Therefore, if the person covers his/her ears with both hands, he or she can still recognize the music coming from a iPod. Figure 6 shows a child listening to the music while holding the spoon part of the bone conduction speakers in the mouth while covering both ears. It is noted, however, if multiple students try the experiment, either the same number of spoons should be prepared or the part of the spoon to be held between the teeth should be covered with a piece of plastic wrap each time for hygiene reasons.

Figure 6. A student is listening the music through the bone conduction speaker

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A Study of Student's Modelling-based Inquiry Ability with Fuzzy Synthesis Evaluation and Analytic Index Assessment

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Abstract. This study is to investigate the assessment of Analytic index and computer evaluation of Fuzzy synthesis assessment on the scientific modelling ability assessment. The participants of this research were made up of fifty-nine (the 5th graders) students. This study adopted the qualitative method to compare the characteristics of modelling learning assessment. The two classes were taught the same teaching units, including Thermal Expansion (TE), Atmospheric Pressure (AP), Light Reflection (LR) and Electrostatic Force (EF). Overall, for the two kinds of assessment of modelling ability assessment among the 5th graders, the two raters think that the sub-items are either too fine or difficult to evaluate. The Analytic Index assessment mode, teachers must reach a certain level, then, can only give an integer point. The Fuzzy Synthesis evaluation of the permissible value given between integers, however, teachers must pay attention to the whole performance, appropriate adjustments gain / fader, easy to score by the computer calculation.

Keywords. Analytic index, assessment, Fuzzy modelling-based learning, synthesis evaluation, modelling ability.

1. Introduction

Models and modelling have gradually been recognized as an important approach to Science learning and play important roles in science teaching and learning. But, the scientific modelling ability is too complicated. Therefore, in the general view, inquiry learning modelling abilities is not easily assessed through paper and pencil tests. The assessment and evaluation, as applied to education, play crucial roles in the teaching and learning process, which gives the information not only about the learning effect but also about the ability to learn.

As for performance evaluation with a fuzzy logic reasoning approach, a research result regarding the comparison between fuzzy and traditional average technique shows the advantage of weightage allocation in fuzzy approach [1]. The evaluation results may indicate the level of student ability so that the teacher could take some preventative measures. Therefore, this study is to investigate the assessment of Analytic index and computer evaluation of Fuzzy synthesis assessment on scientific modelling ability assessment.

2. Overview the Modelling and Fuzzy

Scientific model, the key to understand the natural world, is an application between theories and concepts.

2.1. Modelling

Over the past decades, models and modelling have gradually been recognized as an important approach to science learning objectives [2]. The research points out that one of the critical approaches is the scientific modelling, which achieves the goal of science learning. The report indicates that models have many forms [3], including physical objects, plans, mental constructions, mathematical equations and computer simulations. Based on previous assumptions, the researchers concluded three kinds of models, including object model, conception model and mathematical model [3]. Modelling is a kind of inquiry, and modelling learning can enable students to share their models and perspectives. Nowadays science education frequently focuses on scientific inquiry. Teachers commonly use models to explain ideas to students.

However, the scientific modelling is complicated abilities and not easy for researchers to adopt a quiz to assess. Therefore, this research has to develop some tools, including a learning sheet, and a modelling ability analytic index. An open design of the learning sheet is used as a guide, and the teacher can observe students' modelling process. The learning sheet is often used to assess student's modelling ability. Junior high school students can explore science knowledge and cultivate their thinking ability if we adopt the course which is based on Model-based

Inquiry. Nevertheless, for elementary school students, this method has to be developed and verified. The evaluation is not easy to evaluate so Analytic index based on the 5-point Likert Scale is separated into five levels.

2.2. Fuzzy Evaluation

Fuzzy set theory is treated of fuzziness in data, which was proposed in 1965 [4]. We make decisions in fuzzy environments by using fuzzy variables. In order to simulate human decision making in computer environments, fuzzy variables should be represented in computers. Therefore, fuzzy set theory can play a significant role in our student evaluation process.

There are 5 aspects in modelling ability [5-6]. Each aspect can be extended sub items with the gain/fader which can set up their values. Teachers can judge students' modelling ability according to their behaviours in processes of modelling just by adjusting the gain/fader.

3. Research Tools

This research focuses on developing some tools in order to conduct the synthesis of modelling ability evaluation.

3.1. Research Design

The participants of this research were made up of fifty-nine (the 5th graders) students. This study compared the characteristics of modelling learning assessment and adopted the qualitative method to analyse. The two classes had been taught the same teaching units, including Thermal Expansion (TE), Atmospheric Pressure (AP), Light Reflection (LR) and Electrostatic Force (EF). Both two classes were taught by the same teacher, who has been teaching science in the elementary school for more than 30 years. The teacher, who is professional in science teaching, has a doctorate in science education and has published some papers about modelling. Before the experiment, he communicated with the researcher well.

3.2. Analytic index

In order to assess elementary school students' modeling abilities, we must consider the students' abilities. The levels of the Analytic Index have to be concised. So, reference scholars defined the Modeling Ability Analytic Index [7-8], and classified each modeling process into five levels, as shown in Table 1:

- Level 0：No response.
- Level 1：Replying an intuitive experience.
- Level 2：Replying within self-experience more than scientific knowledge.
- Level 3：Replying within self-experience less than scientific knowledge.
- Level 4：scientific model

The evaluation is easily conducted so the Analytic index was classified into five levels, which is shown in the table 1.

Level	Definition	Modeling process 1.Model selection	 2.Model construction
Level 0	No response.	Don't know Can't do Can't find	Don't know Can't do Can't find
Level 1	**Replying an intuitive experience.**	**The cover will move.**	**Gas will be washed out and the cover will move.**
Level 2	Replying within self-experience more than scientific knowledge.	Temperature Hands temperature	Cold and hot Temperature
Level 3	**Replying within self-experience less than scientific knowledge.**	**Hands temperature Causing move.**	**Thermal Expansion and Contraction**
Level 4	scientific model	Hot causing Expansion and Cold causing Contraction	Thermal Expansion and Contraction, causing the substance to expand

Table 1. Modeling Abilities Analytic Index - Thermal Expansion

3.3. Fuzzy Evaluation

In the past, other researchers did evaluation with ambiguous terms or signs based on fuzzy theories. But in this research, we assess abilities with gain/fader, and the evaluation will be fitter for the characteristics of fuzzy theories. This study was to compare Fuzzy Evaluation with Analytic index, not by Percentile rank and 5 points is the highest score. Based on the "hierarchy of the modelling ability item", this research used software to implement the

"Modelling Fuzzy Synthetic Evaluation System", as shown in Figure 1.

There are 5 aspects in modelling ability. In each aspect, there are 3 to 4 sub items with the gain/fader which can set up their values. Teachers can easily judge students' modelling abilities according to students' behaviours in modelling processes just by adjusting the gain/fader. On the fader buttons, each code indicates the different levels from A to E. The A = "Excellent", B = "Good", C = "Average", D = "Lower" and E = "Bad". Each level has a corresponding value, and the membership function is decided by experts.

Figure 1. Modeling ability gain/fader evaluation

3.4. Modelling ability

In science education, teachers should help students realize the importance of every question, and appreciate the needs for such a comprehensive process in successful problem solving. Models and modelling already play important roles in teaching and, teachers commonly use models to explain ideas to students. The modelling ability includes 5 aspects [5-6].

According to relevant literature surveyed and revised [5-6], the main ability of modelling includes: "Model Selection", "Model Construction", "Model Validation", "Model Analysis", and "Model Deployment". Then, it chooses each assessment of ability sub items, for example, in "model selection" aspect includes: "system consist of", "what type of", "what reference", and "appropriate for", it totally have 4 sub items. That is shown in the following Figure. 2.

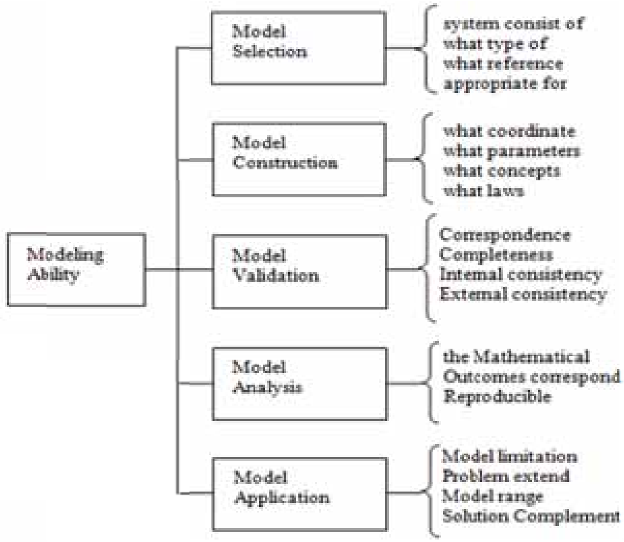

Figure 2. Modelling ability 5 aspects and subitems (modifier from Halloun, 1996, 2004)

1) Selection: Solving textbook problems often involves basic models and/or emergent models which are combinations of specific basic models.

2) Construction: In this stage, students are guided to construct a mathematical model that helps them solve the problem.

3) Validation: Validation includes different forms of assessment that provide students with opportunities to fulfill a major objective of science education: critical thinking.

4) Analysis: Model analysis in solving textbook problems consists primarily of processing the mathematical model, getting answers to the questions asked in the problems, and interpreting and justifying the answers.

5) Application: Finally, the students are able to apply the model to other life-related things can make a reasonable explanation and prediction of natural phenomena and able to put forward new scientific issues (the formation of scientific issues), scientific inquiry proceed to the next question.

3.5. Four Learning Units

Via the learning sheet, students have a clear tasks and teacher can evaluate learning effeteness based on the learning sheet after the teachers' instructions. The four learning units is shown following as Figure 3.

(1) Thermal expansion

Dip some water on the bottle, the cap inverted, placed on the lip of bottle. Holding the bottle different positions.

(2) Atmospheric pressure

In a transparent plastic cup, filled with water and put one bigger Styrofoam ball in it.

(3) Light reflection

Taking the laser pointer and shoot to the mirror, the other student move the stick to find out the lighting point of refection.

(4) Electrostatic

Rolling & shake quickly. We were able to see the edge of the plastic cups attached Styrofoam balls.

Figure 3. Hands on the four learning units and students' modelling activities

4. Results and Discussion

The results of this research showed that in order to assess modelling abilities among elementary school students, we must consider the students' abilities, and the levels of the Analytic index can't be set too high. The Analytic index mode was based on different physical object models and conceptual models of learning sheets in each unit, and the researchers established 5 levels of analytic index for each unit.

The Fuzzy synthesis evaluation mode is mainly based on the modelling process. Therefore, the mode needs to establish items and sub-items and check the learning sheet whether the mode reaches the goals, and then synthesis evaluation can be applied as teaching and learning software.

Overall, for the two kinds of students' assessment of modelling ability assessment, the two raters think that the sub-items are either too fine or difficult to evaluate. Analytic Index assessment mode, teachers must reached a certain level, then, can only give an integer of 1~5 point. Fuzzy comprehensive evaluation of the permissible value given between integers, however, teachers must pay attention to the whole performance, appropriate adjustments gain / fader, easy to score by the computer calculation.

Currently, the Fuzzy synthesis modelling ability evaluation system is a stand-alone operation mode. Further, it can be developed as a database system and APP for mobile tablets, facilitating data processing and statistical analysis. This qualitative study only explored the preliminary characteristics of system development, the study will further explore and quantify the practicality of relevant systems. Ultimately, it can easily assess the scientific abilities.

5. Acknowledgements

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A Study of General Education Course Designing e-Picture Books to Promoting Popular Science Activity

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Abstract. The purpose of this research was to investigate the e-picture books to promote large-scale popular science activities. In order to enhance students' scientific thinking in science fair, first of all, this study hold a teacher professional development activities for 30 teachers to design the 10 set checkpoints scientific activities. Next, in the General Education-"Humanities and Technology course", there are 40 Fine Arts Department students design the original science picture books, and made into e-books. Finally, for a county science fairs, there are primary and secondary schools of a total of 1200 participants in science fair and activities. We selected 243 students as the sample to fill out the questionnaire. The whole of activities was focused on scientific thinking of inquiry activities and application of the concept of flipping education to enable students to participate in activities before viewing e-books, and then pass through the science fairs activities.

Keywords. e-Picture books, science fairs, general education, popular science activities.

1. Introduction

Since the Department of Fine Arts University, very few offer scientific e-picture book Creation course. The art department students when he was in the eleventh grade, to prepare for university entrance exams, less access to science curriculum, science awareness are also relatively scarce. The scientific picture book creation as an important forward the "science learning" goal, we must begin by the students of the nature of science and the understanding of the history of science. Therefore, the use of general education courses, the teacher taught Popular Science in the meaning of education, but also provides a history of science, the nature of science and other relevant information as the "science and humanity," the discussion. Further explore the social impact of science and culture, it offers many examples of creative, inspiring students' inspiration.

From the viewpoint of informal science curriculum, science fair is an effective method to enhance the scientific literacy. Have developed motivate students to think about learning unit for in-service teacher education in non-scientific, such ability is very important. Science fair activities not only learn science, knowledge, but the scientific way of thinking and attitudes to help students in the future to deal with complex social problems. For the importance of models and modelling in science education, scholars [1] have pointed out: the hands-on science should provide opportunities for students to create, express and test their models.

Moreover, in the process of science inquiry, when students conduct the predicting phase of experiments, if they did not think, the experimental work is often only a trial and error, and do not know what variables are feasible.

Education authorities advocate for students with portable competency, is an important goal of education nowadays. A science fair sponsored by the Department of Education activities in Pingtung County, Taiwan. It requires in-service teachers' assistance and participation. The teachers have the ability of design for carrying out an inquiry-based science game is very important. In order to improve the quality of teachers' questions, and to explore the contents of the teacher's questions, the way in order to promote students' thinking, which also showed the importance of scientific thinking.

Many teachers in the Science fair targeted at simple game, the dialogue almost nothing to do with education-related meaning. If the teacher does not mention any problems to the students to think, just a simple play, a departure from the purpose of education. As long as teachers can be a little hard to design the questions, the students can be guided by the teacher's questions, and promote scientific thinking, and even solve the problem.

The hands-on science learning activities were not only for fun but emphasizes to promote the students' scientific thinking ability.

2. Popular Science and Picture Books

The purpose of this research was to investigate the e-picture books to promote large-scale popular science activities. We must recognize their importance for the application of science education.

2.1. Popular Science

Popular Science is the use of a variety of media to the general public facile way to popularize scientific and technological knowledge, promote scientific methods and the dissemination of scientific thought, the spirit of science activities.

In the classroom formal science teaching and the Science fair is usually different purposes. Science fair can activate students' interests, and then achieve the science concept learning goal. The hands-on science learning activities were not only for fun but emphasizes to promote the students' scientific thinking ability [2].

Comprehensive analysis of the literature from the perspective of the scientific process: the ability to advocate scientific inquiry is a collection of science process skills as well as from the use of scientific inquiry into scientific thinking strategies: ability to advocate scientific inquiry is a scientific thinking skill. Cognitive psychologists [3] considered an important goal of education is to promote students' thinking. Science education should not be visible purely cognitive science knowledge, but should focus more on exploring methods and processes, particularly in the thinking process during the inquiry.

2.2. Picture Books

In recent years, with the popularity of picture books, and educators for educational function of picture books have a new understanding. Picture Book is not only well received by the people's favourite, picture books for children also has a considerable interest in the field of education for all have played a lot of functions, therefore, in many studies of empirical nature has been confirmed. The study of scientific picture book, on the one hand, we can focus on the creation of scientific theme, to enhance students' motivation in science, as well as enhance the capacity of scientific reasoning; on the other hand, can foster talent in art college to become engaged in science the picture book creators.

A study result indicated that the experimental-group students using e-picture books integrated into teaching were definitely superior to the control-group students for science reading comprehension. In addition, the students seemed highly related to the cognitive ability, attitude value and behavioural effectuation for science learning after executing the instructional strategy with science e-picture books. In order to enhance students' motivation to learn science, science exploration activities when the handle must be combined with effective assisted learning. We believe that with the e-picture books can quickly enable students to understand the subject, and before the "hands on science", to establish the basic concepts of the application. Otherwise inquiry activity will be like an amusement park, the students involved in science learning to absorb knowledge is very limited, it will be difficult to achieve the goal of scientific learning. Therefore, in the study of planning, designing tools and processing science fairs is particularly important.

3. Research Tools

Before the county science fair, we hold a professional development workshop in order to regain the teachers' ability of designing suitable for junior high and elementary school students' hands-on science learning units.

3.1. Research Design

In order to enhance students' scientific thinking in science fair, first of all, this study hold a teacher professional development activities for 30 teachers to design the 10 set checkpoints scientific activities. Next, in the General Education-"Humanities and Technology course", there are 40 Fine Arts Department students design the original science picture books, and made into e-books. Finally, for a county science fairs, there are primary and secondary schools of a total of 1200 participants in science fair and activities. We selected 243 students as the sample to fill out the questionnaire. The instructor of in-service teachers' professional development seminar who is an Elementary School science teacher and has taught more than 30 years. By the way, he has a doctorate in science education and has published two papers on journal about models and modelling.

3.2. Professional Development

In the in-service teacher professional development seminar, the instructor prepares some demonstration about inquiry material. A week later, each group needs to pay out the design documents for review by three experts to check the content. Based on previous experience of in-service teachers design science fair activities to integrate the seminar was shown on the Figure 1 as following: a) professional development learning time 3 hours; b) design the inquiry units developed one week; c) passing the review by three experts to check the content; d) material prepared 1 week.

Figure 1. In-service Teacher Professional Development Seminar

3.3. e-Picture Books and Science Fair

Figure 2. Slides of Picture Book

Based on the scientific theme, Fine Arts Department students analyse and develop the picture books in the general course, it was shown on Figure 2. In the science fair activities, students from the county can hold checkpoints cards, explore each stop. There were 10 units, including the type of mathematics, physics and chemistry activities for students to explore, it was shown on Figure 3.

Figure 3. Science Fair Activity

4. Results and Discussion

4.1. Results

The results of analysis show as following:

1) Scientific e-picture books, although not significantly improved student's argumentation ability in a short time, but the learning interests are reached significance. This activity can enhance students' motivation to learn science and the scientific reasoning ability.

2) In the Humanities and Technology course of General Education, the Fine Arts Department students in the design and production of e-picture books teaching activities, become a deeper understanding of science. It also can cultivate Art Talents in science e-picture books cr*eation.

3) This study was constructed a large-scale popular science activities operating model, which makes science fairs more efficient.

4.2. Activity Processes Discussion

A Framework of Popular Science processes shown on the Figure 4 as following:

1) Before going through the county science fairs, to design science game activity units, in this study held the teachers' professional development workshop. It can guide teachers on how

innovative themes, implementation testing, materials preparation, and most importantly, how to ask questions, so that students improve their scientific thinking and reasoning ability.

2) The game theme of scientific development, submitted by Professor reviewed and confirmed, you can determine the subject. Meanwhile, it will also be the theme of scientific development by the general curriculum and Fine Arts Department students to analyze it for the history of science(HOS) or Nature of Science(NOS) theme.

3) Students edit the subject matter of storyboard, then draw the picture books, and finally made into an e-picture book.

4) In science fairs, to play electronic picture books video for the students, causing the motivation and thinking. When conducting the hands-science, the teacher should be timely questions, so that students have the opportunity to thinking.

5) Finally, a sample and questionnaire test to understand performance of learning.

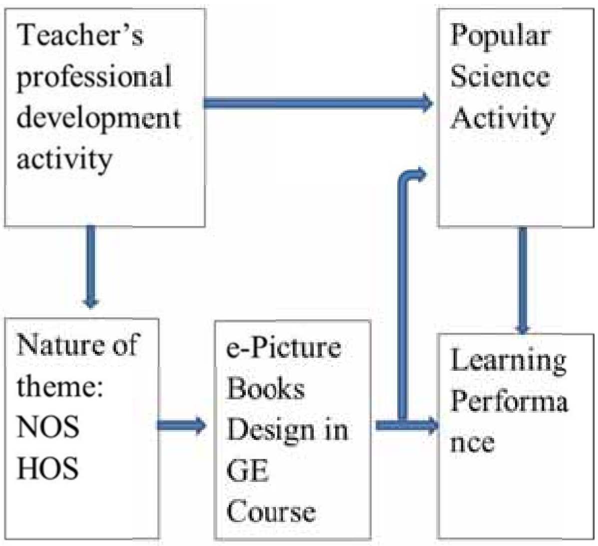

Figure 4. A Framework of Popular Science processes

In addition, this study was proposed a number of recommendations, future increases mobile device, so that the e-picture books can contain individualized and interactive learning activities. Modelling-based inquiry import more scientific thinking subject, the students do not only hands-on, but mind-on in science learning.

5. Acknowledgements

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Homemade Astronomical Experiments

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Abstract. Many educators need to explain basic astronomical phenomena to children. It is nothing new that experiments are powerful tool to teach physics and related sciences. But is it possible to perform experiments in astronomy?

To help Czech teachers in the primary schools, we developed several experiments to explain various astronomical topics. The experiments are part of an Astronomical Year project, which started in 2015. It brings not only experiments, but also project lessons and observation instructions every month.

Keywords. Hands-on experiments, astronomy education, informal education.

1. Introduction

It is desired to teach astronomy in schools because it can have motivational role for pupils [1, 2]. Also, many people are popularizing astronomy outside of school, for example in observatories, summer camps or children clubs. For all of them it could be useful to have a catalogue of experiments they can perform to demonstrate various phenomena. Experiments can be highly effective in teaching science. We bring a list of eight experiments here, some of them consisting of several consequent steps. It is possible to perform them with utilities usually present in every household and all of them are suitable for performing by children themselves. For instance, you will learn about the best ways of observing lunar surface, the skills of human eye, and the emptiness of the universe.

2. Homemade experiments

Now, let us start with specific topics. All of the experiments are described in Czech with more pictures in the webpage of the Astronomical Year project [3].

2.1. The phases of the moon

This experiment explains how it happens that we can see the moon in various phases. We will need: small balloon, strong flashlight, assistant.

We can perform this experiment in a dark room, for example at home after sunset. We need enough space so we can turn with outstretched arms. Let us hold the balloon in one hand. Ask the assistant to stay in one place and turn on the flashlight. Now, he represents the Sun, we are the Earth and the balloon is in the role of the Moon. Now we start to turn around while observing the balloon.

We can see that different parts of the balloon disk are illuminated just like in the case of the moon (Figure 1). The relative position of us, the assistant and the balloon are the same as the positions of the mentioned celestial bodies.

Figure 1. The phases of the moon

2.2. Simulating lunar surface

We will show what is the best time to observe lunar craters and other surface features with a telescope. We will need: 1 kg of flour, spoon, plastic bag, strong flashlight.

Again, we need a dark room. Moreover, it should be a room where some mess will not be a big problem. A bathroom or a garage is appropriate. In this room, we spread the plastic bag and put flour on top. With the spoon, we make pits (craters) and “mountain ridges” in the flour. Now it represents the surface of the

Moon. We turn off any lamps in the room and start using the flashlight. First, we point at the flour from above and try to observe the terrain features we made. Then we can shift the flashlight and illuminate flour landscape from different angles.

In the first part, the features are not easily visible. All of them are much more prominent when illuminated from side (Figure 2). The same phenomenon we can observe on the surface of the moon. If observing during full moon, we can hardly see any other features except for lunar mares. During other phases, we can sharply see craters, mountains and valleys close to the boundary between day and night (so called terminator).

Figure 2. Simulating lunar surface

2.3.The Earth's precession

We will make a spinning top, observe its movements and discuss the link with Polaris. We will need: play dough, skewer, cardboard, scissors, compasses, crayons

At first, we shape a small ball made of the play dough (approximately of the size of a hazelnut). Then we put it on one end of the skewer so that only small part of the skewer sticks out of it on one side. To protect the ball from deformation and to make the effect more observable, we make a circle of the cardboard and place it above the ball (Figure 3). Optionally, we can use crayons to make drawing on that and observe the mixing of colours later.

We made a spinning top. If we put it on table and try to quickly spin it, we can observe rotation around the skewer but also precession movement of the skewer itself. This effect can be described by solid mechanics and it appears when more than one force is making a solid to move. It is the same with the Earth (gravitational forces of the Sun, Moon and others). The Earth's rotational axis completes one such circle in approximately 26 000 years. Thus, we can use Polaris to estimate direction to the North only in our time and it will be possible after 26 000 years again. Meanwhile, we will have to use other stars or methods. After 10 000 years from now, Vega in the Lyra constellation will substitute the role of Polaris for some time.

Figure 3. The spinning top

2.4. The relation between the angular size and distance of objects

We will try to observe objects from various distances and compare their angular size – the angle they occupy in our field of view. We will need: paper, scissors, crayons, compasses, string, marker.

For this experiment, we need also plenty of space on the floor. We take the string of approximately the same length as is the length of the floor. We bend it in half two or three times so we can mark one half of the twine, the quarters etc. Then we spread it across the floor. We make two circles of the same size from the paper. We put the circles on two marks. It is recommended to use the first and second mark in the beginning. We sit at the beginning of the rope and compare the angular sizes. We can use the mark as a scale if we take it into our hand, put it in front of our eyes with outstretched arm while looking at the circles and marking their size with a finger. We repeat this "measurement" with the second circle placed on various marks.

As we can see, the remoteness of objects influences also their angular size. In the case of small angles, the ratio of distances of is almost the same as the ratio of angular sizes. For example, this is the reason we observe so different sizes of the disk of planet Venus throughout the time.

Note 1: The bigger angular sizes we observe, the less the ratio rule is valid. It is often valid in astronomy but hardly applicable in real life.

Note 2: If we compare sizes of different astronomical objects of the same kind, we can face another problem. Many of them can by extremely different in size despite the fact they belong into similar categories. For example, various planets, nebulas or galaxies are of various diameters in reality so we cannot easily estimate their distance just by comparing the angular diameters or it is very inaccurate. Astronomers usually prefer using other methods to measure distances.

2.5 Spectroscope

We will construct a simple spectroscope to explore the spectra of various common objects like lamps, bulbs, fluorescent tubes, or the sun. Such a device was described for the first time by Wakabashi et al. [4].

We will need: glue, downloaded template, old CD or DVD with written data, scissors, cardboard.

Before we start, we must download a template for the spectroscope, for example our Czech version from [5]. We stick it on the cardboard and cut it out when it is dry. Cut all the solid lines, also inside the shape of the spectroscope (especially the slit). In the places with dashed line, we bend it. We cut out a piece of CD or DVD and stick it on the template in the labeled place. Finally, we put the glue on the rims of the template and stick the spectroscope together. When the glue is dry again, we can start with observations. We put our eye to the big opening and point the slit to a light source. Inside, we can see the spectrum of the source.

Although it seems that various objects around us emit light of specific colours, it often consists of light of several colours in the same time. The grid on the disk inside the spectroscope decomposes the light so we can see all the colours next to each other. Some light sources emit practically all colours, some of them just several and we observe spectral (emission) lines. Sometimes, the spectrum is full of colours but some of them are missing, these we call absorption lines. The situation is the same in the case of celestial bodies. Based on the appearance of their spectra, we can investigate many of their physical properties such as temperature, pressure, binarity and others.

2.6. The tricks our eyes can or cannot do

We will perform three simple experiments demonstrating several surprising features of human eyes. We will need: white paper, pencil, crayons, scissors, mirror, flashlight.

Figure 4. The blind spot experiment

Let us start with drawing a star in the left and a dot in the right on a piece of paper. Their distance should be about the width of a computer mouse (Figure 4). After this, we hide one eye with a hand and watch the symbol further from the eye. We move our head from higher distance closer to the paper. Suddenly, the other symbol disappears. Small movement of the head back- or forwards allows us to see both symbols again.

We have just discovered the existence of so called blind spot. It is a place on human retina where the optic nerve starts and leads signals into the brain. Here, no receptors are present. In a certain distance from the paper, the light rays from the symbol reach exactly this spot so we cannot see it.

In the second part, we draw colourful circles with red, brown, violet, dark blue and dark green crayon on separate pieces of paper (Figure 5). We can easily distinguish between the colours. Now, we turn off the lamp and use only our flashlight. Let us hide more and more of the flashlight so the illuminance decreases. It starts to be difficult to distinguish between the colours. If we have a red flashlight, we can try to use it. When looking in the red light only, the red circle disappears.

Figure 5. The experiment showing colour sensitivity of human eyes

In the human eye, there are two types of receptors, rods and cones. Cones allow us to distinguish between colours. Rods do not allow this but they are more sensitive. It means that in the lack of light we can use only rods, we can still see, but we do not distinguish between colours. For this reason, we can hardly see colours while observing space objects with a telescope. It is possible only in the case of relatively bright objects such as planets. With very powerful telescopes we can also see faint colours in some nebulas (e.g. M42).

To explain the observation with red light, we should understand what happens when we draw a colourful circle. Such a circle absorbs all other colours from white light so we can see only one. When using monochromatic light (red flashlight), it seems either black (if the colour of the light is different than the colour of the circle) or we can see it with the same colour (it reflects the light of the same colour it has). The white parts of the paper reflect everything. So in the case of red flashlight, the whole paper is reflecting red light and there is no contrast. The other papers are reflecting the light on the rims, absorbing in the circle, and thanks to the contrast we can still see the circles.

In the last part, we use the mirror and flashlight. We turn off all other lamps, look into the mirror and focus on the pupil of one eye. Now, we turn off the flashlight and wait about 10 seconds. Now, we turn on the flashlight again. First, the pupil was larger than before but it is getting smaller fast.

Our eyes can accommodate to the level of light we are experiencing. The pupil gets smaller when there is enough light and protects the inner parts of the eye. When there is less light, the pupil enlarges so the retina can still gain enough light and we can see. The accommodation is fastest in the first seconds or minutes but it can take up to half an hour if we want to see as many stars as possible in dark sky.

2.7. Measuring angles with a hand

Figure 6. The measurement of angular size

For amateur astronomy, sometimes it is useful to measure angle sizes (or rather distances) in the sky. For example, news articles tell us how far celestial objects are from each other during close conjunctions or how to find weak objects using the bright ones. In this section, we will learn easy method of measuring distances in the sky.

We will need: paper and pencil. When using our outstretched arm, we can roughly remember the angular sizes of the little finger (1 degree), inch (2 degrees), fist (10 degrees) and splayed fingers (15 degrees). We can try to measure angular sizes of various objects around us, such as cups, cars, hills etc. (Figure 6). All the measurements should be done with one eye closed and the arm outstretched. Let us write down the results and think about the actual sizes of the objects.

Apparently, objects of various sizes both on the Earth and in the Universe can have similar angular sizes and vice versa (see chapter 2.4). The method we have learned is useful to measure angular sizes. The small precision of it is compensated by the main advantage – our hands are always "at hand" when we need to make a rough measurement in the sky.

2.8. The model of our solar system

In the last experiment, the construction of a model of solar system is described. It helps to imagine the relative sizes and distances of the Sun and planets.

We will need: scissors, yellow crepe paper, glue, pencil, paper, cardboard, play dough, two ping-pong balls, balloons of 8 and 10 cm in diameter, markers, fishing line or other tools.

This is probably the most demanding experiment but the result can serve as a decoration for long time. We will produce a model 1.4 billion times smaller than the reality. It means that our Sun must be 1 m in diameter. If we can, we use an exercising balloon. Otherwise, we stick two pieces of crepe paper together and make a circle of desired size. This we can stick on wall. Let us continue with models of planets. For this we will use the play dough and balls. Mercury, Venus, Earth and Mars should be 4 mm, 1 cm, 1 cm and 5 mm big. Jupiter Saturn, Uranus and Neptune should be 11 cm, 9 cm, 4 cm and 4 cm big and we can use the balls for them. To make the rings of Saturn, we can cut out an annulus of the cardboard. In our model, the inner radius is 8 cm and the outer radius 15 cm. The width of the cardboard is also corresponding to the relative width of Saturn's rings. The colours of the planets can be adapted to reality using markers and pictures from cosmic probes. After we create the models of planets, we can think of putting them into proper relative distances. Considering our (children's) steps are about 0.5 m long, we can express the distances in steps. Then, Mercury is 140 steps from the Sun, Venus 220 steps, Earth 300 steps, Mars 440 steps. However, the outer planets are much further. We can find some places to place them in a map. Jupiter should be ¾ km from us, Saturn 1.5 km, Uranus 3 km and Neptune 4.5 km. Obviously, we do not have any room big enough. Let us just hang the planets next to each other, for example using the fishing line. We can make small cards with planet's names and basic information found in books or in the Internet.

What is the result? Now we can see that the Universe is extremely empty. And that is not valid in our solar system only. To reach our neighbouring stars, we would have to travel tens of thousands of years by the fastest rockets we currently have. We can only recommend to visit one of the existing planetary paths to have even better idea.

3. Conclusions

We present 8 experiments developed for the Astronomical Year project of the Czech Astronomical Society. Each of them focuses on different astronomical phenomenon. Lists of necessary tools and detailed instructions are included. It is possible to perform all of the experiments with easily accessible tools. Thus, they are appropriate both for educators in schools or outreach activities and for children at home.

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Mobile Devices in IT Education: a Survey on How University Students Use Smartphones and Other Mobile Devices to Access Information and Support Learning Activities

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Abstract. The research investigated the extent to which students at the Ternopil National Technical University, Ukraine, use mobile devices, such as smartphones (for example, iPhone, Android, Blackberry) and tablet computers (for example, iPad), to support their studies. A printed survey was distributed to 201 undergraduate and senior students via email and personal contacts. Undergraduate students, as compared with seniors, used their mobile devices more often and used them for a little broader range of activities. Lack of skills in searching for and using particular resources or applications and technology barriers do not seem to prevent the students from using mobile devices for their information needs on a regular basis, but these obstacles may keep them from locating quality resources. The results presented in this paper will show how the university can make mobile technology an effective educational tool.

Keywords. Information access, mobile device ownership, mobile technology, reliability of information, search habits, smartphone, tablet computer.

1. Introduction

Mobile technology has been widely adopted by educators and students since its inception. Mobile devices are quickly becoming one of the main tools to access academic information of varying quality.

The introduction of the iPhone, iPad, and other smartphones and tablets has changed the type of information that can be easily accessed on mobile devices. These changes have been accompanied by an increase in published research on the use of mobile devices in education.

The impact of mobile technology on higher education has been examined in both theoretical and practical aspects [1-3]. These studies indicated frequent use of mobile devices as reference and information management tools in learning practice by students. The most recent studies conducted by the Pew Research Center show a trend toward higher use among younger and more educated users in both rich countries and emerging economies [4, 5]. However some important aspects have not been addressed, specifically how students search for information and how universities can support them. Most of education research literature is limited to specific user groups or specific geographic regions/countries (e.g. [6]) and rarely considers developing countries, one of which is Ukraine. The current study was designed to fill these gaps in knowledge through examining the mobile device use and searching habits of students who study computer science and information technology at the Ternopil National Technical University (TNTU), Ukraine, with a particular focus on how the university could facilitate the access to the most adequate mobile resources.

2. Research questions and methods

This study was a paper-based survey with respondents from TNTU. The survey consisted of nine items. The research questions addressed by this project were:

- What is the extent to which students use their mobile devices when they are in the classroom or look up relevant information being on or off campus?
- What can facilitate or complicate the use of mobile devices to find information related to students' studies and projects?
- How could the university faculty support mobile users' education-related information needs?

A printed survey was distributed by students volunteered to conduct the survey at the TNTU to undergraduate and senior students via email and personal contacts. Survey data were collected from April 2016 to May 2016. The target population was undergraduate and senior students who study IT and computer science.

3. Results and discussion

There were 201 students who responded to the survey. The breakdown of participants by student group was: 111 (55.2%) participants were 1st – 3rd year undergraduate students, 90 (44.8%) ones were 4th – 5th year senior students (i.e. those in the last year of their Bachelor or Magister programs). Overall, the sample was representative of the student population of the university.

3.1. Device ownership

All participants had at least one mobile device with Internet access (Table 1). Most students (62%) reported owning Android phones, including 54% of undergraduates and 71% of seniors that is consistent with earlier data on mobile device ownership in Ukraine [7].

Device	a	b	c
iPhone or iPod	13	11	12
iPad	9	4	7
Other tablet	14	9	12
Android phone	54	71	62
Blackberry	2	4	3
Other phone	20	20	20
Participants could select more than 1 option, so totals can exceed 100%.			

Table 1. Device ownership by student group, % (n=201): a) 1st – 3rd year under-graduates; b) 4th - 5th year seniors; c) total

3.2. Types of activities on mobile devices

Across all user groups, the most commonly reported uses of mobile devices were checking class schedules (65%), taking notes (54%) and working with Atutor, a customized web learning environment at the TNTU (48%) (Table 2). However, a substantial portion of respondents (40%) also use these devices to perform calculations. Undergraduate students used their devices for a relatively broader range of activities than seniors; many of them reported using mobile devices to search for materials for current course and future diploma projects (50%), self-directed study of new software applications (36%) or copy lecture notes (36%).

Activity	a	b	c
Take notes	61	44	54
Copy lectures	36	31	34
Check schedule	75	51	65
Use Atutor	50	44	48
Find answers during exams and tests	21	22	22
Search for materials for course and diploma projects	50	24	39
Search for publications or software	21	17	18
Study new applications	36	31	34
Read books, articles, etc.	27	27	27
Contact with classmates	34	40	37
Calculations	36	44	40
None of these	14	2	9
Other use	2	2	2
Participants could select more than 1 option, so totals can exceed 100%.			

Table 2. Device use by student group, % (n=201): a) 1st – 3rd year under-graduates; b) 4th - 5th year seniors; c) total

Students frequently used mobile devices to support their study needs (Table 3): 63% of all respondents reported using their mobile devices for this purpose more than once a day. Undergraduate students were the most frequent users of mobile devices in this regard: 66% of them reported greater than daily use, while 95% of undergraduates used their mobile devices at least several times per week or more to access educational information.

As part of the survey, participants were asked to indicate their favorite resources and the resource they last selected to use. Students were free to enter any resource they liked. The most frequently mentioned resources were Google (69%) and Wikipedia (25%). A few (about 4%) participants also stated that they used the web or the Internet, without specifying in greater detail which resources they used. Other resources were few and far between for participants' answers representing a long tail of less common free information resources.

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Frequency	a	b	c
More than once a day	66	58	63
Once a day	25	22	24
Several times a week	4	12	7
Several times a month	0	4	2
Once a month	5	4	4

Table 3. How often a device is used to support study needs. Frequency of use by student group, % (n=201): a) 1st – 3rd year under-graduates; b) 4th - 5th year seniors; c) total

Finally, students were asked how many applications they had downloaded to install on their mobile devices (Table 4). Only two seniors (1%) had not downloaded any applications. Both student groups seem very active users of downloadable or web-accessible applications: 70% of participants had downloaded more than 10 applications; another 21% had downloaded 5-10 resources.

Number	a	b	c
Zero	0	2	1
One to four	9	7	8
Five to ten	20	24	21
More than ten	71	67	70

Table 4. A number of downloaded applications (or used via web site). Application use by student group, % (n=201): a) 1st – 3rd year under-graduates; b) 4th - 5th year seniors; c) total

3.3. Barriers to access and support for users

The survey question explicitly addressed barriers to using mobile devices for study needs (Table 5).

"Wireless access in the university" was reported by 58% of participants as the primary obstacle to using mobile devices for information seeking. Wireless access was definitely recognized as a problem among both groups, but particularly among undergraduate students (71%). Fewer senior students found it to be a problem (40%). The TNTU still has dead spots in WiFi coverage.

"Don't know how to use the resources" (22%), "Lack of time" (22%) and "Technology problems" (21%) were the other most commonly reported barriers to access, among both groups. Installation process was mentioned as a barrier only by 16% of respondents.

Obstacles	a	b	c
Wireless access in the university	71	40	58
Don't know what resources are available	11	4	8
Don't know how to use the resources	20	24	22
Technology problems	20	22	21
Complicated installation	13	20	16
Lack of time	21	22	22
Participants could select more than 1 option, so totals can exceed 100%.			

Table 5. The obstacles students encounter while using mobile devices. Barriers to access by student group, % (n=201): a) 1st – 3rd year under-graduates; b) 4th - 5th year seniors; c) total

In spite of these barriers, 63% of participants said they were successful or relatively successful in locating the information they needed. This level of satisfaction surprises, considering that more than a quarter of participants (28%) reported spending a few minutes or less on their information search.

Support	a	b	c
Friends	68	31	52
Classmates	29	33	31
Cell phone provider	11	22	16
University staff	20	7	14
Other	13	20	16
Participants could select more than 1 option, so totals can exceed 100%.			

Table 6. Source of assistance for mobile devices by student group, % (n=201): a) 1st – 3rd year under-graduates; b) 4th - 5th year seniors; c) total

Preference	a	b	c
Hands-on workshops on using mobile devices	23	0	13
Hands-on workshops on using academic resources on mobile devices	23	7	16
Troubleshooting assistance	11	29	19
Online how-to guides on ATutor	11	24	17
Access to more resources	66	80	73
Participants could select more than 1 option, so totals can exceed 100%.			

Table 7. The support students would like to get from the university. Desired university support by student group, % (n=201): a) 1st – 3rd year under-graduates; b) 4th - 5th year seniors; c) total

Most participants got support for their mobile devices from friends (52%) or classmates

(31%). Only 7% of seniors and 20% of undergraduates chose the university as a place to get support (Table 6).

When asked what support they would like the university to provide, the most popular answers were ‘‘Access to more (mobile) resources’’ (73%), ‘‘Troubleshooting assistance’’ (19%), and ‘‘Online how-to guides on ATutor’’ (17%). Table 7 shows desired university support by student group.

4. Discussion

The survey of 201 students who study information technology and computer science at the TNTU reveals that every respondent without exception uses at least one mobile device. This widespread use of smartphones and tablets is consistent with previously reported trends in mobile ownership in Ukraine [5, 7].

It is obvious that mobile devices are well fitted for use in educational settings, where students often have to find information quickly.

Across all the data, undergraduate students, as compared with seniors, used their mobile devices more often, used them for a little broader range of activities, but downloaded nearly the same amount of resources for their devices. A higher percentage of this group wanted the university to provide hands-on workshops on using mobile devices to access academic resources. By intuition, this pattern of use makes sense: undergraduates still have more classes and labs and still need to look up a great deal of information.

It is less clear what role mobile devices play for senior students. They used their mobile devices for information seeking less frequently than undergraduates did. Since many senior students are focused on their research projects, they demand instant information less and thorough literature searching and reading more.

Although iPads and tablet computers are very helpful for reading PDF files and other documents, a small proportion of senior students reported owning these expensive devices (4% and 9% respectively). This may explain why searching for and reading articles and books is not among top uses of mobile devices: only 27% of respondents used their devices (as well as smartphones) for this purpose. The three top uses of mobile devices (checking class schedules, taking notes and working with Atutor) are routine.

Wikipedia was most frequently ranked as students' favorite resource, and Google was most frequently mentioned as the last-used resource in a search for information. One possible explanation for this difference is that most students default to Google as a search engine when they do not have the time or do not want to change this setting. This guess is supported by the fact that most participants spent less than a few minutes on their search. Google is easy to access through mobile web browsers, and Wikipedia records actually rank quite high in Google search results.

As a consequence of unfamiliarity with relevant resources, many respondents seemed ‘‘satisfied’’ with their search, preferring convenience and speed over finding better quality information. They were aware of better resources, but the confluence of several different barriers (time, access, knowing the resources) kept them from using these more trustworthy resources. Most participants reported being able to get a satisfactory result within a few minutes, but it might not be the best possible result.

The fact that many students are using free resources on a regular basis and are using so many resources raises questions about what efforts the university should make in regard to mobile resources. Students may turn to the library for reliable mobile resources, but the library still provides access to a limited number of such resources, with most of them being available in a test mode or via a local network only. One potential strategy for the university library is to focus on providing access to a smaller number of select, authoritative mobile resources instead of trying to offer access to an extensive collection of mobile resources. In this way, the university could focus on these select resources until more licensed mobile resources become available. Then it will be easier to promote these resources through online guides, social media and other electronic means. Even though many of students surveyed did not know about reliable mobile resources, the survey demonstrated that the majority of them (66% of undergraduates and 80% of seniors) appreciated and needed this content. Targeted hands-on sessions for specific mobile resources are another important way of raising awareness among students. These hands-on sessions are more difficult to plan because of the variety of devices that users bring to the workshop. Active promotion and hands-on workshops would also address some of the major barriers to access and encourage more students to use credible resources on their mobile devices.

5. Conclusions

The results from this survey show that TNTU students who study IT and computer science are using their mobile devices to answer academic questions in many ways. Usability of these devices has facilitated wider use, but slow or nonexistent wireless connections and poor information retrieval skills still remain as major shortcomings. Although these problems do not seem to prevent students from regularly using mobile devices for their information searches; barriers to access and lack of awareness regarding particular resources and applications might be keeping them from using the most appropriate resources. By better understanding the habits of this expanding population of mobile users, the university can help them find the best resources for their information needs and can begin targeting its support efforts and resources to the university students.

Mobile devices will have an ever-growing presence in science education, and universities must realize the impact that these devices have on the learning/teaching process. The TNTU faculty should focus on advising with regard to the use of a smaller number of highly used mobile resources instead of a huge collection of resources which raise concerns about the quality of information.

6. Acknowledgements

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Vegetables, Salad Dressing and Color: Hands-on Food… for Thought!

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Abstract. The vivid orange of carrots and pumpkins comes from carotenoids, the green of spinachs and cabbage from chlorophylls and the purple of berries and eggplants from anthocyanins. The different colors of vegetables and fruits are due to different substances that play different biological roles. They have also different properties that may be used to separate them by using solvents with different polarities. Anthocyanins are more soluble in water than chlorophylls, which in turn, are more soluble than beta-carotene or lycopene, which are only scarcely soluble in water but display a strong affinity for non-polar solvents such as petroleum ether or hexane or edible oil. Solid-liquid extraction techniques are the most common approach to isolate natural pigments as well as a vast number of natural products. These techniques are the focus of this hands-on activity targeted at middle-school and high school students. The extraction of natural pigments from food of diverse colors uses homely "reagents" only: water, vinegar and edible oil. The presence of the natural coloring in extract will be made by visual inspection. From the results they can rank the liquids according to their ability in isolating each food coloring. This experiment can be expanded and more household liquids may be tested in the lab (rubber alcohol, acetone, glycerin). For high school students more conventional solvents may be employed: hexane, ethyl acetate, etc. This inquiry based activity may be easily modified so as to adapt to diverse age groups.

Keywords. Colourings extraction, hands-on learning, high school, inquiry based research, laboratory work, middle school, natural dyes, outreach activity, vegetables.

1. Introduction

The activity here proposed consists of the extraction of natural pigments from vegetables: carotenoids from carrots and tomatoes, chorophylls from spinaches and anthocyanins from red cabbage. These vegetables were chosen because they contain representative natural pigments, are inexpensive and are also edible. And the extracting solvents are edible too; actually, they are used to season those vegetables when preparing a salad: oil and vinegar.

Figure 1. Vegetables used in this study: carrots and tomatoes (carotenoids), spinaches (chlorophyll) and red cabbage (anthocyanins)

The structure and properties of the food colorings to be extracted differ; therefore, the solvent to extract them should be chosen accordingly. Carotenoids (lycopene and beta-carotene) are non polar so they are poorly soluble in water but soluble in non polar solvents such as edible oil [1,2]. Chorophyls are also much more soluble in solvents with reduced polarity [3]. On the contrary, anthocyanins, being polar (or even charged) molecules, are very soluble in water but insoluble in apolar solvents [4]. In this inquiry based activity, the non polar solvent is typified by edible oil the polar one is acetic acid/water. These solvents differ not only in their polarity, but also in other properties (eg. density) and are immiscible. The inquiry based activity is hence a useful tool to introduce or revisit relevant topics such as density, molecular polarity, intermolecular forces and acid-base reactions to middle school or high school students.

The experiments here proposed illustrate in a simple way an important technique in the isolation of natural products, the solid−liquid extraction (SLE). This technique is widely used in the preparation and the separation of a diversity of compounds in industrial, academic or research fields [5,6]. It is a standard way to obtain natural pigments in a batch operation. Using static methods of extraction, the raw materials are macerated in contact with the solvent [4,6], and then the liquid is filtered, and a colorful extract is obtained. In industry, after the extraction, a purification procedure follows, but this is not within the scope of our activity; the extracts will be obtained and inspected and no further purification will be made.

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Practical experience in a familiar context can be the best tool to understand what factors are important to solubility, including which solvents are miscible with each other, and which solvent is going to be on top of the other when solvents do form two layers. And it is even better when familiar and colored "reagents" are the theme of the investigation.

High school students may deepen the understanding of the processes of extraction of substances. To that aim an experiment is proposed where the partition of two apparently similar substances, but with very different polarities is investigated, using solvents of different characteristics.

2. The colors of food

The different colors of vegetables and fruits are due to different substances they contain that not only differ in color as play different biological roles.

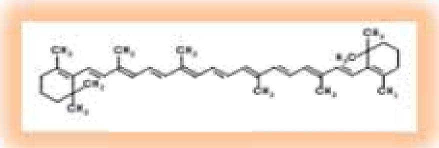
"Eat a rainbow of colors" say nutritionists; eating a variety of colorful food provides vitamins, minerals, and antioxidants to nourish our body [7].

Figure 2. The rainbow colors of natural pigments from fruits and vegetables (from [7])

Color, such as what makes a blueberry so blue, and a carrot so orange, can indicate some of these substances, which are thought to work synergistically with vitamins, minerals, and fiber (all present in fruits and vegetables) in whole foods to promote good health and lower disease risk.

An attempt has been made [7] to group foods according to their predominant phytochemical group, coding plant foods into seven color categories: red, red/purple, orange, orange/yellow, yellow/green, green, and white/green. While research regarding color's effect on health is ongoing and nor clearly established [8,9], one thing may be ascertained, the intensity of color is actually one sign that the food is ripe and ready to eat. So, color is definitely an important characteristic of food.

Although structurally very diversified and originating from a variety of sources, natural food colorants can be grouped into a few classes, the three most important of which are: tetrapyrrols, tetraterpenoids, and flavonoids. The most important member of the tetrapyrrols is chlorophyll, which is found in all higher plants. Carotenoids are tetraterpenoids that are as ubiquitous as chlorophyll, since they too are part of the photosynthetic apparatus. They also give the yellow–orange–red color of many fruits. Anthocyanins are a group of flavonoids that provide the red–purple shade of many fruits, in particular berries (e.g., strawberries, elderberries, and black currants). Other classes of colorants are the anthraquinones (carmine, lac, kermes, and madder) and the betalains (beetroot) [1].

a) 

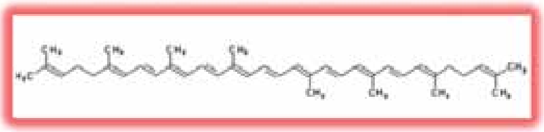
b) 

Figure 3. Two well known carotenoids: β-carotene (a) and lycopene (b)

Carotenoids have a deep red, yellow, or orange color. Carotenoids owe their name to carrots (*Daucus carota*), and xanthophyll is derived from the Greek words for yellow and leaf. Together with anthocyanins, carotenoids are the most complex class of natural food colorants with around 750 different structures identified [1]. Carotenoids have a deep red (lycopene), yellow (lutein), or orange color (carotene). Probably the most common carotenoid is β-carotene (Fig 3.a), which is responsible for the bright orange color of pumpkin and carrots. Also abundant is lycopene (Fig 3.b) which imparts red color to watermelons and tomatoes.

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Chlorophyll is the green pigment utilized by all higher plants for photosynthesis. The name derives from the Greek words for green and leaf. Chlorophyll is a cyclic tetrapyrrole with coordinated magnesium in the center (Figure 4). In plants, there are two forms of chlorophyll (*a* and *b*) which only differ in the substitution of the tetrapyrrole ring (Figure 4). All green vegetables, as well as tree leaves and most algae, have chlorophylls that impart them either a bluish green (**chlorophyll A**) or yellowish green (**chlorophyll B)** hue**.**

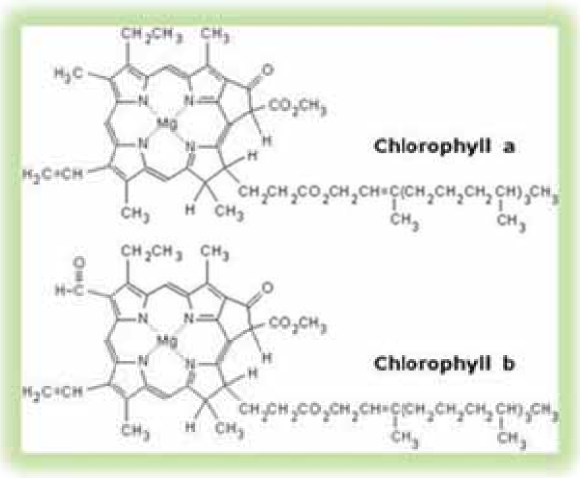

Figure 4. Chlorophylls: chlorophyll A (bluish green) and chlorophyll B (yellowish green)

Anthocyanins occur in all tissues of higher plants, (leaves, stems, roots, flowers), and fruits) and display a wide hue variety, giving rise to the blue–purple–red–orange color of flowers and fruits. The best natural sources for the deep purple and blue colors of anthocyanins are eggplants, red cabbages, blackcurrants, grapes, blueberries, cranberries [1]. Also many flowers owe their rich color to this organic compound, and the name comes from two Greek words meaning flower and dark blue (and not the blue–green color we usually associate with cyan). Anthocyanins can be used as pH indicators because their color changes with pH; they are pink in acidic solutions (pH < 7), purple in neutral solutions (pH ~ 7), greenish-yellow in alkaline solutions (pH > 7), and colourless in very alkaline solutions, where the pigment is completely reduced. The general structure of anthocyanins is shown in Figure 5.

Figure 5. Anthocyanins: the different R groups of the basic structure may vary: –H, –OH or –OCH_3

Natural food colorants have been the focus of the research community interest due to the potential valuable role they play in health. The claimed benefits of eating fruits and vegetables is due to possible antioxidant properties of the natural pigments but also of the phytochemicals they are associated with. A vast number of studies have been conducted in the past decades to investigate and understand how these substances (polyphenols, anthocyanins, and related compounds) contribute to antioxidant properties [8,9]. Both health and economical reasons are behind the great interest upon the isolation of these products (polyphenols, anthocyanins, and related compounds) from natural sources.

3. The isolation of food colorings

Natural plant dyes have been used all over the world for centuries to color textile and, more recently to color food, so as to turn it more appealing by replacing the color lost during processing, enhance color already present, or to color otherwise uncolored food [1].

The extraction of colorings as well as other phytochemicals from natural plants and fruits requires a large amount of material to be processed due to the low content in the desired substance and needs further a purification procedure. This entire process is costly industry replaced natural dyes by synthetic ones, and to meet their increasingly wide use needs. Synthetic colorings can be mass-produced at a fraction of the cost of gathering and processing the materials used to make natural food colorings. Other advantages are that artificial food dyes might be longer-lasting than natural ones of the same color and the unlimited variety of colors that be artificially produced in a lab. In U.S. Food and Drug Administration granted approval to seven synthetic food colorings for widespread use in food (two blue hues, one green, two reds and two yellows).

However, many studies seem to recognize that synthetic food dyes trigger hyperactivity or inattention in children [10]. The public opinion has been claiming authorities to regulate the use of artificial colorings and implement more restrictive regulation. Anticipating legislation, industry is moving to natural colorings to please their customers' demands. Nestlé's chocolate "Smarties" in Europe contain radish, lemon and red cabbage extracts for coloring, rather than yellow six or red 40 in USA. Also Mars® recently announced it would be removing artificial colors from all of its food products until 2017 and already filled a patent to make natural blue colors from anthocyanins that resist to changes in color. So extraction of colorings from natural sources is a pertinent and up-to-date issue.

The standard way to obtain natural pigments is a batch operation using static methods of extraction where the raw material is macerated in contact with the solvent. At the end of the process, the liquid is filtered and purified in order to obtain the extract [4].

4. Hands-on food

The inquiry based experimental work is divided into 2 subsets of experiments aimed at different levels of students. The basic set of experiments uses common homely "reagents": fruits or vegetables, edible oil, vinegar and water. This first set is adequate for both middle school and high school students and is obviously safe to be made at home. If planned to be performed as part of a class or an outreach activity, then two 60-90 minute periods would be enough. The time interval (lunch time or overnight) allows a better separation of the mixtures.

The second set of experiments consists of a more conventional chemistry work: the solvents used for the extraction are those recommended in the literature for this samples [1-6] and safety procedures must be followed.

4.1. Extraction of natural pigments from vegetables: salad dressing

The basic set of experiments uses The vegtables chosen were carrots, tomatoes, spinaches, red cabbage (Note 1). Concentrated pulp may be used instead of fresh tomato for a more intense color in the extract. The liquids used as solvents should be colorless or slightly colored only, thus olive oil and red wine vinegar are not appropriate for this experiment.

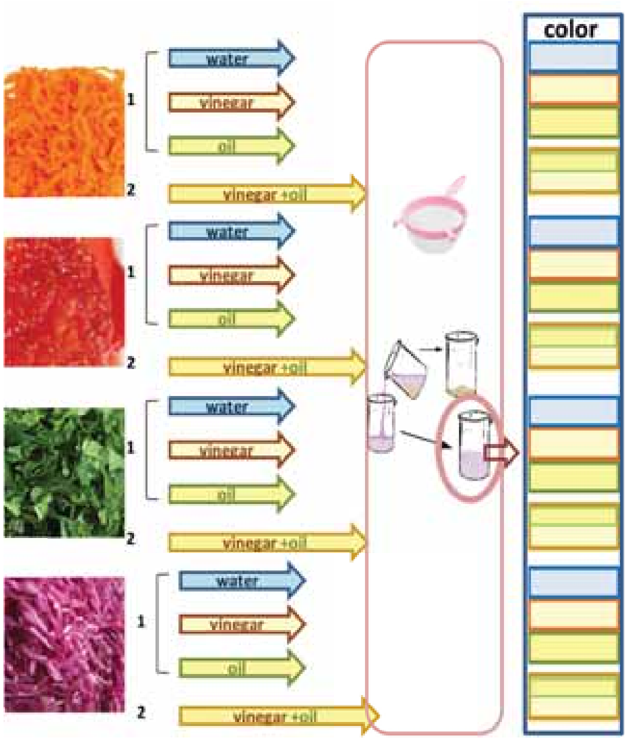

Figure 6. Scheme of the extraction experiments

For each vegetable four samples are required, the same number as the solvents to be used: water, vinegar (or acetic acid solution), edible oil, in a first step and then a mix solvent formed by oil/vinegar. A scheme of the experiments is presented in Figure 6. To help the participants throughout the experiments a protocol with the procedure and indications for writing down the data and observations is provided.

The solid liquid extraction procedure is carried out at room using approximately the same amount of each shredded vegetable in a definite volume of each "solvent".The shredded vegetable sample (*circa* 1 table spoon) is grinded in a mortar with the solvent using a pestle to help breaking the cell walls of the vegetables. Around 50 mL of solvent is added in small portions at a time. Since this is a qualitative analysis, the amounts do not need be very precisely measured.

The mixture is left to macerate for a fixed period of time and then the liquid is decanted or filtered. A coarse filter (strainer, sieve) or a paper is usually appropriate. The students observe the filtrate to evaluate if the solvent extracted any colored substance from each vegetable.

After this single solvent set of experiments they use a mixed solvent composed by equal parts of oil and water.They must realize that oil and water are not miscible and form two layers; a small portion of water is added to oil and each layer should be identified. Since vegetable oil is slightly yellowish the students should be able to recognize the layers.

The two solvents are then are added to the shredded vegetable in the mortar, in very small quantities at a time. The mixed solvent experiments take longer since the solvents are immiscible. After a while (ca. 30 minutes) the liquids are filtered/decanted from the vegetables, as done in single solvent extractions. However it should be noticed that, since the two solvents are immiscible, an emulsion sometimes form. If available, the use of a centrifuge greatly helps the separation. Otherwise, the mixture should be left standing the necessary time to achieve a good separation between the two layers (eg. overnight). Again, the students observe if there is color in each layer and compare with the results obtained with the single solvent experiments.

4.2. Extraction of natural pigments from vegetables: conventional solvents

For high school sudents, the experiments described before, using salad dressing „solvents“ may be assigned as pre-lab home work. Once in the lab, they use the same vegetables but a different set of solvents. Instead of edible oil, which is a mixture of nonpolar substances, they use a single substance, acetone, ethyl acetate and/or hexane may be used (Note 2), since they are commonly used to extract, chlorophylls and carotenoids [1,4]. Also a solution of acetic acid replaces vinegar. To evaluate pH effect, particularly when extracting anthocyanins, hydrogen carbonate solutions may also be used.

The extraction conditions should also be more controlled, so that results allow for a semi-quantative analysis. The shredded vegetables should be weighed to the nearest gram, the solvent volume measured with a beaker; both the grinding time and the maceration time should be kept constant for all samples.

The set of experiments here described can be expanded and adapted allowing students to go further and learn more about separation procedures and general chemistry. A project around the color of food may be developed by i) analyzing the color of the extracts by performing a chromatography ii) assessing the effect of pH in the color or iii) using other samples such as commercial food colorings or acid base indicators.

4.3. Extraction of iodine and permanganate

This part of the activity is aimed at providing a conceptual understanding of the principles that govern the liquid - liquid extraction procedures. A brief discussion should take place on the polarity of each solvent, water and hexane and on their expected mutual solubility. The students pour 10 mL of each liquid in a test tube and notice they do not mix. They should also be able to conclude that water is denser and forms the lower layer.

Then, the solubility of each solid, iodine and potassium permanganate in water and in hexane has to be investigated. This experiment has a high visual impact, but, due to safety reasons, should be performed as a demonstration only (Note 3). According to the instructor's will a dramatic and more entertaining penchant may be introduced in the demonstration [12].

In four 100 mL beakers the same amount of solid substance (0.5 g) is added to 50 mL of each solvent. From the colors of the solutions (or its absence) it is noticeable that iodine is soluble in hexane but very little soluble in water; the opposite is observed for potassium permanganate. The students may discuss the “like dissolves like“ rule; hexane and iodine are non polar substances while permanganate is a salts that originates ions that soluble in a polar solvent such as water.

5. Final Remarks

In this hands-on activity the extraction of natural pigments from food of diverse colors is proposed as a multilevel experiment aimed at students of different ages and levels. Part of it may be performed at home using domestic "reagents" only, as an outreach activity for younger students or as a pre-lab experiment for high school or general chemistry college students. It is aimed for all the students to observe that different food colorings are soluble in different liquid, so it is possible to devise a procedure to selectively extract them.

Practical experience can be the best tool to understand what factors are important to solubility, including which solvents are miscible with each other, and which solvent is going to be on top of the other when solvents do form two layers. The more clearly so when the compounds have different colors, which are easily observed and more vividly remembered.

Extraction of natural coloring from plants and fruits is a pertinent issue in today's society and provides a wonderful subject for both outreach activities and in-class labworks. Apart from their importance in both health and economy, natural colorings are an attractive starting material to study chemistry. And of course, this work is also compliant with the effort to use natural products to teach chemistry topics [12].

Along with its scientific pedagogic value this work bears also an opportunity to draw the youngsters attention to the importance of eating healthy food, an increasingly important issue in present days, where poor quality food is becoming increasingly more popular.

These inquiry based home/lab experiments embody an informal, entertaining and colorful way for young "researchers" to become familiar with solid-liquid extraction, liquid-liquid extraction, density, polarity and miscibility of solvents. The subject and context chosen for this activity may stimulate colorful debates around chemistry subjects (e.g. structure and properties of matter, separation and isolation techniques, analysis) and also on food, nutrition and health (e.g. food quality, dietary intakes, nutrients, additives). Have a delightful rainbow of natural colors on the bench and on the table!

6. Notes

[1] For the sake of reducing costs, carrots, tomatoes, spinaches and red cabbage were used but other samples (vegetables, fruits or flowers) may be employed.

[2] As mentioned before, high school students may have a more diverse list of extracting solvents: acetic acid, bicarbonate solution, rubbing alcohol, acetone, ethyl acetate or hexane. But when using the organic solvents the fume hood is mandatory and they should not be poured down the sink but kept in bottles for later disposal.

[3] Both iodine and permanganate are oxidizing agents. The instructor should wear safety goggles; after use, hexane and hexane-iodine should be stored in a solvent waste bottle and permanganate solutions in another for later disposal and not poured down the sink.

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Science Communication: Mini Scientists Working on Scientific Method

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Abstract. The uses of demonstrating experiments allow children to undertake any reaction from passive contemplation to active experiments and results exploration. In this approach, we introduce a didactic play related to "Scientists and general science" and some experiments related to both physical and chemical properties using daily procedures and substances in order to offer teaching tools to primary school science teachers. In addition, these activities performed out-of-school, are developed in groups in the openlab at the Scientific Park of Barcelona. Finally, we want to contribute to the improvement of the scientific culture amongst primary school students and to promote their scientific vocation.

Keywords. Chemical and physical testing, children, experiments, playing science.

1. Introduction

In science communication, the use of different educational approaches gives young students a new point of view and increases their science attitude. In addition, the uses of demonstrating experiments, allowing children to undertake any reaction from passive contemplation to active experiments [1] and it results a better exploration of nature, new times need new educational and communicative methods.

Through the Scientific Park of Barcelona (PCB) [2] and the Department of Biochemistry and Molecular Biomedicine [3] at the University of Barcelona (UB) [4] we make available to the young students in their fourth-sixth year of primary school education some experiments using the scientific method. With these activities students have the opportunity to know and investigate several parts of science fields. In this approach, firstly we introduce a didactic play related to "Scientists and general science" preparing young students to increase their science interest. Then, some experiments related to both Physics and Chemistry science fields are completed. Physical and chemical properties using daily procedures and substances in order to offer teaching tools to primary school science teacher are done. In addition, these presentations, activities performed out-of-school, are developed in groups [5] in the openlab (PCB) Figure 1 shows the place and distribution of the openlab.

Figure 1

About 500 children between 9 and 11 years old participate each year from Catalonian primary schools. All of them have a bright and open mind; however, they also have preconceived erroneous thoughts. It is essential to have to correct them when they will start to studying science.

Are you interested in science? This was/is our first question to them. It is well known that many science fields are all around us, around our young students. Thus:

- Living animals and plants in our backyard or garden (biology);
- Curing cancer and other diseases (medicine);
- The speed, the strength and the gravidity in our lift (physics);
- Many substances and chemical reactions in our kitchen (chemistry).

Usually children make a good relationship between science concept and one or more science fields above presented.

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Following this educational approach, each session was first supported by a didactic playing and learning from the old and modern scientists that started with “Think of a double-figure number including 1 to 9” and ended “The scientist in the box with your number is …., he/she was important for…”. Furthermore, the scientific method was used to explain some experiments related to physics as “Weight is not essential when bodies are falling to the ground”, “Light and Rainbow” and “Density concept”. In addition, the scientific method was also used to explain some experiments related to chemistry as “An unexpectedly chemical change” and “If it smells – it is chemistry”

Finally, this article has been written as a dialogue between students and teachers to contribute to the improvement of the scientific culture amongst primary school students, their families and the general public and at the same time promote the scientific vocation among young people.

3. Playing and learning from the old and modern scientists

To bridge the gap between primary school students and the initial knowledge of science led us to propose games [6] to play with classmates that can be developed in the classroom and out-of-school.

Here is a summarize of "Playing and learning from the old and modern scientists"

Think of a double-figure number including 1 to 9, for example: a) 38; b) 92 and c) 55.

Now subtract from the above number the sum of the two figures. For example:

if the number is 38, you have to subtract 3+8=11 and the new number will be 27,
if the number is 96, you have to subtract 9+6=15 and the new number will be 81,
if the number is 55, you have to subtract 5+5=10 and the new number will be 45,

Remember the result.

The scientist in the box with your number is..., Newton, Einstein, Marie Curie, Severo Ochoa, Ramón y Cajal, James Watson, Linus Pauling, Galileo Galilei, Stanley Miller, Ada Yonath, Lavoisier, Dorothy Crowfoot, Frederick Sanger, Friedrich Wöhler and others.

1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25	26	27
28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45
46	47	48	49	50	51	52	53	54
55	56	57	58	59	60	61	62	63
64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81
82	83	84	85	86	87	88	89	90

Table 1

Albert Einstein and Antoine Lavoisier's biographies are explained and discussed.

ALBERT EINSTEIN He was born in Ülm in March 14th 1879 and died in April 18th 1955. He was a physicist and a scientist. He received the Nobel Prize in 1921 for Physics. He is famous for his theories about light, matter gravity, space, and time, which helps scientists to understand these things much better than they had before. His theories are called the theory of special relativity and the theory of general relativity. His most famous equation is $\mathbf{E = mc^2}$ [7]

ANTOINE LAVOISIER He was born in Paris in August 26th 1743 and died in May 8th 1794. He was the father of modern chemistry, was a French nobleman prominent in the histories of chemistry, finance, biology, and economics. He stated the first version of the law of conservation of mass, recognized and named oxygen (1778) and hydrogen (1783), disproved the phlogiston theory, introduced the metric system, wrote the first extensive list of

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elements, and helped to reform chemical nomenclature [8].

Figure 2. Picture shows the scientist faces of: Albert Einstein (1); Marie Curie (2); Linus Pauling (3); Severo Ochoa (4); Antoine Lavoisier (5); Ada E. Yonath (6)

3. Using the Scientific Method to explain science

Scientists want to find, to solve many problems and they get the solutions using the scientific method. The scientific method is a set of techniques for investigating phenomena and acquiring new knowledge [1].

Usually it begins with an observation, and then scientists make a hypothesis which will be proved or rejected by an experiment. The purpose of an experiment is to determine whether observations agree with or not with the predictions derived from a hypothesis. If the hypothesis is confirmed they can formulate a theory.

3.1. Weight is not essential when bodies are falling to the ground

At the beginning of class, the teacher takes a pen and a piece of paper. Then he or she asks the young students, which of these will reach the floor first, the pen or the piece of paper.

An easy question; all the students usually answer that the pen will definitely reach the floor first, because of its weight. It is heavier than paper.

Then the teacher tells the pupils that it is necessary to demonstrate this by the “Scientific Method” and he or she gives them a sheet of A4 paper which they have to cut into two equal halves.

When the students have finished cutting the paper, the teacher does the same. Then he or she, with the two pieces of paper in hand, asks the students which of two pieces is the heavier. The answer is always the same, both have the same weight.

Next the teacher asks the students again, which one will fall to the ground first. Some clever students suggest different situations: Will the two papers fall from the same height? Will there be any wind? Will you let the papers fall the same way or throw one?

The teacher then replies with some more questions. Which one will reach the ground first, if both pieces of paper fall from the same height, there’s no wind and no tricks.

The student’s immediate reaction is that both pieces of paper will reach the ground at the same time. The teacher asks them why and they answer because both pieces of paper have the same weight.

The teacher crumples one of the papers and the students immediately start to complain saying that this is not fair play and they predict that the crumpled paper will reach the floor first. Then the teacher lets both papers fall at the same time and obviously the crumpled paper gets to the floor first. But why, the teacher asks and, suddenly, a part of the students conclude

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because the crumpled paper is heavier than the flat one.

This preconceived mistake is neutralized by the rest of pupils who say that both papers still have the same weight. However, usually a general discussion about the concept of weight starts. The crumpled paper reaches the floor first because there is less air friction. In other words the flat piece of paper falls more slowly because there is more air-friction which creates a "parachute effect". The teacher uses a picture (Figure 3) of the Galileo Galilee's experiment on top of the Tower of Pisa [9]. The scientist let two identical objects fall to the ground, both objects had the same weight and they arrived on the ground at the same time.

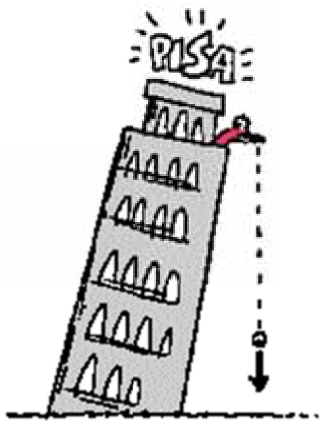

Figure 3

The teacher shows the experiment in a different way; he takes two pieces of flat paper in his left hand and the crumpled one in his right hand. He then asks the students again what is heavier, the two pieces together in his left hand or the crumpled piece in his right hand. Immediately the students answer that the two pieces in his left hand are twice as heavy as the other, the crumpled one. Perfect says the teacher and asks them which one will reach the floor first. The students say that the two pieces in his left hand because together they are heavier. Finally, when the teacher lets go of the papers, "surprisingly" the crumpled paper again reaches the floor first. Conclusion, weight is not essential when bodies are falling to the ground.

3.2. Density concept

The teacher asks the students about heterogeneous and homogeneous mixtures. Then he shows them some photos of different solutions: a glass with water and sugar and another glass with water and oil. The teacher explains that in homogeneous mixtures one cannot distinguish the components for example the sugar diluted in the water. In this solution the "solvent" is water and the "solute" is the sugar.

The teacher asks the pupils: In a mixture of milk and cacao, which one is the solvent and which one the solute. The students answer that milk is the solvent and cacao is the solute.

The teacher asks the pupils again: What is milk? Which components is it made up of? The students answer that milk is made of water, vitamins, fat, proteins, sugar, calcium and more. At this point the teacher clarifies that the solvent in the mixture of milk and cacao is actually water.

Figure 4

The teacher shows a picture of a glass containing oil and water (Figure 4). He then asks: Which one of these two liquids has a higher density? The students answer that oil has a higher density. The teacher then asks again if the students are sure of this and they confirm. Consequently the teacher asks them if they know whether a one-euro-coin has a higher density than oil and water. Their reaction is "Yes, the coin has a higher density."

The teacher asks again what would happen if he put the coin into the glass and they say that the coin would fall to the bottom of the glass. But why is that so, is the teacher's next

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question. The students suppose that the reason for this is the higher density of the coin.

The teacher agrees by saying that things with a higher density will always be below or under things with a lower density. That is why the oil keeps floating on top of the water. The oil floats on top because water actually has a higher density.

3.3. An unexpectedly chemical change "M&M's"

Chemistry studies the composition, structure, properties and change of matter. Each chemical substance intrinsically possesses a serial of properties which can be used to our advantage. The aim of this chemical experiment is to introduce young students to the chemistry world and increase their interest in this science [10].

The question proposed by the teacher was: How to separate the components of food colouring? The students answer that water can dissolve them and the teacher gives them the experiment protocol.

The students distribute "M&M's" into several test tubes with water which will be used to separate the components of food colouring. They shake the test tube until the pill of "M&M's" turns white. Then, the teacher explains that the dissolved food colouring remains in the water. It may not be eaten! The teacher exclaimed. Immediately, the teacher gives to students some test strips (chromatography papers) with a red line painted on them and explain them that they have to put a drop of the extracted food colouring on each of two chromatography papers.

Students follow the protocol and they introduce the paper, with a dry drop of colouring food, in a new tube with clear water and observe the dry drop changes in colours and movement. Finally, the teacher sends to each student this questionnaire:

- What was the initial colour of your M&M's?
- What was the liquid colour obtained from your M&M's?
- Draw the chromatography paper whit a drop of liquid.
- Draw what happens?
- Why it happens?
- How it happens?
- Which changes in drop mobility you could observe?
- Did you observe any changes between different coloured drops from different M&M's?

3.4. If it smells – it is chemistry

Smell is an important sense. Our ability to smell comes down to different molecules activating different combinations of olfactory receptors

In order for us to smell something, molecules, chemical products, from that thing have to make it to our nose. Everything we smell is created by molecules. For example, it smells bread in the bakery or onions and banana in a vegetable shop; he/she smells good, he/she smells a perfume.

At the top of our nasal passages behind our nose, there is a patch of special neurons which are excited by volatile molecules, chemicals that float through the air into our nose. We can smell the volatile molecules, as a result of their evaporation (if it is a liquid, for example: ethanol, limonene or acetone) or as a result of their sublimation (if it is a solid, such as camphor or menthol). However, small changes in these molecules can make a huge difference to their smell.

On the other hand, some volatile molecules cannot be smelled, such as water (H_2O), oxygen (O_2), nitrogen (N_2) or carbon monoxide (CO) which is a colourless, odourless, and tasteless gas that, tragically, is toxic to humans.

Moreover, a piece of plastic, cement or an iron screw have no smell because nothing evaporates from them, plastic, cement and iron are non-volatile solids. Primary school students have been interested in smell several molecules for many times. Several test tubes were prepared and, in each one, a volatile liquid was introduced. Students, finally, have recognised: vinegar, ethanol, acetone, citric acid, orange or lemon juices, ammonia, oil, menthol, hydrogen sulphide, dung bomb, and rosewater perfume.

Authors support that a high-quality science education provides students with a helpful theoretical and experimental concepts and also life skills and career options.

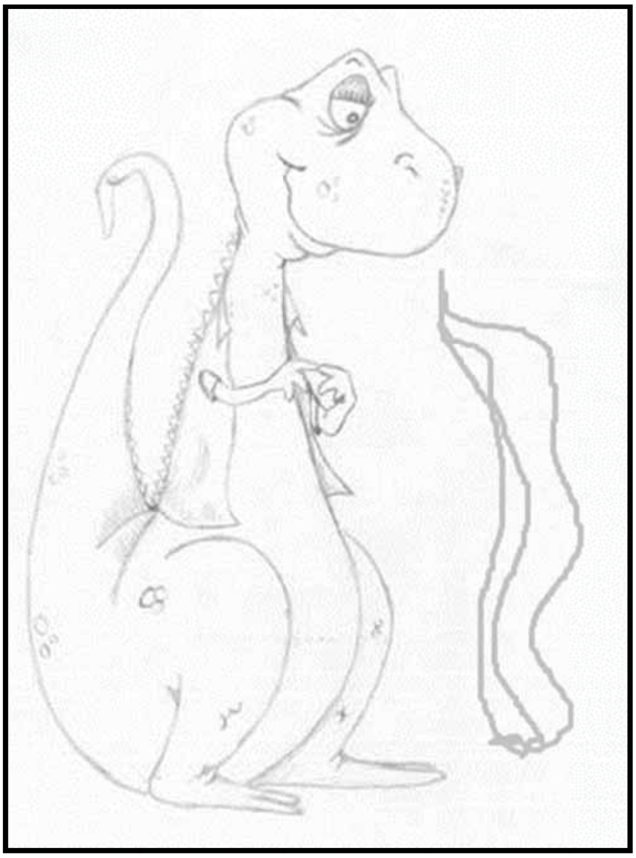

Figure 5. This dinosaur also smell

4. Acknowledgements

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Robotics and Entrepreneurship for a Better Society. Opening Doors to Mobility

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Abstract. This article reports the development of an educational robotics project at the Basic School (2nd and 3rd cycles) André Soares in Braga, with students from 6th grade, integrated in an international cooperative partnership for innovation and good practices of the European Erasmus+ programme.

This project was initially designed to address the need to share innovative teaching practices through the development of new methodologies and multidisciplinary approach in teaching-learning processes in the 2nd and 3rd cycles of basic education combined with the stimulation of entrepreneurial skills and co-creation of knowledge. From the beginning, the project had the collaboration and support of the Hands-on Science Network Association, having given rise to the submission of an application to the 13th edition of the contest "Projeto Ciência na Escola" of the Ilídio Pinho Foundation on the topic "Science and Technology at the service of a better world". This application has been selected for the 2nd phase of the competition and obtained financial support for the development of activities which gave an added dimension to the project, attracting and further motivating students for learning science and the choice of technology areas.

Students were challenged to identify a situation/problem and find a possible solution/answer in the context of educational robotics. Thus, there was the study of the LEGO MINDSTORMS NXT programming environment for programming routines or scripts and simultaneously the work methodology hands-on was implemented using participative methodological approaches, enhancing the development of key skills and entrepreneur spirit. At first, students' creativity was stimulated through the ideas generation process called SCAMPER, channelling it to solve situations/problem where the students' task was to unlock a situation and optimize it. From a simple stick and a simulation of a path for blind people, ideas were collected to innovate this object, in order to promote a more efficient and fairer mobility. With the collection/gathering of ideas/suggestions, a guiding principle for our project was developed giving an intended metacognitive knowledge. Starting with the acquisition of this knowledge, students focus on building and programming robots LEGO MINDSTORMS NXT, developing the prototype of a smart and innovative cane for the blind people. This is an interactive process that combines the concrete and the abstract in solving a problem involving steps such as: design, implementation, construction, automation and control mechanism. In all of these steps the construction of knowledge took place, arising from different scientific fields (science, mathematics, physics, technology), as well as the acquisition of transversal skills.

The work focused mainly on the dynamics of the process rather than the products or results. Many citizenship skills were developed when creating a tool to minimize the difficulties and obstacles faced by blind people, enabling the improvement of their quality of life. It was observed, from certain experimental activities, that one can transfer new skills and knowledge acquired at school to everyday life.

Keywords. Citizenship, creativity, entrepreneurship, educational robotics, hands-on, programming robots, SCAMPER, smart walking stick.

1. Introduction

The development of this project represents, for the authors, an excellent way of application of an exploring and investigative metacognitive approach of science, Inquiry Based Science Education (IBSE). They believe this approach gives students a metacognitive understanding of procedures leading to discussion, communication and argumentation among peers. The creation of ideas and solid cognitive structures gives to this project a way of linking science to society. The methodology used allows the use of the experimental method to evaluate the validity of the ideas and test them, allowing the best choice of ideas and answers that may arise.

The culture of entrepreneurship in the classroom emerges as a differentiated learning, whose final proposal is to strengthen the student's personality and the development of initiative and innovative skills, creation, planning and integration in the real world of work. The stimulation of entrepreneurship skills and the use of knowledge is a process mediated by the teacher's intentional action which promotes a stimulation atmosphere of the thinking and creativity, based on principles of mutual respect, freedom of communication and expression of affection. As stated by Sá et al (2004) [1], through entrepreneurship, confidence is stimulated by the need for finding solutions to the challenge presented by this competition.

School has a role of promoter in the development of creative and decision-making skills as these are key aspects for scientific innovation which is fundamental for the labour market and to society.

The learning trigger has its start in the formulation of questions about the presented challenge, making the world better and fairer, using a programming language and a robotics kit, debating and using science teaching in an experimental, reflective and deductive approach and thereby building knowledge, connected to entrepreneurship.

School plays an essential role in stimulating entrepreneurial skills, rooted in scientific knowledge consolidating the professional and personal development, future for a successful society and interested in others. Probably the project-based learning has its origins in John Dewey (1916) and Kilpatrick's ideas (1918, 1921) who defended the preparation of students for their active participation in real life and in an environment with meaning and purpose. According to Knoll (1997) [2], the project is considered a method by which students can: i) develop independence and responsibility and ii) practice social and democratic forms of behaviour. It is based on active learning where students learn to connect theory to practice and whose theory should provide examples of key aspects of professional goals [3]. Learning methodologies are strategically focused on student's involvement in carrying out activities and think about these activities, involving them in their own learning. This involvement in the project allows them to develop new skills as teamwork, critical thinking, creativity, problem solving ability, communication and project management skills [3].

2. Characterization of the award contest Science in School Project - by Ilídio Pinho Foundation

The contest "Projeto Ciência na Escola" is promoted by Ilídio Pinho Foundation jointly with the Ministry of Education and Science and the Ministry of Economy of Portugal. It established an annual award which aims to motivate all students, from Preschool Education, 1st, 2nd and 3rd cycles of Basic Education till Secondary Education. Using different ways of educating and training, to learn science and choose technological study areas, it is intended to stimulate students' interest in science, by supporting innovative projects.

The project must have an eminently practical and multidisciplinary feature, mobilizing the various curriculum areas for its development, and engage students in experiences and group work, enabling them to recognize the importance of knowledge and the scientific method and entrepreneurship skills.

The 2015/16 edition, on the contest topic "Science and technology at the service of a better world", seeks to promote the potential of science and technology as a response opportunity to the challenges and main problems of today's world, with a view to creating a better world for all. The award is made up of five levels, organized as follows:

- 1st: consisting of projects involving pre-school education children
- 2nd: consisting of projects involving students of the 1st cycle of basic education;
- 3rd: consisting of projects involving students of the 2nd cycle of basic education;
- 4th: consisting of projects involving students of the 3rd cycle of basic education;
- 5th: consisting of projects involving high school students.

The contest is developed in two phases:

1) Ideas Competition, ideas are proposed to be supported by the foundation.
2) Development Phase, after being chosen in phase one we proceed to product development.

After phase two the 100 best projects are selected and invited to make a public presentation in the national display. In this exhibition the most relevant projects will be chosen.

The evaluation of applications has the following criteria:

i. Innovation and creativity (originality of the idea; differentiating elements to the market, enhancing competitiveness);
ii. Planning and organization (processes / procedures and products);
iii. Pedagogical relevance (opportunity to centralize the element - learning and multidisciplinary approach, involving different areas of the curriculum);
iv. Potential of social impact and institutional partnerships (forecast the consequences of project implementation, the expected effects over the target audience);
v. Viability (achieving potential/value of the idea).

The project presented in the competition is worth 70% according to the above criteria and in the national exhibition, while the public presentation is worth 30% of the final project evaluation.

After a first approach to the project and its ideas, students were challenged to discuss and present motivating ideas for the development of an object based on robotics and experimental sciences, and at the same time follow the accuracy of a structured project and respect an established schedule. At the stage of collecting ideas, inspiration material was provided for students and the meaning of entrepreneurship was discussed.

Sessions were given to make students aware of the practice of entrepreneurship and motivate them to promote entrepreneurial practices and build up entrepreneurial activity ideas to make a positive difference in their lives and stimulate thought and understanding processes. This reflective process proved to be important so that students could understand the applicability of ideas and respect the rules.

3. Characterization of the idea

It was decided to proceed with a class project in which students created a valid idea for a business and assumed the role of entrepreneurs. Thus, several steps for this application were defined:

i. Create an idea in which science and technology were at the service of a better world
ii. Develop the product and the necessary scientific expertise to support it;
iii. Define a strategy and a timetable for its development;
iv. Divide roles and responsibilities;
v. Perform different initiatives and testing to build the product;
vi. Disseminate the project to the community;
vii. Promote the product to market;
viii. Prepare an exhibition about entrepreneurship.

A project based on entrepreneurship education is a fundamental type of project for the 21st century youth. According to Pereira, Miguel; Ferreira, José; Figueiredo Oliveira (2007) at school you can learn and practice skills and attitudes that promote a positive relationship with risk, learn to plan and calculate opportunities and identify threats, develop the ability to take the lead and innovate with responsibility and rationality [4, p. 5]. This project seeks to inculcate in students some of the key skills of entrepreneurship and science; built on the interests and availability of teachers and the nature of each context. Its development was integrated in the school subject “Oferta Complementar“ in a period of 45 minutes per week, with a 6th grade class (6º I) from the Basic School 2nd and 3rd cycles André Soares. There were also moments outside the school context, through the creation and promotion of meetings between teachers and parents.

It was decided to integrate this initiative into an international cooperative partnership for innovation and good practices of the Erasmus + program. The "Opening Doors to Europe" project, aims to open doors between schools and enterprises and put students in touch with the working world so they become aware of the skills needed to access the labour market. It assumes the main role in promoting in schools different ways to prepare students for the needs of employers, at a national and international level, highlighting the similarities and differences between the European employers.

This partnership aim is to open communication channels among young people, the education system and entrepreneurship. Students have the opportunity to cooperate and collaborate not only with their school mates but also with students from different countries in Europe. It will also be an opportunity to disseminate all the work in an entrepreneurship exhibition to be held from 6th to 11th March 2017.

Initially it was necessary to create an idea in which science and technology would be at the service of a better world and to achieve this goal the potential of robotics to improve society was discussed. At the very beginning the mobility problems of blind people in our city emerged. After an initial contact with the sensors of Mindstrom Lego kit provided by the Hands-on Science Network, they quickly suggested the creation of a smart stick with the help of these sensors. The first notes were taken and then the first programming approach for the use of the sensors appeared to help solving the problems pointed out by the students. The educational potential of this tool in the teaching / learning process was clear, linking different fields of knowledge, with emphasis on Mathematics, Physical and Natural Sciences and Technological Education.

The result was a very motivating learning process for students and teachers, with an undeniable enthusiasm of all in this phase of the project, as they were able to create, test, make mistakes and learn actively and consistently with the hands-on approach and all the IBSE cognitive processes. At this stage students have acquired self-confidence, which led to an effective and responsible group work.

4. Project implementation

After exploring the computer programming language and its sensors, collaborative work was carried out with school mates, supported by teachers. The process of generating ideas begins. Generating ideas is one of the most important stages of the process, since it is the starting point to make any project successful.

4.1. Generating ideas

It has been established to recreate the walking stick with SCAMPER methodology, developed by Bob Eberlee [5], whose name comes from the acronym created by the initials of the seven steps that make up this technique: Replace, Combine, Adapt, Modify, Find other uses, Delete and Revert. These steps work as possible generic solutions leading to think about specific solutions. This is a very effective method when we need to improve or create new objects, systems or processes based on something already existing. Its application aims to stimulate creative thinking in a targeted way, by exploring different ways to reinvent and solve a problem. The technique also uses a set of questions directed to a problem in order to generate new ideas that normally would not occur, making it possible to guide and organize the discussion of a group and achieve a more productive outcome.

Figure 1. Students explore different possibilities

4.2. Debate and reflection

Questions were put to stimulate reflection and solve this specific problem of mobility. It was possible to explore different possibilities and alternatives with the answers given and the moments of debate that followed it. Students felt the world differently and concluded that the human being not only see with their eyes, but also with all their senses. The debate ended in a set of valuable information source for all participants. The exchange of points of view was a way to encourage new ideas, launching new paths and challenges, urging the progression and bringing them closer to solutions (Figure1).

4.3. Testing

The development phase of the project went through a test of "Orientation and Mobility" for the blind people carried out by students, by walking through a path to assess the physical barriers. After the accessibility diagnosis, a further study of the sensors and possible materials to be used in the development of the prototype was initiated (Figure 2).

Figure 2. Test of "Orientation and Mobility"

This step was extremely important because it gave a more concrete knowledge on this issue, allowing the idealization of a possible and feasible product. The learning by doing means that the student is the main actor of his own apprenticeship, and to do so he has to adopt a research methodology around his own process of learning / teaching (Pereira et al., 2007) [4, p. 16].

4.4. Sketches

Sketches of what students think the walking stick can be appeared as a result of this experience. Through the ideas and features existing in the drawings we can clearly see a world vision closely connected to the Internet. The scanning of this concept quickly set off (Figure 3).

The Internet of Things (IoT) is a technological revolution that connects electronic objects of our daily lives, such as electrical appliances, means of transport and, in this case, the walking stick, to the Internet and interacts with the surroundings. With the active work methodologies that have been applied, students actively participate in the construction of their own knowledge. Young people have to face new situations to prepare themselves to be useful in our society. We must put them in front of challenges and let them find the answers and build solutions. This process promotes learning by trial and error and self-correction. Mistakes serve as source for new experiences that, by this means, reinforce learning.

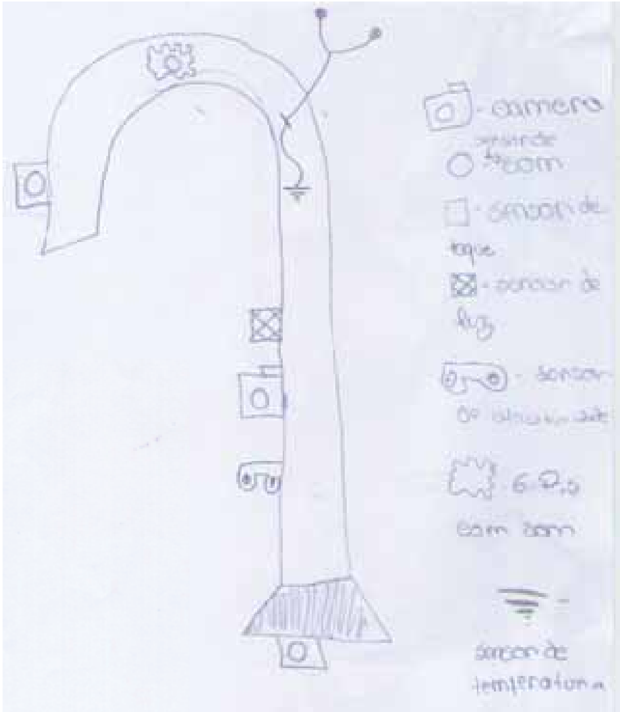

Figure 3. Sketches of the walking stick

5. Communication

The communication process and the dissemination of results, findings and steps is a key aspect for the project's success. The verbalization and discussion of ideas is a tool that enhances the building and sharing of knowledge.

During the process, a group of four students and a school teacher from “Sydvestjyllands Efterskole” school, in Denmark, visited our school to be acquainted with all the work developed based on robot programming. This meeting has reinforced the importance of a clear and accurate communication of the different stages of the project. When facing this situation, students felt the need of a more formal and efficient language to convey the scientific knowledge acquired. The challenge was difficult, since all the dialogue was in English (Figure 4).

Figure 4. Students and a school teacher from "Sydvestjyllands Efterskole" school

Most of the obstacles were overcome and the whole experience was a time of learning and fundamental progress. On the one hand, they realized that sending a message in an efficient and accurate way is very important, especially if we are being observed by people from outside of the school community. On the other hand, this was a unique opportunity to communicate in English and be aware of its usefulness in a real communication context.

Students will have the opportunity to speak foreign languages again, mainly English, during the presentation of this project in an exhibition about entrepreneurship, which will take place in 2017, in Portugal, within the European Erasmus + partners' mobility.

6. The development of the robotic walking stick creation

The implementation of the plan is the time when the class group interacts effectively with the environment, in order to change it, adding value to a fairer society project. Quoting Pereira, Miguel; Ferreira, José; Figueiredo Oliveira (2007) [4, p.49] this is the most motivating activity for students, but also the most demanding, since they will confront all their energy and desires with a complex reality and will learn to cross these two worlds; theirs and the others. It is an extraordinary opportunity to learn and practice their skills productively.

Finally the first version of the smart walking stick is created which seeks to provide society with an affordable prototype, easy to use, and functional model that helps the mobility of the visually impaired. The prototype recognizes the environment and points out possible obstacles and threats to mobility (Figure 5).

Figure 5. First version of smart walking stick

The smart walking stick, for the blind people, helps the user to detect objects, people, and stairs or holes. This stick is composed by a NXT Smart Brick module, which processes all the students' program code. It has a RCX processing block (Robotic Commander Explorer), based on an ARM7 microprocessor. The new RCX processing block is compatible with Bluetooth communication and It has a 32-bit ARM7 microprocessor with 256 KB of memory; USB 2.0 port; 4 RJ12 input; 3 RJ12 output; 1 LCD monitor; 1 speaker and a rechargeable 9V battery (or six 1V5 AAA batteries). This device also has a bag to make it easier to transport.

Two ultrasound sensors are at the bottom of the stick to make the path scanning. They are connected to the smart brick module by RJ12 cables which pass through a PVC tube. These sensors are designed to "see" their surroundings, sending RF signals and waiting for its feedback in order to process the data. The best signal reception is detected when the object is in front of the sensor and it also measures the distance. However it loses efficiency when the object is in a side perimeter. This is why the stick needs to be handled in a pendulum like movement. The sensorial communication is carried out by the servomotor and reinforced by the emission of a sound warning that there is no longer any obstacle set in the program code. This is programmed in a Visual Basic language, based on blocks. This way, students can easily build and test all decision and repetition structure blocks. The NXT Smart Brick module controls the servomotor by the RJ12 outputs. This communication is established when the system detects any object on its way. When the servomotor is operated it creates a counter-clockwise rotation that is felt in the user's hand (Figure 6).

Figure 6. The smart walking stick

These cables are connected to the ports numbered from 1 to 4 of the smart brick. Ports A, B or C there is another RJ12 cable connected to the servo motor responsible for communicating with the user.

This prototype can be a starting point for future and more advanced prototypes for blind people, who can benefit from an easy-to-use walking stick that interacts with the environment. One of the biggest potentialities of this smart stick is the ability to communicate via wireless with the environment, such as traffic lights, shop windows, signs, GPS, etc. and become part of the list of Internet of Things' objects. Students have referred several times that the intelligence of each object could increase the power of the network to return the processed information to different parts of the city, making it an object that interacts with other city objects (Internet of Things).

7. Evaluation

The project evaluation is made on the basis of targets and dates that the group/ class proposes as well as, in case of changes, through the corrective actions undertaken throughout the project development. The evaluation and validation of the idea is based on external organizations that interact with the project.

This project was worthy of a financial support for the implementation of the first phase and was selected for the 13th edition contest "Science in School Project", promoted by Ilídio Pinho´s Foundation, entitled Science and Technology at the service of a better world.

The project is among the eight best projects of the 3rd level, selected to attend the national exhibition, chosen by: i) A representative of Ilídio Pinho's Foundation; ii) A representative of the General Supervision for Schools (DGEstE); iii) A representative of the General Direction of Education (DGE); iii) A representative of the Ministry of Economy; iiii) A scientific expert invited by Ilídio Pinho´s Foundation; iv) A representative of each of the Regional Education Boards of the Autonomous Regions; v) A representative of the National Confederation of Parents' Associations (CONFAP). This selection provides an external evaluation of our working group and the validation of the quality of work done by students.

As a result of the international cooperation partnership for innovation and good practices of the European Erasmus + program, the final product will be presented to a group of foreign students and teachers in March 2017, inserted in an innovative exhibition of products, during an entrepreneurship contest called "IDEAS", as agreed with the "Opening Doors to Europe" project team.

8. Project result

The strategic planning for the development of cultural, social and educational changes involved in the free and unconstrained environment by rigid educational programs and contents make these initiatives a single and promoting tool of autonomy.

The encouragement of collective creativity, widely promoted by international, national and local initiatives, for instance the "Science in School" prize – of Ilídio Pinho's Foundation and Erasmus + program, is an opportunity for teachers to choose for the implementation of activities focused on the reflective teaching of science and its applicability to a more entrepreneurial society.

In this project the entrepreneur or entrepreneurial spirit has been introduced in order to be combined with what is learned at school. As a result, the class faced the need to manage, budget and present the project in an official and formal way towards the scrutiny of the school community and other actors in the world of entrepreneurship.

In the EU2020 Strategy document it is said that “the emphasis should be placed on priority areas such as (...) conditions for R&D, innovation and entrepreneurship, including social innovation". It also adds that to create value by basing growth on knowledge one should "integrate creativity, innovation and entrepreneurship concerns from basic school" [6; p. 5].

Entrepreneurship involves a new way to look around us, to deal with problems and needs and take advantage of the changes and opportunities. Since this is a dynamic process, students have assumed this role by planning actions, putting into practice strategies, proposing solutions and overcoming some of the obstacles in a true teamwork environment. The awareness of the cost of labour is a significant impact on the viability of it, promoting a reflection on the business part, and another variable is added: the financial sustainability of what has been worked and developed (Figure 7).

According to Sá (2007) learning becomes a metacognitive experience when students are encouraged to develop a clear intentionality in their actions, becoming reflexive in planning activities and in its implementation and evaluation [1]. And Piaget (1972) states that children develop their way of thinking based on their interaction with the world around them. Consequently, the effect of hands-on during the process brings added value to the discussed concepts, as well as a clear representation thereof [7].

This teaching experience had a significant training benefit to the understanding of science and programming from the experimentation, design and internalization of all processes. The self-reflexive character was challenging and promoted the critical and reflexive skills, providing the means for a mobilizing and facilitator thought of the dynamics of construction of their own knowledge. It is clearly an entry into an important cognitive phase for the group/ class. There is a degree of self-esteem that allows the group to start developing assumptions and seek to support them.

Figure 7. Students programing

The involvement of different areas allowed the development of educational, communication and technological skills proving to be an advantage for the creation of new knowledge and the promotion of more enduring skills. It was also possible to instil in our students an entrepreneurial culture, which certainly will prepare them to be active and socially integrated citizens.

9. Conclusions

We conclude that, in the initial phase of construction of knowledge, autonomy and the use of language as a metacognitive tool has been predominant for the project discussion, organization, planning and correction. Another important aspect is that one can tell when a student starts a formative learning process through observation, even if it is initially inaccurate. Papert (1980) supports the idea that human beings learn in a more sustainable way when involved in the planning and construction of objects or artefacts they considered significant, sharing them with the surrounding community [8].The external construction process of the object is followed by inner knowledge development that gives a level of metacognitive learning to this experience. There is a degree of self-esteem that allows them to start developing assumptions and seek to support them with valid arguments, exemplifications and verbalizations. It is through the questioning process that students have the possibility to check and test what really learned and validate what they accomplished.

They just did not result in concrete products due to technical limitations of the hardware. Through "hands-on" approach, combined with entrepreneurship education, it is possible to develop in students different technical and soft skills. Some students' ideas were unique and with potential, but they did not give rise to concrete products due to technical limitation of the hardware. The use of programming at school is an educational tool with great potential that stimulates collaborative work, as well as an excellent vehicle to develop project's work methodology. It is considered that to be an added value if these students have the opportunity to keep exploring these pedagogical approaches. The school has to evolve and to experience educational strategies for entrepreneurship, in order to interact with the real world. This project tries to explore the current challenges, although at a reduced scale and at an experimental level. The project here described is a contribution to show the importance of developing entrepreneurship skills, and demonstrates the need for their integration in our educational system. This is a way it brings our young people´s learning closer to what is expected in the real labour market.

On the other hand, it promotes the formation of responsible young people able to have an active and critical role on their own future, with civic and interventional awareness and a key role in building a fairer society for all.

It is with an entrepreneurial Europe that school must proceed, without concealing responsibilities in this process, and also without wasting what all have to give for the construction of an entrepreneur country and a Europe able to recognize these skills.

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Magical and Chemical Summer Camp

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Abstract. The uses of demonstrating experiments allow children to undertake any reaction from passive contemplation to active experiments and results exploration. In this approach, we introduce a didactic play related to “Scientists and general science” and some experiments related to both physical and chemical properties using daily procedures and substances in order to offer teaching tools to primary school science teacher. In addition, these presentations, activities performed out-of-school, are developed in groups in the openlab (PCB). Finally, we want to contribute to the improvement of the scientific culture amongst primary school students and the general public and promote the scientific vocation.

Keywords. Chemical and physical testing, children, experiments, playing science.

1. Introduction

Chemistry is an attractive field of study. There is an unbelievable and marvellous amount of phenomena that children [1-2] might think one is learning about magic and science fiction rather than, actually, about chemistry. The aim of this article is to describe a set of activities related to chemistry that were carried out during a summer-camp in Catalonia, Spain.

UEC, “Unió Excursionista de Catalunya” [3] or in English “Excursionist Union of Catalonia”, is an association promoting mountain sports and offering a platform for organized group activities, technical material and other facilities since 1941. One of its sections called “initiation” is held by a group of recreational monitors who prepare trekking or hiking trips for children or teenagers (there are a total of five groups within different age-ranges).

At the end of the last educational or academic course, in summer 2015, the first group of primary school children, aged 7 to 10, spent a summer camp near Saldes, a village situated at the centre of Catalonia. Figure 1 shows it.

Figure 1

At this age, the participants cannot do long, hard and obviously technical trips, so the summer camps are usually divided in five days camping in the mountains, two days of trekking and two days at a campsite.

During the summer camp there is a script to follow named “interest centre or target”. It is a kind of story where the children play an important role. In 2015 the "interest" was about the "magical world" when our world had collapsed because an evil Arch mage had deleted the magic. The kids participated in some activities to recover the wonderful magic of the elements, every day focused on a different element, and at the end of the journey a ritual was made in order to verify that their actions had been enough to recover the magic.

One more, following this screenplay, chemistry and magic became one. Each ritual was supported by a chemical experiment, such as the disappeared sheet music, the Pharaoh’s snake, toothpaste to the elephants, mastering fire, colour-changing cabbage infusion or the air generation inside a closed bag. Children could not understand [4] each experiment but they knew that one of their monitors was a biochemistry-student, so they didn’t believe in magic, rather they were sure the amazing result was related with chemistry.

To solve these situations, the pre-scientist and magician monitor tried to explain as simply as possible the results, he introduced concepts such as pH in terms of basicity and acidity (not proton concentration) or that gas was just a matter state, thus, by releasing a component in gas-form, result of a chemical reaction inside the bag, the bag would expand similar to an airbag.

The experiments explained in this article are easy to do and harmless so they can be used to explain chemistry concepts to the children, more or less thoroughly. Moreover, most of the reactants or materials used can be obtained in any supermarket or drug store.

3. Magic Rituals - Experiments

The materials used in the rituals can be easily found in any supermarket, with the exception of the potassium iodide which can be obtained at University of Barcelona.

3.1. First Day – The Mysterious Crystal Bottle

Following the hero's instructions, the first day the children found a mysterious crystal bottle which contained magic water. The coaches saved this item which was later part of the ritual of the day.

3.2. Second Day – The Disappearing Music Sheet

This was the day of music and the objective of the ritual was to teleport a sheet of music to the fantasy world.

Procedure (to do before the experiment): write a magical song (the easiest would be a G major scale, this way the children can easily sing it during the ritual to make a greater show of it) with the marker on the expanded polystyrene. This is done before the experiment starts to safe time.

Materials and reactants: expanded polystyrene (din-a4 size would be optimal), marker, acetone, colourless and transparent recipient that resists acetone (glass, common plastic bottles work).

Experiment:

1) Children are told to keep a certain distance to the recipient. There is no risk, but the strong smell of acetone can be easily detected, if the audience is too close. Still, if the odour is sensed, it can be attributed to the marker.
2) Add magical water (acetone) to the recipient, making sure it covers almost half of it. Optionally, a spell written on the sheet of music can be sung in order to create the magical gate.

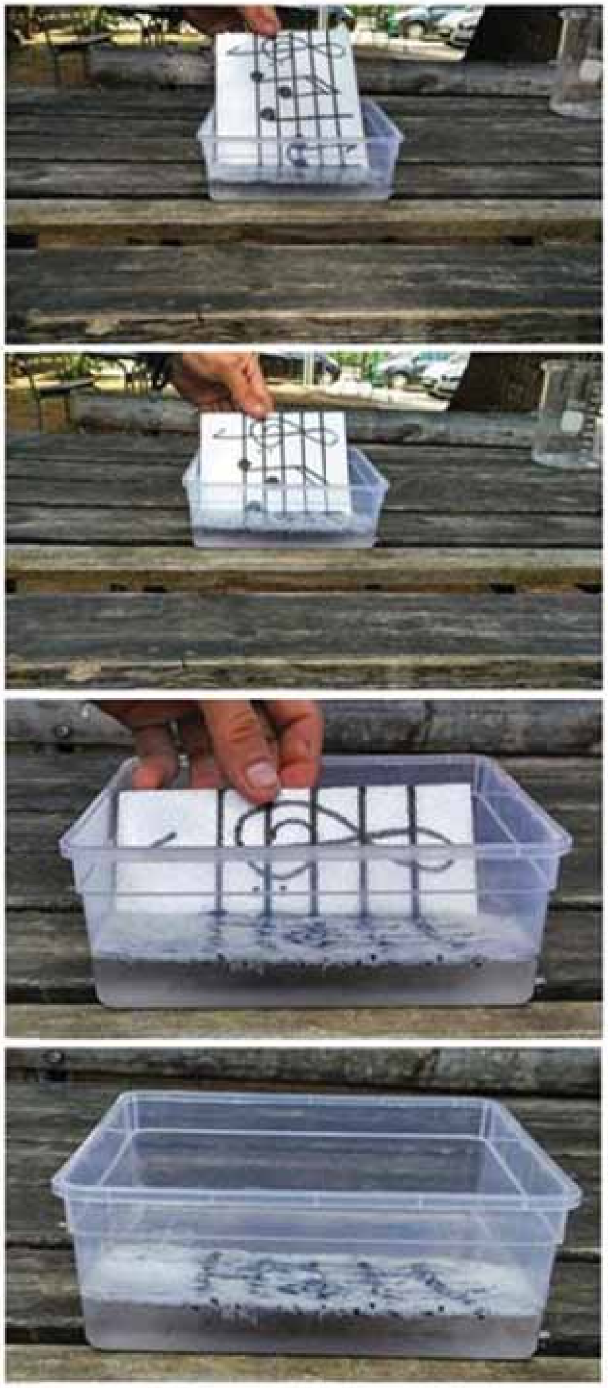

Figure 2. Experiment [5]

3) Slowly, the sheet of music is introduced into the acetone, where it dissolves instantneously.
4) The experiment can be tried with water to show that the ritual only works with magical water.

3.3. Third Day – The Pharaoh's Snake

This was the day of celebrating life, and the objective was to summon something from the other world.

Materials and reactants: “glacé” sugar (if possible, if not, common sugar); domestic bicarbonate; domestic ethanol (98º); sand; fire source; fire – resistant recipient.

Procedure (to do before the experiment): a) mix sugar and bicarbonate in proportions 3:1. The more quantity you use, the more impressive the experiment will be; b) add a bit of ethanol to the sand (enough to set fire to it for a few minutes); c) add sand to the sugar and bicarbonate mixture.

Experiment:

1) Be sure there is enough security space between the children and the recipient. The fire is confined to the recipient, but make sure there are no dangerous products or easily combustible materials.

2) Fire is set to the mixture. Optionally, a spell can be sung before or during this magical process. A snake-like structure will appear from the sand, which is supposed to be the Pharaoh’s snake we invoked.

Figure 3. Experiment [6]

3.4. Forth Day – Elephant Toothpaste

This was the water day, and the objective was to form a huge amount of foam instantly.

Materials and reactants: glass cylinder (as recipient); KI; H_2O_2 (30%); colorant (optional); liquid soap.

Procedure (to do before the experiment): add soap to the recipient. Colorant can also be added to make the experiment more impressive.

Experiment:

1) Add hydrogen peroxide is, but tell the children that the liquid is common water. Make sure the children are far enough away from the reactant since H_2O_2 is corrosive. Gloves can be worn for security reasons. The more reactant used, the more impressive the experiment will be.

2) When some drops of magic water (KI) are added, foam is rapidly generated and overflows from the recipient. This foam is generated by water and soap without mixing because magic has been restored. The children can play with the foam.

Figure 4. Experiment [7]

3.5. Fifth Day – Dominating Fire

This was the fire day, and the objective was to avoid fire from burning a paper.

Materials and reactants: common water; domestic ethanol (98º); clothes pin; recipient; paper.

Procedure (to do before the experiment): a) optionally, some enchantments can be written on the paper; b) prepare 1:1 ethanol and water mixture.

Figure 5. Experiment [8]

Experiment:

1) Ensure there is enough space between the children and the experiment so they won't get burned and won't sense the ethanol smell.

2) Submerge the paper into the mixture, the magical water.

3) Take back out the paper with the clothes pin and set it on fire. Although the paper is covered in flames, it does not burn, because "the magical scripts are protecting the paper". Furthermore, and to the astonishment of the audience, there are flames although the paper is wet!

Another experiment can be done using plain water instead of magical water to see that the fire is not set.

Figure 5 shows this magical experiment. A paper into magical water. B and C, this paper does not burn. D a piece of paper is burning without magical water [8].

3.6. Sixth Day – The Colour-changing Cabbage Juice

Figure 6. Experiment [9-10].

This was the nature day, and the objective was to change the colour of cabbage juice. Figure 6 shows colours of depending on pH and red cabbage juice [9-10].

Experiment:

1) Cut the cabbage and blend it (half of the blender's volume filled with water).

2) Add some drops of magical water (this time it will be plain water, just for the show of it).

3) Add the juice to the glasses.

4) Add a spoon of soda to one of the glasses and a spoon of vinegar to the other one.

3.7. Seventh Day – Air Generation

This was the air day, and the objective was to generate air inside a closed bag.

Materials and reactants: two bags, one smaller than the other. The big one has to be opaque and hermetic; vinegar; domestic bicarbonate.

Figure 7. Experiment [11]

Procedure (to do before the experiment): a) put bicarbonate inside the big bag; b) put vinegar inside de small bag; c) close the small bag and introduce it into the big one. Close the big bag hermetically.

Experiment:

1) Drop some magical water on the bag (just for the show)
2) Compress the bags until the little bag explodes and the vinegar mixes with the bicarbonate. Then the big bag starts swelling up, supposedly because of the generation of magical air. Optionally, the kids can be asked to blow at the moment when the bag is compressed, as if the kids where swelling the bag themselves.
3) The big bag may burst open if too much CO_2 is generated.

The experiment must be practiced beforehand to adjust the amount of bicarbonate or vinegar.

4. Acknowledgements

We thank children’s participants, for their inputs, fundamental cooperation and enthusiastic magical think.

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Can You Tell if It Is Sugar or Salt Without Tasting It?

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Abstract. This challenging question served as an introduction to the chemistry part of the program “Academia de Verão Junior” - an initiative that brings middle school students to participate in summer school activities at the University of Aveiro. The laboratorial experiments of the activity here described are programmed for two 2 h periods. The young researchers are prompted to solve the query “Can you tell if it is sugar or salt without tasting it?” They commence by building a hand-held conductivity meter to detect if the sugar and the salt solutions have ions. They are then able to tell if which of the two unknown samples is sugar or salt. Next they use the hand-built ion detector to investigate many other solid and liquid substances either provided by the lab or brought from home. From the results of this plan-observe-explain activity they are able to classify solutions (or liquids) into conducting and non-conducting. In an inquiry context they also learn that visually similar substances may have very different properties. And in an implicit way they learn that this fact may have implications in their investigation and also in safety procedures.

Keywords. Conductivity, hand-built conductivity meter, ions, liquids, molecules, solutions.

1. Introduction

Sugar and salt are to all appearances similar, since they are both formed by white crystals, as Figure1 evidences. Yet, they are remarkably different, not only in the chemical elements that constitute them, but also in their physicochemical properties. Since different substances are made from different atoms, ions or molecules, they interact with water in different ways. In fact, some substances contain ions that split apart when dissolved in water. Others contain molecules that upon interaction with water form ions, and finally some substances are formed by molecules that just separate from one another, and get surrounded by water molecules and do not form ions.

Figure 1. White crystals of table salt (left) and sugar (right)

The solutions of those substances that decompose into or originate ions are good electrical conductors. For the rest, whose dissolution process consists of water molecules surrounding neutral molecules, there are no charged particles in the solution to conduct electricity. Electrical conductivity may be a simple way to distinguish visually similar substances.

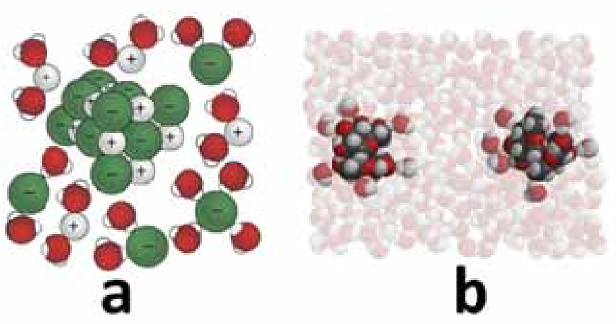

Figure 2. Water dissolving a) salt (NaCl) b) sucrose (from [1])

Table salt is chemically a salt formed by sodium and chloride ions, NaCl; when the salt crystals are dissolved in water, the negative and positive ions are surrounded by water molecules, and the solution formed is a good electrical conductor (Fig 2.a). Sugar is a generalized name for a class of sweet and soluble carbohydrates, sucrose being the most commonly sweetener used. This substance is formed by molecules containing hydrogen, carbon and oxygen atoms: $C_{12}H_{22}O_{11}$. When dissolved in water, sugar molecules go apart from each other and are also surrounded by water molecules (Fig, 2b). The molecules bear no charge, so their solutions do not conduct electricity. In spite of being two white crystalline substances that originate colourless solutions, table salt and sugar solutions have different characteristics: the first originates positive and negative ions while sucrose solutions have none.

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2. Conductivity of the solutions

The difference in the ion content of their solutions is the property that tells the difference between sugar and salt. The conductivity of each solution has to be measured and an adequate apparatus is needed. Instead of using a commercial conductivity meter - a black box with numbers in the display - it is much more pedagogic and exciting to build one. The hand-build device here described is not able to quantify the ions in solution, but is able to detect its presence (Note 1). Nonetheless, this rudimental instrument serves its purpose well and the benefits of building it up far outweigh its limitations.

The activity here described commences with a discussion about its theme and its objectives. An experimented supervisor guides the debate, so as to intervene the least possible but keeping a lead towards the goals of the inquiry based experiments.

3. Hand-build conductivity meter

Having discussed the problem, the young researchers realize that, first of all, they need a device to detect the presence of ions. And to their surprise, they are prompted to build one.

The hand-build conductivity detector is an electrical circuit formed by a 9-V battery, a light-emitting diode (LED) (Note 2), clips, wire and resistors [2,3]. To assemble the circuit, the required components were to be soldered together using a low-melting mixture of several metals (solder). However, that procedure is neither convenient nor safe for young participants, since they might injure themselves while attempting to solder the wires. To overcome this limitation, in this work, a circuit board (Figure 3.a) is used instead of solder to make the required electrical connections [4]. The electrodes were previously made from 1,5 mm stripped copper wire (Figure 3.e). Instead of clips to connect the electrodes, an electrical plastic connector may also be used (Figure 3.d). It has the advantage of keeping the distance between the copper wire electrodes fairly constant. As for the other wires, one strand ones are to be preferred since they can be easily inserted onto the board.

A scheme (Figure 4) is handed to the young students to help them throughout the process of assembling the circuit. For the sake of simplicity no resistor was used in this circuit, since the objective is solely to determine if the solution contains ions.

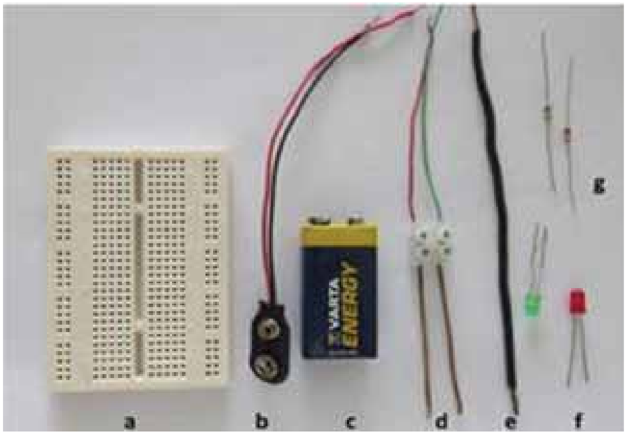

Figure 3. Parts needed to build a conductivity meter: a) board, b) battery cap, c) 9V battery, d) electrical connector with copper wire electrodes, e) copper wire, f) LEDs g) resistors (optional)

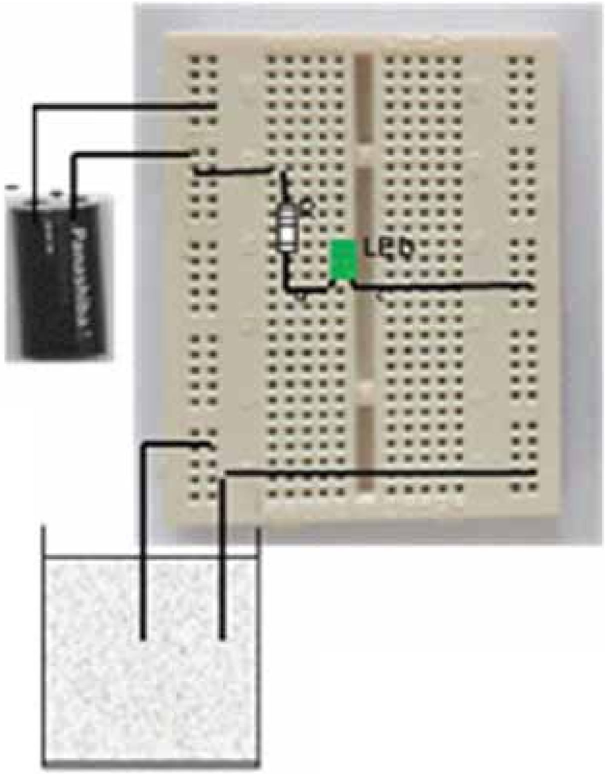

Figure 4. Scheme of the circuit to be assembled on the board to build a conductivity meter

The participants are encouraged to build the conductivity detector by themselves with minimum intervention from the instructors. Besides safety, the use of a circuit board has also the advantage of making it much easier to assemble and disassemble the parts, thus

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providing a wonderful opportunity for trial-and-error learning.

After building and testing the non-sophisticated conductivity meter (Note 3), by putting a resistor between the two electrodes, the young researchers are ready to analyse the samples.

4. Salt or sugar?

After a brief oriented conversation, the participants usually realize that they should prepare a solution of each known substance. Also that the same amount of substance and the same volume of water should be used. They prepare each solution by dissolving 10 g of substance in 100 mL water in a beaker (and stick a label on it!).

Holding the ion detector in their hands, the young scientists are ready to inspect each of the known solutions of sugar and of salt.

They follow the sequence below:

- immerse the copper electrodes in the solution
- observe if the LED emits lights
- infer on the presence of ions in solution
- evaluate the conductivity of the solutions
- classify the substance into electrical conductor and non-conductor, respectively.

Having clearly observed the difference between sugar and salt solutions (Figure 5), the participants are ready to identify the two samples of unknown crystals and correctly answer the query. They just have to prepare a solution of each and detect which contains ions: that will be the salt! So, one does not have to put the samples in the mouth to tell which is which; the electrical conductivity of the solutions of sugar and salt may be used to identify them.

Care must be taken not to contaminate the solutions; the copper wire electrodes must be carefully rinsed with distilled water and dried with a paper towel before being submerged in the sample solution. The electrodes should be immersed in distilled water and the LED should not illuminate. If it shines, the copper electrodes should be rinsed with distilled water.

If a semi-quantitative estimation of the conductivity were to be made, the inter-electrode distance as well as the height of immersed electrode should be kept as constant as possible, but that is not the purpose here.

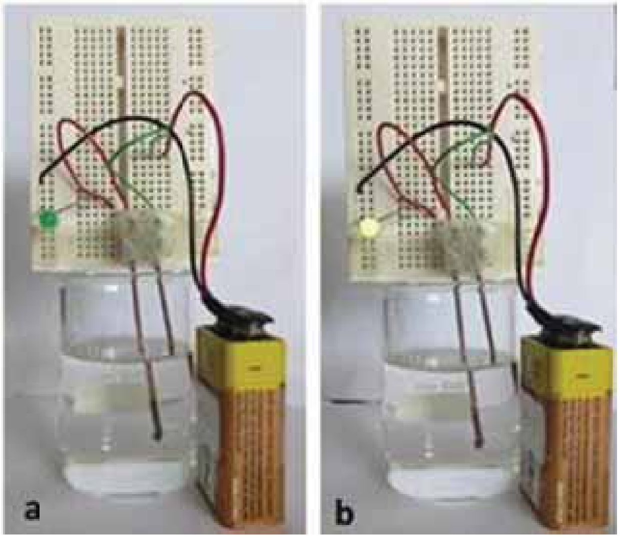

Figure 5. Detecting the conductivity of the sample solutions: a) sucrose solution – the LED does not shine; b) salt solution – the LED shines brightly

5. Not just sugar and salt

The participants may further test several other substances to find out if the liquid samples or the aqueous solutions of solid ones contain ions.

The substances that are available to analyse include potassium chloride, citric acid, acetic acid, ethanol and acetone. It is advisable to begin with a similar substance, another salt, e.g. potassium chloride, to make it easier for the young scientists to predict, observe and explain what happens.

And the young researchers also have the opportunity to investigate their own samples. By the time the summer school program is advertised, the participants are invited to bring along samples they would like to investigate. And many do so, the most frequent samples being drinks (cola, juices, soda water) but also Epson salts, baking soda and similar. They are also motivated to compare tap water and distilled water.

Finally and in case the suggestion did not come up along the activity, the instructor should question the participants if it would not have been simpler to just measure the conductivity of the solid samples, directly. Many answers will be affirmative, so the participants should carry out the test by immersing the electrodes in salt and sugar crystals. A debate then emerges to explain the discrepancy (at least for some) between prediction and observation. The young investigators usually come up with a fairly correct explanation, but if that is not the case, the instructor should help them to find an explanation for the lack of conductivity observed for solid samples.

6. Final remarks

This labwork took place as part of the program “Academia de Verão júnior” [5], an initiative that brings middle school students to participate in summer school activities at the University of Aveiro. In the past two editions (2014 and 2015), nearly forty 7th, 8th and 9h graders were involved in this hands-on laboratory experiment. A senior member of the staff with the help of 3 or 4 university students (1st and 2nd Chemistry related degrees) oriented the group of 18 visitors.

An important goal of this hands-on activity is having the young researchers building a device to assist them in solving the prompting query, which is a direct illustration of happens in modern science. In this inquiry based labwork, the participants are incentivized to predict, observe and explain what happens. This kind of activities fosters their reasoning and also helps them to make their views explicit through explaining the reasoning behind their predictions and observations [5]. Furthermore, these experiments help the lab apprentices to interiorize the fact that similar substances may have very different properties. A fact that implies that to investigate apparently similar samples different methods may have to be used. Although in an implicit way, this activity also sets the grounds for safety procedures. Substances that look alike may be dangerously different so careful procedures should be followed to ensure safe lab work.

7. Notes

- 1: This type of conductivity meter was used for several editions of a general Chemistry lab for freshman of different non Chemistry degrees (Environmental Sciences, Physics, and Biology) [4]. In that course, a variable resistor was put before the LED, as suggested in [3]. This way, differences in intensity of light of the LED are easily recognized, and a semi-quantitative evaluation of the conductivity of the solutions may be achieved.
- 2: When using a LED, it may be advisable to use a 1 kOhm resistor to protect it when the conductivity of the samples is high. Also important is to remember that LEDs have polarity, and the longer wire is to be connected to the resistor which is turn is connected to the positive wire of the battery cap.
- 3: To test the conductivity meter a metal plate may also be inserted between the electrodes; middle school students usually identify metals as good electricity conductors. If all the parts are properly assembled, the LED shines on; otherwise, every connection should be checked until the desired light is observed.

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School' Hands–on Science Education and Surface Plasmon–Polaritons' Scientific Research

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Abstract. Surface plasmon - polaritons' study is a hot topic in nowadays Science world. The potential applications of surface plasmon - polaritons in areas as data storage, near – field optics, solar cells, waveguides, spectroscopy and biosensors, justify the huge interest and on-going research efforts of both theoreticians and experimentalists. This paper outlines the surface plasmon – polaritons' characteristics, some applications and provides online resources for nanotechnology and plasmonics hands – on experiments for the classroom.

Keywords. Surface plasmon-polariton, nano-technology, hands-on experiments.

1. Introduction

Surface plasmon-polaritons (SPP) are non-radioactive, trapped (confined) electromagnetic waves on the interface between a dielectric and a metal, and they are obtained by the collective oscillation of the free electrons from the metal (Figure 1).

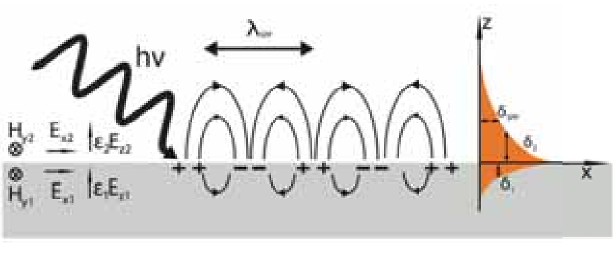

Figure 1. Surface plasmon-polaritons [1]

SPPs are localized to the surface of the metallic nanostructure. Even first observed in 1902 [2] and theoretically described by Ritchie in 1957 [3], SPPs attracted again the scientists' interest in recent years, when metallic nanostructures were built. Special properties of SPPs are currently studied by specialists in data storage, microscopy, wave guiding, spectroscopy, biology, medicine, solar cells and so on.

In this paper I will present the surface plasmon – polaritons' characteristics, some applications and provides online resources for nanotechnology and plasmonics hands – on experiments for the classroom.

2. SPPs main characteristics

The first main characteristic of the SPP is the mismatch between incident light momentum $\hbar k_0$ and the SPP momentum $\hbar k_{SPP}$, for the same frequency ($k_0=\omega/c$ is the free-space wavevector).

Solving Maxwell's equations and imposing the boundary conditions at the dielectric-metal interface, we obtain the SPP dispersion relation:

$$k_{SPP} = k_0 \sqrt{\frac{\varepsilon_d \varepsilon_m}{\varepsilon_d + \varepsilon_m}}$$

where k_{SPP} is the SPP wave vector, $k_0=\omega/c$ is the free-space wavevector, ε_d is the dielectric relative permittivity and ε_m is the metal relative permittivity (ε_m is frequency dependent). For a single metal-dielectric interface (Ag-air) in the absence of losses, the dispersion formula (1) is shown in Figure 2:

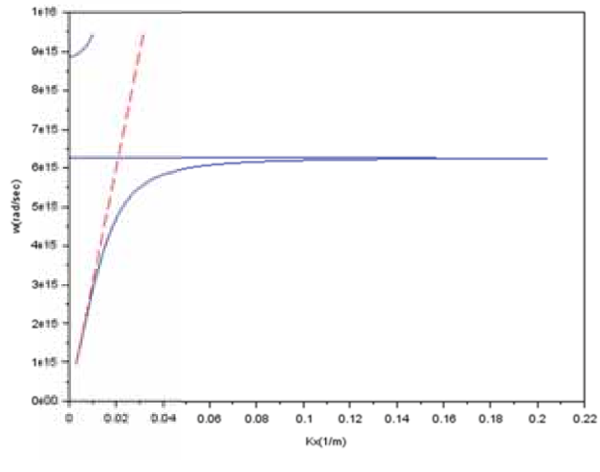

Figure 2. SPP dispersion curve (blue curve) and the light line (red)

The red line in Figure 2 represents the vacuum free-space light line. This graph was plotted using Scilab open source software [4]. The imaginary part of the k_{SPP} was neglected.

In order the SPP to exist, ε_d and ε_m have to have opposite signs. This condition is satisfied because ε_m is both complex and negative. The response of the materials to the external fields is, generally, dependent by the field's

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frequency. Consequently, the material polarization doesn't instantly answer to the application of an external electric field, but there is a difference in phase. From this reason, the metal permittivity is considered a complex function frequency dependent, because complex numbers allow specifying the module and the phase. In the Drude-Lorentz model and in the absence of losses, this dependence is as follow:

$$\varepsilon_r(\omega) = 1 - \frac{\omega_p^2}{\omega^2}$$

The real part of the relative permittivity $\varepsilon_r(\omega)$, plotted in Scilab for silver, gives Figure 3 graph. Surface plasmon-polariton wave must satisfy Maxwell's equations and the continuity conditions the separating metal-dielectric surface.

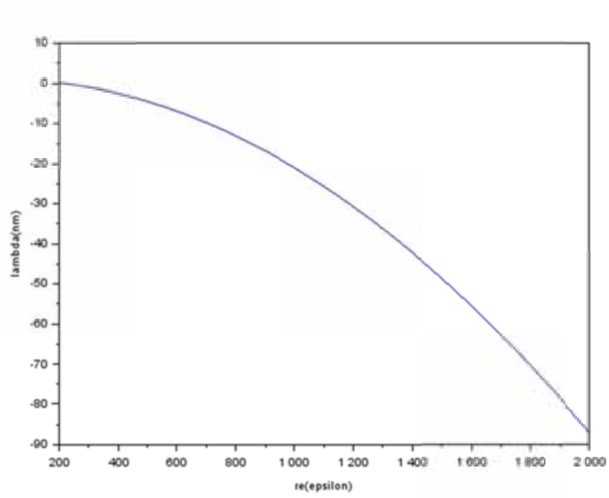

Figure 3. Silver real part of the relative permittivity, in agreement with the Drude-Lorentz model, plotted as a function of the wavelength in nm

Considering an electromagnetic wave p-polarized (E vector parallel to the incident plan) falling on a metal-dielectric interface (Figure 4), propagating in the x-direction, another characteristic of the SPPs is that the field decays exponentially away from the interface (in the z-direction), in consequence, it is said to be evanescent.

The scientists define the propagation length δSPP and the skin depth δ. The propagation length δSPP is the distance for which the SPP wave intensity in the x-direction, drops at 1/e from the initial value (see Figure 1). The skin depth in the metal/dielectric material (δ1/ δ2) is the distance in z-direction for which the field intensity decreases to 1/e of the value from the surface (see Figure 1).

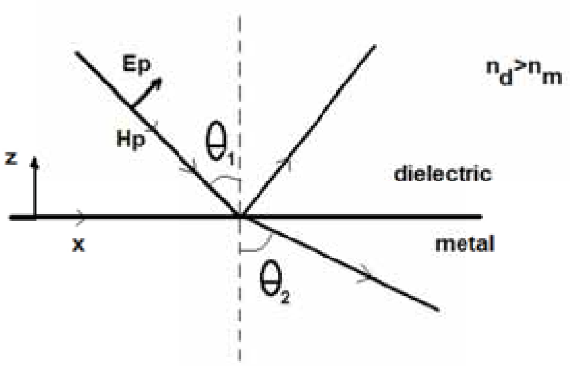

Figure 4. P-polarized wave incident on a metal dielectric interface

The propagation length is an important measure because it sets the upper limit of the size of any photonic circuit based on SPPs. The depth of penetration determines the minimal size of the circuit elements that can be used and may be one or two orders of magnitude smaller than the wavelength of the used light.

The ratio δSPP/ δ gives the number of plasmonic components that can be part of the integrated circuit. The researchers concluded that silver is the best metal for this purpose, for a wavelength of 1,5 µm.

If, instead of an interface, we have two interfaces, such a dielectric-metal-dielectric (DMD) configuration or a metal-dielectric-metal (MDM) configuration, the plasmon-polariton waves of the two interfaces can interfere, depending of the thickness d of the middle layer.

3. Some potential applications

A very interesting property is that SPPs allow guiding light using devices with dimensions smaller than the wavelength of the used light, which can lead to miniaturization of the circuits under the so-called "diffraction limit", considered insurmountable until recently.

In order to design compact optical integrated circuits with surface plasmons, scientists have to work out some practical methods to control the direction of propagation of the plasmon-polariton waves. A group of researchers from China [5] presented a holographic direct method of SPP's control on a metal surface using Huygens-Fresnel principle.

Another group of physicists from the UK, China and Germany [6] created a metasurface with a metallic film containing rectangular holes of nanometric size arranged in a certain way so as to control the quasi-particles occurring during the interaction between the incident light and the metal surface.

SPP photonic waveguides on computer chips can be another application. Because of their low power consumption and their large bandwidth, SPP photonic waveguides can function either as off-chip or on-chip interconnects. Also, they are the signal carriers in integrated photonic circuits. For both possible applications, an important goal of the scientists is to arrange the waveguides as densely as possible

SPP waves can be applied also to make high-efficient solar cells. In such device that makes use of plasmonic field concentration to minimize the active dimensions of the cell, sunlight first needs to be converted to SPPs, which should subsequently be absorbed by the active material.

Surface plasmon resonance (SPR) has high perspectives to be used for label-free sensing of small concentrations of molecules. Medicine, Biology and Chemistry can benefit enormously from SPPs study, due to the very high sensitivity of the plasmonic interaction between metal nanoparticles to their separation and to the refractive index of the surrounding medium.

Another powerful application of localized plasmonic resonance (LSPR) is the enhancement of Raman scattering in surface-enhanced Raman spectroscopy (SERS) to reveal chemical fingerprints of molecules with sensitivity up to the single-molecule level. In a similar way, the fluorescence of an emitter in the proximity of metal nanostructures, allows the utilization of metal nanostructures as nano-antennas.

Material engineers also explore the possibility to construct a material composed of multiple SPP waveguides that can show negative refraction in the third dimension as well.

4. Online resources for nanotechnology and plasmonics hands–on experiments for the classroom

2015 was declared by the United Nations, The International Year of Light, just to celebrate the importance of light for Science and Arts, and to realize the overall impact of light-based technologies at all levels of society.

Plasmonics and nanotechnologies are cutting-edge areas in today Science research world, but no so familiar to many high-school students. Still, the fact that these two domains are a potential source for innovation and on the top ten list of main challenges for the 21st century, make them very attractive for many STEM teachers interested in interdisciplinary creative and innovative teaching. European universities and high-level vocational training programmes already cover nanotechnology extensively. I'll try to provide here a list of online resources to support Science teachers.

For example, NanoBioNet [7] provides vocational courses and training for teachers, but has developed also a multilingual (German, English and French) experimental kit (the NanoSchoolBox [8]) to teach school students about nanotechnology. Some of the experiments in the NanoSchoolBox are suitable for demonstration experiments; others can be integrated without too much preparation into hands-on lessons under the guidance of the teacher.

UnderstandingNano offers lesson plans on three topics: Introduction to Nanotechnology, Nanotechnology in Medicine, and Environmental Nanotechnology [9].

Exploring the Nano World is a collection of videos and course material for teaching K-12 students about nanotechnology, prepared by the University of Wisconsin [10].

The Nanobiotechnology Center at Cornel University has educational opportunities, including a nanotechnology workshop for teachers and a month long summer internship for high school students [11].

Nano.gov [12] offers a new way to learn about nanotechnology.

The German Nanotruck brings people closer to the subject using touring exhibitions that can

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be booked for public events [13].

Of course that this list is non-exhaustive and there are many other online resources that provide information, videos and games for promoting forefront scientific areas for schools and students.

5. Conclusion

As we can see, researchers have much work to do, but the foreseen results worth every effort. We can wonder how our world will look like in the day when much dreamed optical computers will become reality and no data will be processed by electrons, but by light?

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Historical Perspective on School Experiments in Teaching Physics and Chemistry

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Abstract. In the paper we investigate the beginnings of school subjects of Physics and Chemistry and their didactics in the Czech lands. They appeared in the curricula of public schools during the 19th century. Teaching content and methods used at those times are still present in the current education. Great number of simple school experiments developed earlier is still being used at modern schools as they adequately and clearly demonstrate laws of nature. Some important circumstances of the educational system transformation are discussed. Then we present several interesting school experiments selected from original old textbooks and methodology books. At the end the influence of Ernst Mach on the world development of experimental and theoretical physics, philosophy and science education is commemorated.

Keywords. School experiments, science education, physics, chemistry, history, 19th century.

1. Introduction

The requirement voiced by Jan Amos Komenský (1592–1670) to incorporate natural sciences into general education had been ignored for over a century [1]. A fundamental change occurred in middle of the 19th century when the countries of the “old continent” radically reformed their educational systems. Second half of the 19th century was in sign of rivalry between classical education based on classical languages and modern education largely incorporating natural sciences. A controversy rose also about women's equal right for education. Remarkably, this worldwide movement was depicted in the famous novel by L. N. Tolstoj Anna Karenina [2] first published in a serial form 1873 to 1877.

Finally, natural sciences have asserted themselves and nowadays they take a great part of curricula at all levels of education worldwide. We investigate this great transformation from the point of central European view focusing on the role of physics and chemistry school experiments in science education.

2. The science education reform

In the Czech territory compulsory school attendance for both boys and girls started by the imperial Education Act (i.e. Hasner's Law) in 1869 [3]. The law established public schools called “obecná škola“ (in German: Volksschule) and higher quality schools called “měšťanská škola” (Stadtschule) both having 8 grades (for 6 to 14 years old). The language of instruction was to be determined by the Regional School Authorities; Czech became the most widespread language at public schools. The lack of competent teachers was solved by establishing educational institutes called “Učitelský ústav” dedicated to training teachers (4 years studies). At public schools there appeared a new subject “Přírodozpyt” consisting of “Silozpyt” (Physics) and “Lučba” (Chemistry). Other subjects were “Přírodověda” (Biology), “Zeměpis” (Geography), “Dějepis” (History), “Náboženství” (Religion) etc. Physics and chemistry were perceived as investigative disciplines while biology, geography and history were descriptive. An important point is that physics and chemistry were taught as one subject for several decades. In the textbooks of “Přírodozpyt” physics and chemistry were divided into separate chapters although inter subjects links were taught, too.

3. Textbooks

In the middle of the 19th century most of natural science and teaching methodology literature available in the Czech lands was written in the German language. Several titles by J. A. Komenský about pedagogy and didactics written in “Old Czech” and later Czech language were available to scholars and teachers, too. These sources were used to gradually develop and improve original Czech physics and chemistry textbooks for all levels of school education including textbooks and methodology books for teachers. Dozens of textbooks were published by the end of the 19th century – some mostly theoretical, others focusing on experiments.

A very useful book for teachers was written by E. Stoklas: *Instructions for physical and* *chemical experiments, as well as fabrication of simple devices* with 122 pages and 100 figures [4]. Some experiments presented there are rather funny nowadays – see the instructions to demonstrate the effects of electricity on human body: "Pupils make a chain holding each other's hands. Those on the ends of the chain touch a wire connected to the charged Leyden jar. Everyone feels an electric shock at the same time. Weak pupils should be excluded and nobody should be forced to participate, because, as it is said, shocks are not very healthy. Only small Leyden jar should be used. Weaker pupils can take the shock from the grounding wire."

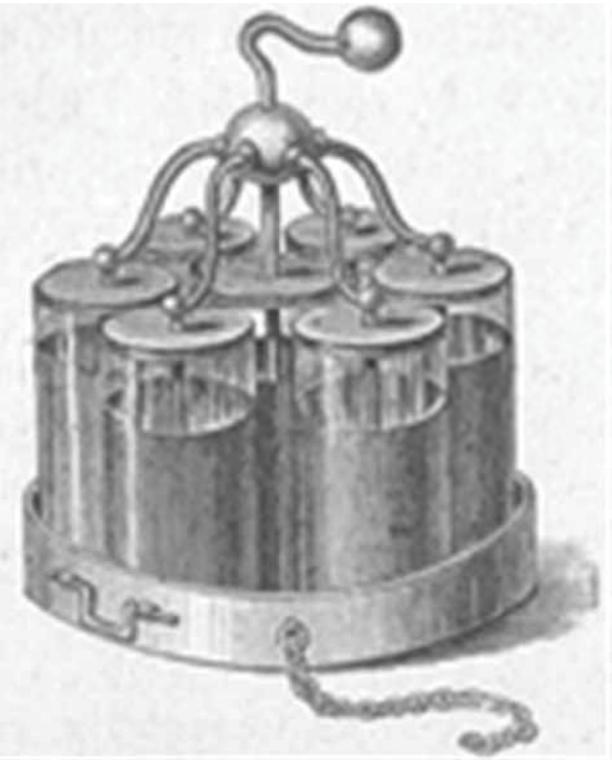

Figure 1. Battery of Leyden jars [8]

4. Methodology books

The old textbooks usually emphasized three common elements of science instruction, which are still important in the current science education: (1) teaching should be explanatory, (2) relate to everyday life and (3) pupils should be active in the instruction.

The first comprehensive methodology book of teaching physics was publishes in 1883 titled *About teaching physics at public schools* [5]. In the book's introduction the author Josef Klika explained, that he presents didactics of physics only, because didactics of chemistry is far behind and needs more time to develop. The book has 199 pages and the following 8 chapters: (1) About the physics teacher, (2) About the pupils learning physics, (3) About the physics curriculum, (4) About the method of teaching physics, (5) About the form of teaching physics, (6) About organizing and timing the teaching content, (7) About the value of physics teaching, (8) About the relation of physics to other school subjects.

Even from today's perspective the methodology presented in the book is very advanced and modern. Experiment was identified as the key element of teaching physics. Emphasis was given on pupils learning laws of nature by observing and doing experiments, description and explanation of the phenomena by language (using physics terminology) should follow next. The described process of learning is actually very close to Piaget's constructivism.

At the end of 4th chapter J. Klika summarised the method of teaching physics as follows (text was adapted for contemporary language, but the content of the message is authentic):

"I. Teaching is conducted via an inductive method in the form of a series of observations. This series begins with the experiment, the other elements are either other experiments or experiment-like insights of the pupils based on their own experience. Pupils compare the basic experiment with their own observations. Observation of each experiment is followed by its description and analysis, i.e. searching for essential points of the experiment and their links.

II. After stating the laws of nature deductive approach is applied to use the new law as an explanatory principle for weather phenomena as well as for tools and machines used in practice. Thus pupils find out: by understanding laws of nature they learned things important for life."

According to J. Klika [5], this method of teaching physics was originally proposed by J. Crüger [6] and further developed by C. Baenitz [7]. Nowadays we can state that the discovery of this method was a milestone of school didactics and after one and a half century the method remains valid.

Although the theory of teaching and

scholarly understanding of learning processes were advanced in the late 19th century, the practice was very different. Application of the theory into day to day practice at schools faced many problems including the lack of qualified teachers and lack of funds for teaching aids.

5. School experiments

Experiments were considered as a very important part of chemistry and physics teaching/learning but underfunded public schools usually struggled to obtain appropriate teaching equipment and chemicals. Although there were good teaching devices available on the market, they were too expensive and teachers were supposed to make a low cost equipment themselves [4]. Having just one particular device per experiment was a success therefore usually the teacher performed the experiment and pupils were to observe and analyse the phenomena.

It is interesting that loads of experiments from old books are still essential in science education. In the next section we present three of these experiments.

5.1. Resonance

Principles of acoustics were well understood in the 19th century. Different musical instruments were used to teach sound phenomena and various teaching devices were designed for this purpose as well.

The following experiment demonstrates a tuning fork's sound reinforcement when the resonance patterns are reached. The water surface in a measuring cylinder constitutes a node of a standing wave. (A standing wave is in fact always associated with resonance).

The tuning fork's vibrating face constitutes the amplitude and should be placed 0.3 × d above the top end of the tube, where d is the inner diameter of the tube. The sound gets loud when the distance between water level and the sound source is $\lambda/4$, $3\lambda/4$, $5\lambda/4$ etc. From measured wave length λ and known frequency f of the tone the speed of sound in the air can be calculated as

$$c = \lambda \cdot f$$

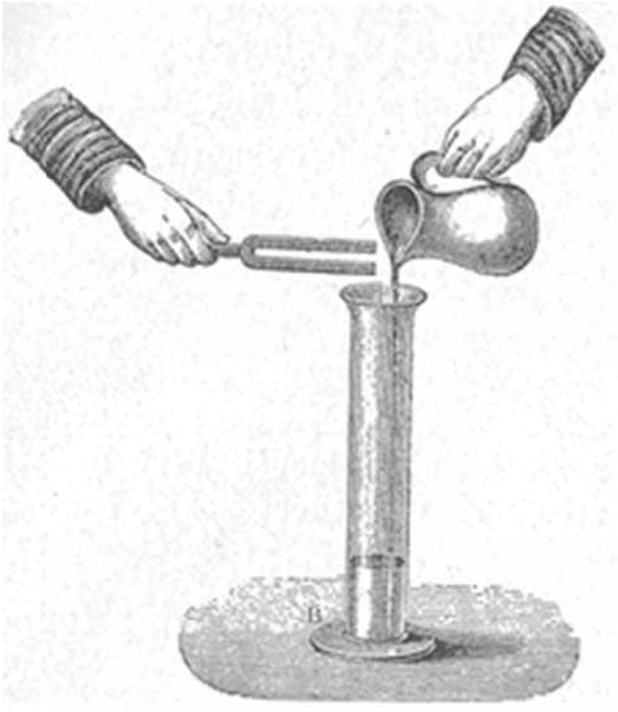

Figure 2. Resonance tube apparatus [8]

5.2. Thermal expansion

Figure 3. Thermal expansion of metals [9]

Thermal expansion of metals can be demonstrated by a simple experiment with a brass ring and a ball of diameter slightly smaller than the inner diameter of the ring (cca 3 cm). When the ball and the ring have the same temperature, the ball can easily fall through the ring. When the ball is heated by a flame, it expands and cannot get throuhgh till it cools down again. This experiment is still well known by physics teachers and remains popular at school lessons of physics.

5.3. Hydrogen generator

Figure 4. Hydrogen generation apparatus [4]

Hydrogen generator is a classic chemistry experiment which has been part of teaching chemistry for the whole time of chemistry education. The following instructions for the experiment were taken and translated from the book published by 1878 [4]:

“We place zinc in the bottom of a bulbous bottle (volume 1 liter). Zinc can be obtained from tinsmiths as strips of zinc plate but using zinc granules is better. We pour water into the bottle up to 1/3 of its volume. We close the bottle with a two holed rubber plug according to picture number 4. We insert in one hole a funnel with a long stem which reaches up to approximately 1 cm under the water level (a). Into the second hole we insert curved tube.

The tube end under the rubber plug is bevelled so that water vapour can trickle back into the bottle. The part b - c of the curved tube must be long enough and inclined so that the water does not collect here. The tube end in the top is only 2 mm wide. We cover this top end by a test tube for the collection of hydrogen gas. After finishing the described apparatus we pour sulphuric acid in this funnel to start the reaction of the preparation of hydrogen.”

6. Ernst Mach's influence

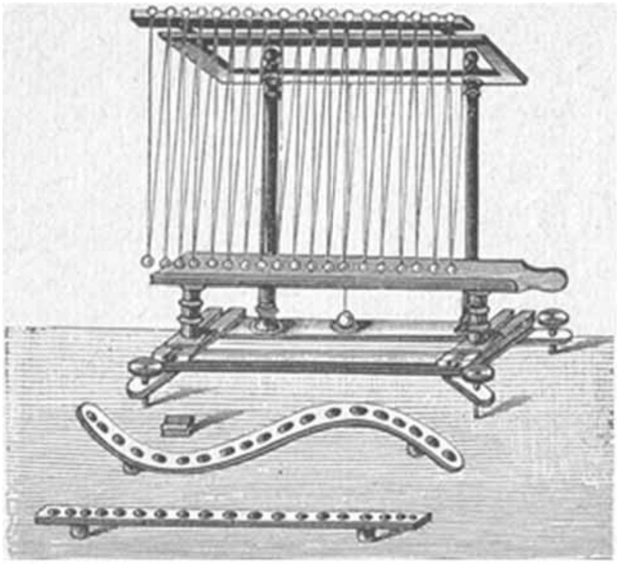

Figure 5. Mach's wave machine, illustration form the textbook published in 1890 [8]

This centenary year (2016) we remembered the death of an extraordinary physicist and philosopher Ernst Mach (1838–1916) who is also known for his efforts in education. Since 1867 he worked as a professor of experimental physics at Charles University and stayed there for 28 years.

Mach promoted natural sciences to become part of general education. In physics he applied both thought experiments and real experiments. He argued for the use of experiments at schools and even invented several educational devices for teaching physics.

Well known are for example *Mach's wave machine* – to demonstrate traveling waves by a chain of pendulums, *Mach's pendulum* – to demonstrate dependence of the pendulum's period on gravitational acceleration (see Figures 5 and 6).

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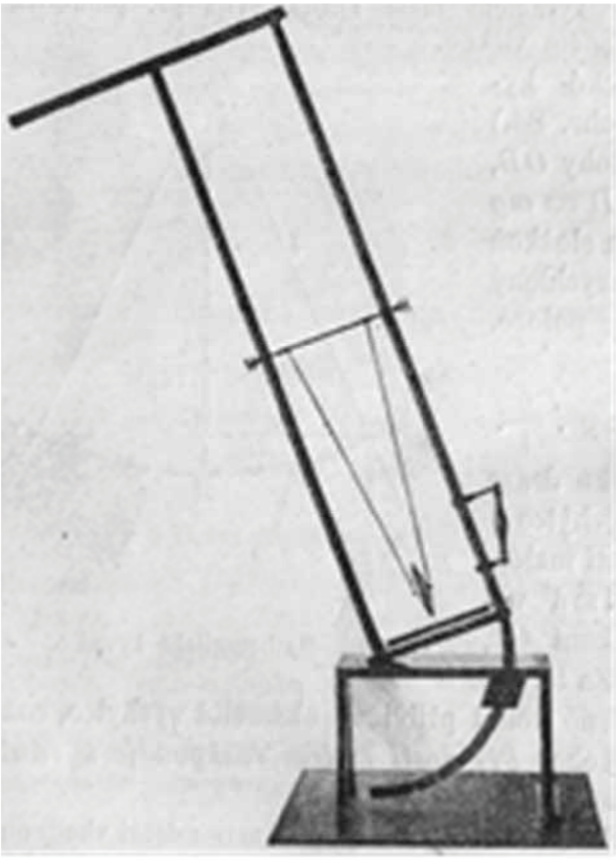

Figure 6. Mach's pendulum, photograph form the textbook published in 1910 [10]

7. Conclusion

At these times of unprecedented scientific and technological progress we often hear complains that the content of school physics and chemistry widely overlap with the science of the 19th century. After the analysis of dozens of old textbooks we can confirm that this statement is actually correct. But is it wrong?

School experiments used in the late 19th century were designed to be as simple as possible. They still clearly demonstrate basic laws of nature. As far as laws of nature have not changed over the centuries, we do not see an urgent need for a reform of school science curricula.

There is no point to teach modern science (e.g. nanotechnology) if a pupil does not understand the fundamental principles of physics and chemistry. We believe that basic school experiments used in the 19th century should not be replaced by electronic toys which diverge pupils attention from pure laws of nature that remain valid and beautiful.

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Focus on Mathematics and ICT

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Abstract. In this paper I will exemplify the IntelTeach method of teaching mathematics through projects for the lesson "Integers". I participated in the training course "Intel Teach-Training in the Knowledge Based Society." This course helped me to make my lessons more attractive by integrating resources and IT tools in teaching mathematics. I present this lesson and in terms of a math teacher in a rural school. Children in this environment have many disadvantages compared to those from urban areas, in particular economic, social and technical. AEL laboratories recently broke into this environment. The project represents an alternative assessment method.

Keywords. AEL, IntelTeach, Mathematics.

1. Introduction

In this unit, students learn the concepts of:

- Integer, representing the number line, opposite, absolute
- Comparing and ordering integers
- Representation of a point with integer coordinates in a system of orthogonal axes
- Assembly integers
- Decrease integers
- Multiplication of integers
- The division of integers when the divider is a multiple of the divisor
- Divisors an integer
- Integer power of a natural number with exponent
- Rules for calculating with powers
- Using the order of operations and parentheses
- Resolution of equations in Z
- Resolution of inequality in Z.

Essential Question: How math helps us in solving practical content?

Unit Questions:

- Why we need to know the concept of integer?
- How help us use these concepts in problem solving?

Content Questions:

- How do we define an integer?
- What is the opposite of an integer?
- What is the absolute value of an integer?
- What is the axis of integers?
- How it compares and how orders are integers?
- What are the operations with integers?
- What is the order of operations in Z?
- How to solve problems that arise in operations with integers?
- How to calculate the power of an integer?
- What are the rules of computing power?
- What are prime numbers?
- What are irreducible fractions?
- How to solve equations and inequalities in Z?

Students will participate in solving individual and group applications, the degree of difficulty gradually differentiated learning styles and level of understanding focused on:

- Identification of issues involved;
- Find real-life problems solved with integers, the development of the graphical representation;
- Identify problem situations, which can be transcribed into mathematical language, using algebraic calculations to determine an unknown period of an equation in Z.

2. Unit's Objectives

1. Use algebra to simplify computing elements calculations and for solving equations.
2. Identify-problem situations, to transpose them into mathematical language and effectively organize how to solve them.

3. Build problems, based on a model (graph or formula).
4. Consistently provide the solution to a problem, using various modes of expression (words, mathematical symbols, diagrams, tables, various construction materials).
5. Identify uses of mathematical concepts and methods studied in solving practical problems.
6. To assume different roles within a learning group, arguing ideas and mathematical methods, using different sources of information to verify and support opinions.

3. Operational Objectives

Students will be able to:

- To write, read, compare and represent whole numbers axis;
- Solve problems that arise in operations with whole numbers;
- To calculate the power of a whole number;
- To know the rules of computing power;
- Divisors-calculate an integer;
- To solve equations and inequality in Z.

4. Didactical Strategy

First hour:

To achieve the unit's portfolio, students must have theoretical knowledge on the concepts from this unit. Will divide students into three groups and will complete homogeneous KWL chart. Students seek information about the concept of individual integer which it saves a folder "Resources". It uses a brainstorm. It makes a whole number and note definition. Activity students will continue to search for information about the opposite concepts of integer, absolute value of an integer, representing the axis, comparing and ordering integers. For each concept will write the definition. Students in each group will be asked to complete their work schedule which will include exercises No.1 degree of difficulty gradually differentiated for each group. Within each group, students can work individually by distributing the workload. Each group will post on the forum worksheet to get an overview and to view and work groups and other forums will complete a checklist on progress. This activity begins in the classroom and will be continued at home. The teacher will continuously observe and work groups will help students when difficulties.

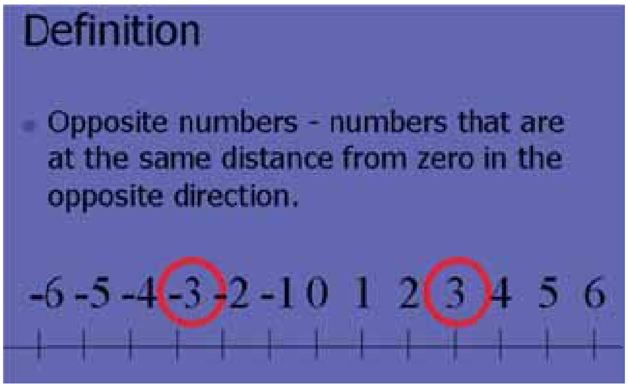

Figure 1. Example: opposite numbers definition

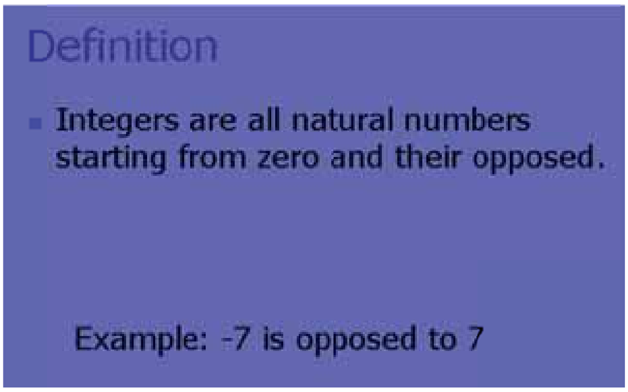

Figure 2. Example: Integer's definition

Second hour:

Students collect information about addition and subtraction of integers. Using examples of worksheet # 2, students will solve such operations. Students will be divided into three groups and the forum will publish results of their work.

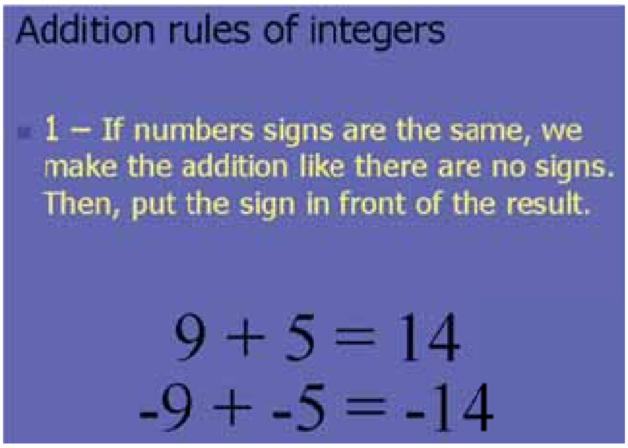

Figure 3. Example: integer's addition rule 1

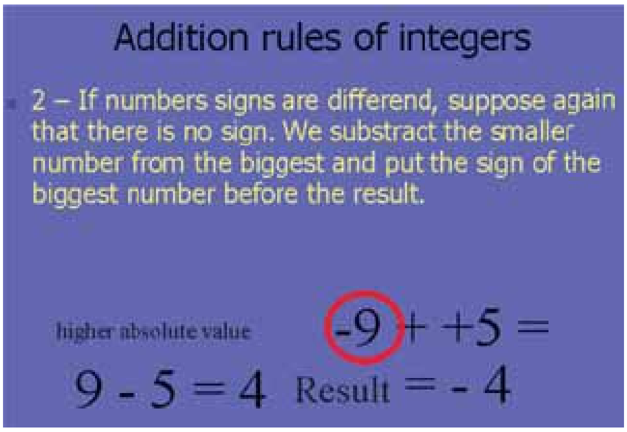

Figure 4. Example: integer's addition rule 2

Third hour:

Information is collected about multiplying and dividing integers. Using examples of worksheet # 3, students will solve such operations. Students will be divided into three groups and the forum will publish results of their work.

Fourth hour:

It collected information on operations with whole numbers and the order of their Z With examples No.4 worksheet, students solve exercises such operations. Students will be divided into three groups and the forum will publish results of their work.

Fifth hour:

It collected information about the power of an integer exponent and the natural rules of computing power. Using examples from the worksheet No. 5, students solve exercises. Students will be divided into three groups and the forum will publish results of their work.

Sixth hour:

Divisors information is collected about an integer, prime and irreducible fractions. Using examples from the worksheet No.6, students solve exercises such operations. Students will be divided into three groups and the forum will publish results of their work.

Seventh hour:

It collected information on equations and inequalities in Z. Using the worksheet examples 7, students solve exercises such operations. Students will be divided into three groups and the forum will publish results of their work.

Eighth hour:

Presentation of the final products of groups, carry out evaluation / self-presented product. After the presentation, teacher discuss with his students in order to analyze the extent to which students have acquired knowledge and developed skills of collaboration, communication, creativity.

5. Evaluation

Students will fill in a KWL chart to identify knowledge needs of students. The teacher will ask students to write in the first column what they know about integers and the second who want to know about it.

Students will be divided into groups according to their level of understanding, will work differently from completing worksheets developed by teacher and will complete lists of progress. To communicate, exchange views or improving certain content, to view products, it will be used discussion method and the forum.

Analyzing portfolios will be as follows:

- Presentation - the key criteria for presentation.
- Students will complete and the table-I know I know - I learned to appreciate progress.
- Each student will complete a feedback form on the forum for presentations colleagues.
- Made on presentation of the valuation work has produced a guide to scoring. Each student will be assessed with a mark.

I used initial assessment, formative assessment and summative evaluation.

6. Conclusions

I noticed that students are very attracted to this type of learning, though I repeated some clips of the lessons because we obtained initial results. Things started hard, students of rural beneficiaries had not benefited from the advantages of urban students. KWL chart (I know, I know - I learned) and the stock has been very effective tools and highly appreciated by students.

They have learned to express ideas, knowledge, learned to discuss, collaborate in teams, something new for them. It is difficult initially to make them think about themselves, take initiative and to express ideas, brainstorm method is to start very fun for them.

To explain the concept of integer, I use many applications and examples from real life, because, as I only managed to attract attention and make him understand.

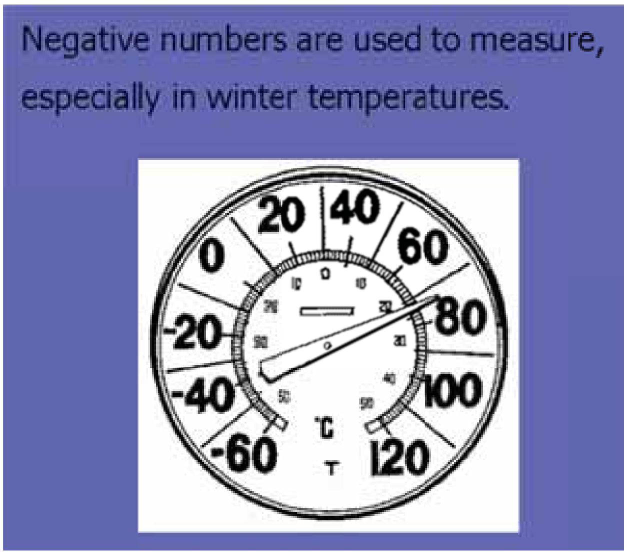

Figure 5. Example: first application

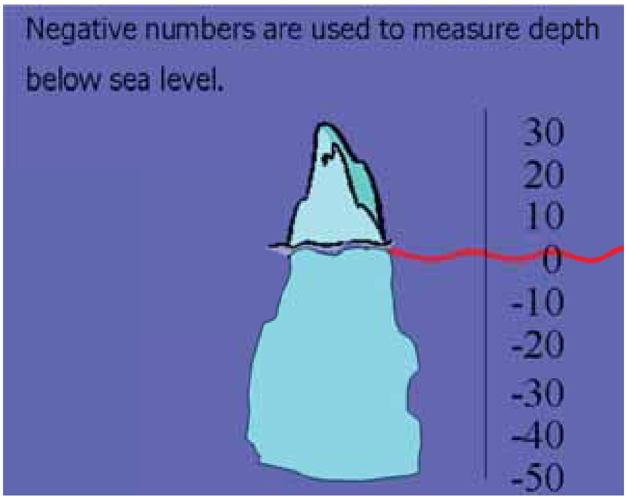

Figure 6. Example: second application

I concluded that only if you consistently apply this method to several materials and at least over a full cycle of four years, results can be achieved with these students. And to give children the same opportunities in the country to provide schools.

7. Acknowledgements

I would like to thank the “Hands on Science” coordinator Manuel Felipe Costa for his support and encouragements.

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Low Cost Robotic Prototypes with Arduino-Compatible Control System for Technological Education

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Abstract. This paper presents the development of a new family of robots for educational purposes. The prototypes meet the requirements of low cost, simple assembly and easy acquisition of components. The mechanical elements can be made with a common 3D printer. The electronic system is based in Arduino. The first robot, called 'Escornabot', created by a group of teachers and volunteers of Galicia (Spain), has been widely tested in activities performed in many schools. Some improvements to this robot have been proposed as a result of a workshop that took place at IES Alexandre Bóveda (Vigo) during the present course 2015-16, aimed at the development of educational resources for the new subjects that will be introduced in the next courses in Spanish high schools.

Keywords. Robotic prototypes, 3D printing, Arduino, educational resources.

1. Introduction

The promotion of technological vocations is a major concern among many teachers and scientists around the world. Technology involves many concepts like mathematics, physics, mechanics and electronics that are difficult to understand by many students what produces disappointment and frustration. In this context, robotics can play an important role because this subject is very attractive for students and covers a wide range of fields like electronic and mechanic design, programming and communications. The market offers a lot of robots to acquire, but many of them are too expensive for small schools that in many cases can purchase only one or two units. Moreover, the design and construction of robots makes them more affordable and provides a lot of knowledge to students and teachers.

With this motivation in mind, many groups of teachers have started their own robotics developments. In this paper we describe a project made in Galicia (Spain) that is a good example of cooperation among people from different cities and teaching specialities. The 'Escornabot' project started in 2014 in A Coruña as an Open Source Hardware and Software project and had a wide success by its simplicity and low cost. We also describe some improvements recently proposed by a group of teachers that attended a workshop at IES Alexandre Bóveda (Vigo), like the design of a new control board with an ATmega328P microcontroller that is compatible with Arduino IDE or the incorporation of another board with optical sensors.

2. The Escornabot Project

Escornabot is an Educational Robotics Project that seeks to introduce small children (3-6 years) into the world of robotics, and serves also for high degree or technical students and interested people in general. The robot is cheap, can be extended with new sensors and elements and can be easily programmed through Arduino IDE. The mechanical parts can be made with a 3D printer and all the design files are freely available in the web page [1].

Escornabot is an Open Hardware and Software Project, what means that anyone can access, change or share the code, mechanical structure or electronics without limitation.

There are different versions of the robot, 'Placidus' (Figure 1) was the first stable version and can be programmed by a keypad or with a mobile device by bluetooth. It has four basic movements, forward, backward, left and right. With these movements, the robot can be placed in a circuit and make a sequence of movements that must be previously planned by students. It is easy to modify the code to make different movements or lengths or change the keyboard assignation. The newest version, 'Brivoi', is smaller, has fewer components and is easier to assemble. There are two different options: 'Brivoi Audacius' (Figure 2), with electronic components mounted in a breadboard and 'Brivoi Compactus' (Figure 3) with specific Printed Circuit Boards that can be ordered from external services or made in an electronics laboratory.

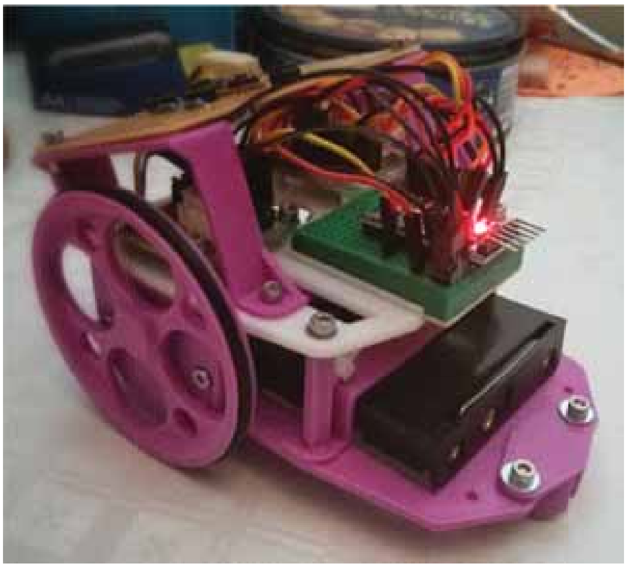

Figure 1. Escornabot Placidus

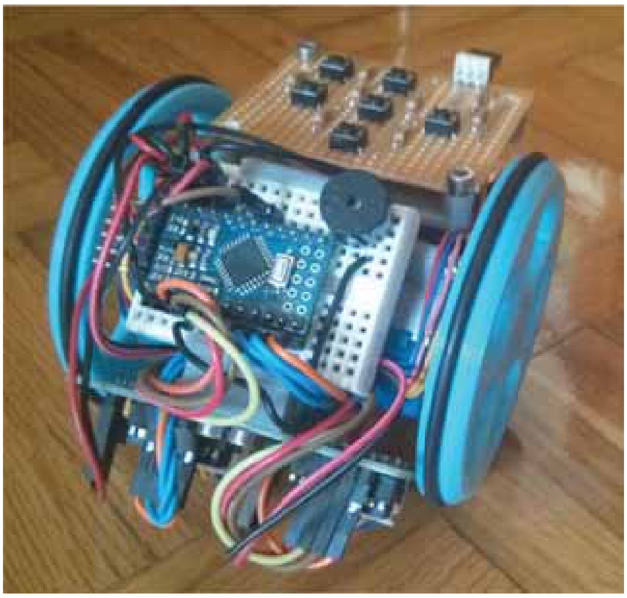

Figure 2. Brivoi Audacius

The Escornabot has no commercial version, anyone interested in it must print the pieces, solder the electronic components, assemble all the parts and program the code into the microcontroller board. All the information and schematics are in the web page of the project and there are assembly guides to help in the process [2,3]. There are also active forums [4] for users and developers. All the components can be acquired by only 20-30 euros, what makes this robot one of the cheapest in the market.

The Escornabot Project was started in 2014 by a team of three developers (Tucho Méndez, Rafa Couto and Xoan Sampaiño). The first version of the e robot was presented at OSHWDem 2014 [5] in A Coruña, Spain. This activity is organized by BricoLabs [6], a technical association based at the Domus Museum [7].

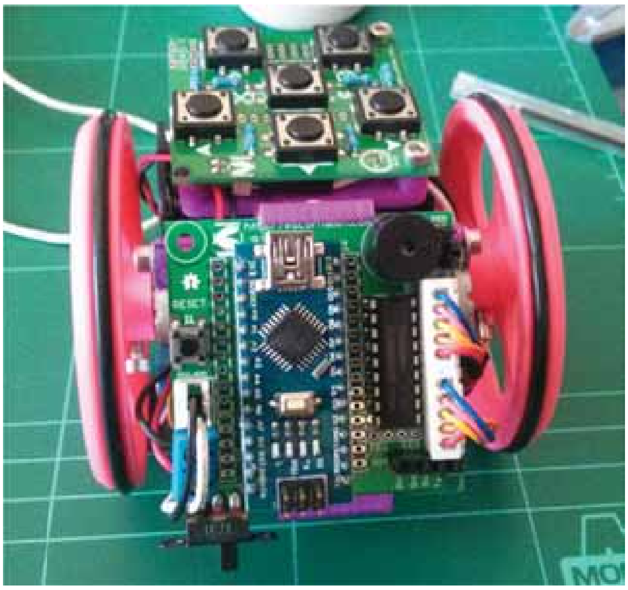

Figure 3. Brivoi Compactus

Currently they are working in a dissemination activity called 'The Travelling Family' that consists of a group of Escornabots visiting schools of different areas of Galicia. Any school interested in this activity can apply for a visit. The have also started a new project called 'Escornabots at the school library' that intends to introduce programming languages as a tool for new activities in school libraries [8].

3. Design of robot pieces with 3D Printer

The Escornabot Project provides the necessary information and files to make all the versions of robots. Each part of the robot has its own STL file (StereoLitography format, widely used in CAD software and created by 3D Systems [9]).

During the workshop at IES Alexandre Bóveda it was planned to make some changes to the original design of the robot to fit new elements like the optical sensors and the new control board. For that purpose three training sessions were scheduled under the direction of

Mr. Gabriel Rodríguez, an external expert from CTAG at Porriño (Spain) [10]. He provided the necessary knowledge about the design tools needed to create or modify 3D pieces and prepare them to make with a 3D printer. The first tool was OnShape © CAD system [11] and the software used for slicing and printing models was Ultimaker Cura © [12].

The result of this learning process was the design of a new set of pieces (Figure 4) adapted to the new boards and some minor changes like the possibility of removing the battery holder for battery replacement.

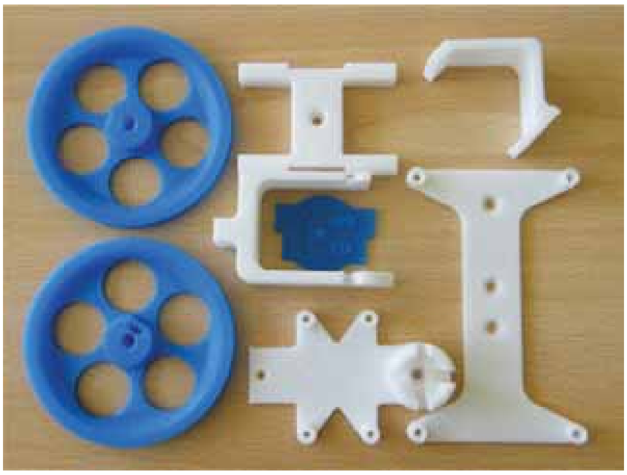

Figure 4. Set of pieces of the modified Escornabot

4. A new Arduino compatible electronic control for robots

Many robots use Arduino boards for their electronic control system. This option has the advantage of a simpler design and no need for electronic components soldering. This choice often produces a robot with multiple small boards (control, keyboard, motor drivers) and many connections among them. Sometimes commercial boards cannot be easily acquired and prices can change.

Another option is to integrate all the electronics in a single board that should be easy to assembly, with no small components (for example, surface mount integrated circuits). This board can be cheaper than a commercial one and provides a lot of learning and fun.

The board can be made in an electronics laboratory or ordered from an external supplier. Another option is soldering the components on a strip board.

For our control system, we have chosen the same microcontroller found in many Arduino boards like Duemilanove, Uno or Diecimila: the Atmega328P in PDIP version for easy assembly on the board. The use of this microcontroller allows the design to be compatible with Arduino IDE.

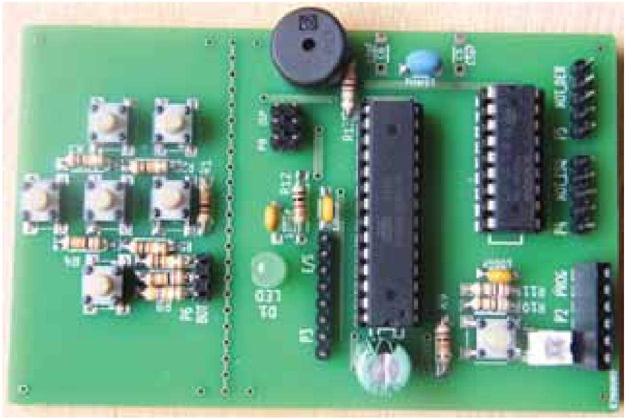

Figure 5. Control board with keyboard, microcontroller and motor driver

If the microcontroller is purchased from an electronics supplier different from Arduino it should be programmed with the same starting software or "bootloader". This is a small piece of code that allows communication with Arduino IDE and sketches downloading into the microcontroller. Arduino has a tutorial that explains in detail how to do this task [13].

Our new board (Figure 5) has the same configuration as Arduino Pro-Mini from Sparkfun [14]. This board has no USB connection and uses a 6-pin external adaptor that must be acquired separately. With this configuration we can have only one USB adaptor and use it to reprogram several robots.

Our robot will use the same motors as the Escornabot, 28BYJ-48 that is a small unipolar stepper motor. It includes the motor and gear assembly in the same case, is very cheap and easy to install. These motors are often sold with a control circuit ULN2003. Our board changes this circuit by a ULN2803 or UL2804 [15] that has 8 output channels that allow controlling two motors with the same device.

A second board (Figure 6) includes three led diodes and phototransistors that give detection capabilities to the robot, useful for path following or obstacle detection. The outputs of the photodetectors are connected to the analogue input channels of the microcontroller. This allows more accurate detection that digital outputs present in many commercial boards.

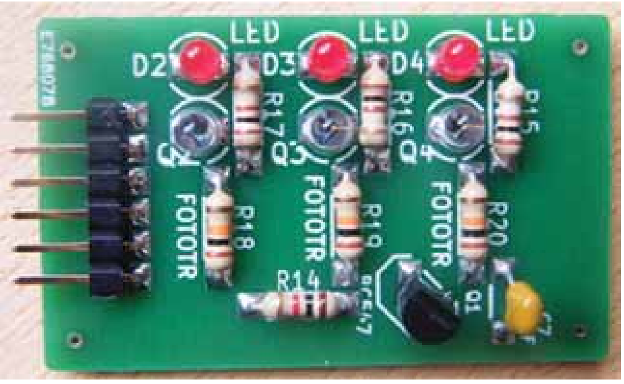

Figure 6. Photodetectors board

5. Assembly of the robots and first tests

During the workshop at IES Alexandre Bóveda several robots were assembled, including printing all the pieces and soldering all the electronic components of the boards. Figure 7 shows the members of the team at work, and Figure 8 shows three of the robots after final testing.

Figure 7. Workshop at IES Alexandre Bóveda

Some practical experiences employing this robot have already been made or are planned for next course 2016-17. In this course, Prof. Rafael Rodríguez-Paz of IES Alexandre Bóveda is making six robots with his 17 students of Bach-1A group. In spite of the lack of time the students are finishing the assembly of the robots (Figure 9) and in next course some of them will be used in a new subject of robotics that will be offered to the students of the high school. Other teachers of technology at different high schools are planning their own experiences and robotic competitions. The robots also will be used at IES Escolas Proval (Nigrán, Spain) as a practical example of microprogramming and electronic design in Vocational Training.

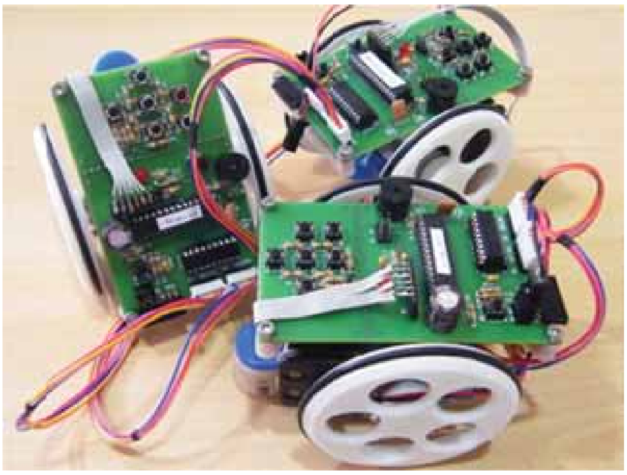

Figure 8. Robots after final testing

Figure 9. Learning experience at IES Alexandre Bóveda

Furthermore, the information about this modified version of Escornabot has been added to the resources of the project (section 'mutations') to make them available to anybody [17].

6. Acknowledgements

The authors wish to acknowledge all the people involved in the development of Escornabot Project and the 'Centro de Formación e Recursos (Teaching Resources Center) of Vigo [16] for the support provided through the activity 'Prototipos robóticos para

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Success Rate Evaluation of Non-Formal Education in Science Camp Motivates to Become a Physics Teacher

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Abstract. Science camp represents well-known a successful format of non-formal education activities. Especially during the summer, students can participate in various science related activities that leave pleasant memories, new acquaintances and adventures. This and something extra in a form of knowledge and skills may acquire the participants of science camp called „PhysEduCamp – better than to rest at home (PEC)!" which was organised in Slovakia.

Two main aims of the science camp were given moths before: 1. To provide practical experiences to the pre-service teachers in the designing, organisation and conducting the science camp, as the collection of different kinds of non-formal education activities. 2. To activate the high school students leans towards the physics teaching study program at the university.

The camp, which was designed for pre-selected upper secondary school students, was focused mainly on the physics education related topics. From pre-service students and postgraduate students, 12 instructors were registered. Instructors were trained for non-formal activities few months before, during weekend training camp. From that point they start to design and prepare the whole Science camp.

Based on registration requirements like application form, letter of student`s motivation and report on a candidate written by a physics teacher, from 61 registered students from 21 different schools, 28 participants have been chosen. Participants were in age 16 - 18. The participants had an opportunity to spend a lovely week (5 full days) in the High Tatras region and also improve their physics knowledge and inquiry skills while solving assigned tasks and problems, play educational games and participated on a scientific trip and discussions.

Core science camp activities are introduced and evaluation tools and criteria are described. Examples of science camp activities are: Young NON-physicists tournament, the scientific excursion to Lomnický peak joined with the outdoor tablets and Vinci Lab measurements, creative physical quantities and a series of Hands-on experiments. Evaluation of student`s motivation and arguments in physics teacher written report on a candidate are analysed with focus on participants selection process strategy. Within the paper, the final questionnaire is evaluated with feedback to pre-service students training in non-formal activities.

Keywords. Evaluation, non-formal education, science camp, pre-service teachers.

1. Introduction

We are watching the lack of interest to be a science teacher, in Slovakia. Actually, there are several reasons like lower range of science subject lessons, weak teacher status in society, challenging study of two subjects, wide offer and availability of university studies and strong concurrence of abroad universities especially for the best students. In an attempt to reverse such trends we focus on non-formal educational activities as supporter in interest increasing in field of teacher training.

Once we have group of pre-service students at university training, most of them are not experienced with Science camp activities not even as participants rather than instructors. Experience based learning is used as a method for introduction into non-formal education. We decided to train our pre-service student by practical application at Science camp. After such experiences we hope they will be self-motivated and skilled to organise it yourselves. Team work plays important role within non-formal education and for that goal we would like to support the student`s community and volunteer`s activities in frame of popularization of science and science education.

Its sensitive for us that for new generation of young people digital technologies, social media, non-linear or hypertext materials with multimedia resources, are powerful tools influence their style of learning and reception of information. For all these aspects specific teacher's skills are necessary to be advanced. We can expect easier adaptation for using of new methods and technologies in education by younger teachers without routine practice experiences than older one.

2. Non-formal education training camp

Within the didactics of physics lectures at university pre-service teacher training we are focusing also on non-formal education, gifted students, science subject oriented competitions and popularization of science. Based on that lectures we follow with two full days training camp for pre-service teachers outside university focused on non-formal education and making a proposal of Science camp specialized on physics education.

We arrange the program from short lectures, good practice examples, educational games, practical exercises and workshops, group work focused on own science camp plan development. External lecturer from Centre for leisure time activities, with long year experiences, participated on programme. Students from different grades work together and team building goals has been traced.

Figure 1. Group work moderated by lecturer

For follow up Science camp preparation, the key conditions and rules were set up: 5 full days programme, 28 upper secondary school pupils as participants and 12 instructors (pre-service teacher and PhD students in physics education), programme focused on physics education, wet and dry programme as alternatives in case of bad weather conditions, participant`s group work, partial activities with final products, one-day science trip included.

After two days programme of training camp with 21 participants the collection of activities, different ideas and approaches were developed as a good starting point for the next preparatory phase.

3. Science camp preparation and participant selection process

The group of volunteers from pre-service teachers and PhD students start shortly after the training camp preparation of science camp. The list of tasks has been created and personally targeted. The short meetings were organised one time per week or per two weeks.

Promotion of science camp was executed by Club of school principals and via contacts to science teachers, faculty graduates and collaborative teachers.

Students must fill application form with letter of student`s motivation and supportive letter from his/her physics teacher. From 61 registered students from 21 different schools, 28 participants have been chosen. Participants were in age 16 - 18.

From application form and letter of student`s motivation we can underline few statements related to students:

- students with higher motivation to science have an interest to participate in science camps with the group of congeneric pupils,
- they are mostly individuals, experienced from competitions, harder to focus them on team work and cooperation,
- higher level of creativity, involvement and stronger expectation from camp programme,
- experiences only from activities like Night of researchers, students conferences.

Based on the long-term cooperation with Leisure centre – Regional youth centre in Košice and other partners, has so far organized six previous summer schools with the title The Introducing Workshop, Galileo would be amazed, Great strength of small particles, Unknown cosmic radiation and Water and air in the motion, Alternative energy sources. By the help and support of Comenius LLP project: Science Camp [4] that the PF UPJŠ was the partner, enables us to build on the tradition, improve our work with youth, benefit from international experience and encourage young people to explore the beauty of science education also during science camp 2015 titled: PhysEduCamp (Physics Education Camp).

4. PhysEduCamp programme

Five full days programme was realised in mountain resort, pension Medvedica, Štrba High Tatras. The programme consisted of different types of activities, balanced between outdoor and indoor, intellectual and relaxing, lectures and active participation.

Figure 2. Participant`s project work

The complete programme with materials is available on webpage [5]. The introductory lecture immersed students directly in the affairs of Young physicist tournament (YPT), one of the known physical competitions for secondary school's students. We explained status of the competition, the course and preparation of team. Lecturer also played a short exemplary video from the regional round of YPT in Košice. It was the theoretical preparation of our students for a later modified YPT, which was as a part of the camp programme. Through six experimental tables with various experiments that have solved in previous editions of YPT lecturers explained of principle of experiment, which they had the opportunity to try and discovery.

On the very first day we tried to get to know each other, our names, faces, but also regions we live in and come from. Each group of students introduced their region, such as Spiš, Abov, Zemplín, Horehronie and Šariš by making a presentation. We learned about natural beauties, cultural sightseeing, the most visited places and schools, the students come from. At the evening we had discussion with member of Mountain Rescue Service. The big surprise for us was the presence of his rescue dog Yoko. We found out about rules of behaviour in mountains, equipment, which we can need for our trip, and also a bit about avalanches. Then the students had time for questions, which they used fully.

The lecture"Filtrate boredom on PhysEdu Camp" and follow- up workshop was inspired by adventure journeys into unknown lands full of dangerous and pitfalls. Filtration is an actual topic to discuss for countries, especially for those who consider the situation with drinking water in Africa as the grave. For each group were prepared experiments related to filtration, distillation or separation of mixture. The group "the earth" had been crafted water filters from grass, leaves, moss, sand, crushed black charcoal, gravel. The group "the fire" had been obtaining clean water by evaporating, subsequently condensing polluted water on the cooper tube, cooled by the wet cloth. After that, they had been crafting protective mask. Finally, they had been exploring conditions of white flour burning. The group "the water" had been constructing a functioning model of the kidney.

During the third day of the PhysEduCamp students was realized a trip to the second highest peak in Slovakia Lomnický štít (2634 m). During the trip, students using sensors and VinciLab (measuring device for data acquisition) measured for example change temperature, humidity, atmospheric pressure with increasing the altitude and various other addictions. Students during the trip used the tablet with GPS navigation, which plotted the movement of each group to the map and also created graphs of the altitude and speed of the move each group from distance travelled, from which you can read different interesting information on the movement of the group of students. On the Lomnický štít, students had insight into the workplace of SAV (Slovak Academy of Science), where they learned a lot of interesting information about observations, measurements and their significance, which are performed there every day.

We try to focus our participants into creation of own physical quantity. Then we started the measurements of crispness for different salty products (chips, biscuits and other) and noisiness of keys and zippers. Students had different samples, which they tested via application in their tablets for analysis of sound. They estimated the least crunchy samples (appropriate for theatre) and the crunchiest samples, which can be used for advertisement.

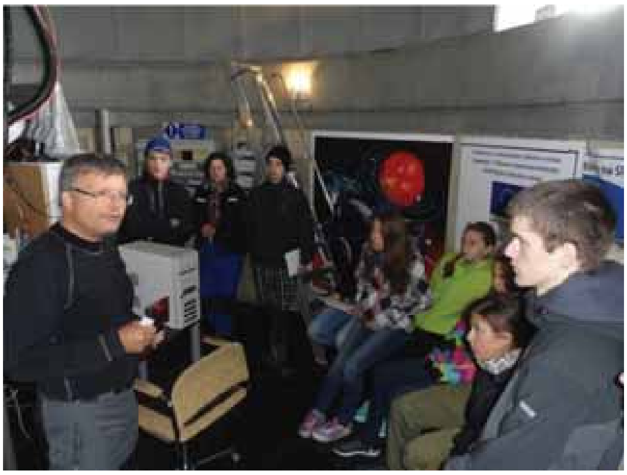

Figure 3. Discussion with researcher at Lomnický štít observatory

Finally, the groups presented their work on Thursday evening. Students prepared interesting presentations about their results of measurements, experiments, photos and videos. The last part of presentation was given for questions of other students or lectors. The quality of projects was high, which was proved by the small difference between ratings of students. Then the lectors took their own time, re-evaluated the votes of students and announced the results after dinner. Students got the diplomas and prices (physical toys), which they picked by their own taste.

5. Science camp evaluation

Evaluation questionnaire was used as the last activity before departure. Evaluation was focused on each single activity by 6 close questions with possibility so select the answer level in 5 marks scale and two open questions. Each of close questions has been added by argumentation space.

From 28 respondent`s answers we can conclude:

- lectures and activities with not so strong active participation are better accepted (H, K, L, P green columns) then own participant results presentation (B, C, E, N red columns), see Figure 4,
- the best marks in scale 1 – 5 were granted for informal lecturer approach (1,04), peer relations (1,11) and management of science camp (1,15),
- as strongest contribution participants evaluates recognition of new peers, experimental skills development and new scientific information acquirement,
- how participant`s expectations were filled we can see from Figure 5,
- only two participants would like to be a physics teacher, but eight are close to such decision and other are rather not interested.

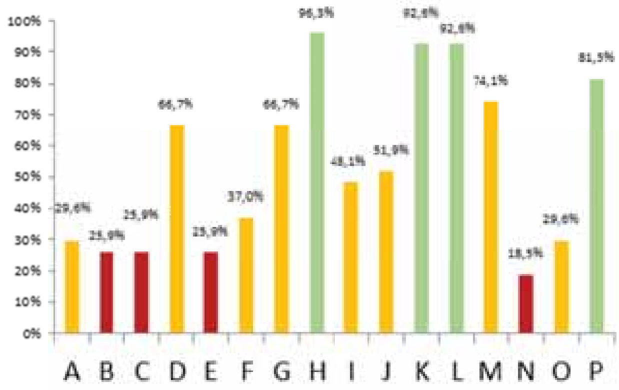

Figure 4. Evaluation questionnaire results

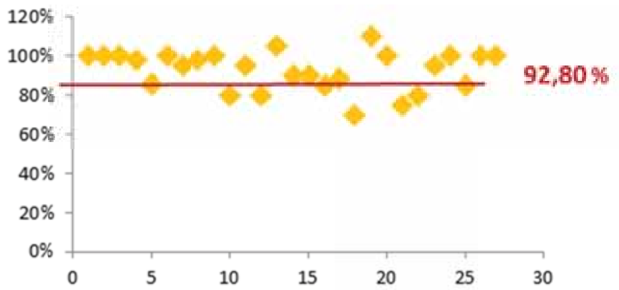

Figure 5. Participant`s expectation

6. Conclusions

Non-formal education within science camp should be good practice for pre-service teachers, especially if they haven't own previous experiences. The whole process of camp preparation must be initiated in advance with group of motivated and self-organised pre-service teachers with almost all responsibilities. In field of student motivation to physics teacher profession science camp should be as one piece of complex mosaic consist of series of activities during their studies, but cooperation with teachers are important at least for pre-selection and further support and regulation.

7. Acknowledgements

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The Power of Water. How Hands-on Activities Can Foster Learning and Communication of Science

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Abstract. Scientia.com.pt is a science communication and outreach project born at the Universidade do Minho, in Braga, Portugal. One of its initiatives during 2016 was the celebration of the World Water Day by organizing an exhibition that engaged undergraduate students in an active hands-on but also learning activity focused on the value and the importance of water. Students worked in groups and created about 30 artworks that were placed in several different locals at the University Campus. In the present communication, we will present and evaluate this Science.com.pt initiative, in particular regarding aspects related with the idea/ concept, the involved actors as well as the exhibition itself and its first impacts. Different aspects regarding the informal and active learning methods used, the science communication processes, and the Scientia.com.pt outcomes will also be considered.

Keywords. Formal & non-formal learning science, hands-on activities, society, university, water.

1. Introduction

Science communication is part of the everyday life of any scientist [1]. Scientists must give talks and conferences, should publish their research results writing scientific papers, must write proposals to apply for funding, and need to communicate with a variety of audiences. Thus, scientists should know how to communicate and must learn to do it in an effective way.

At the same time, employment agencies and committees are increasingly voicing their concerns about the communication skills of recent graduates, stressing the need to develop such skills in students, particularly the ones engaged in undergraduate and graduation programs of sciences, engineering and technology [2].

Science communication is undoubtedly important for this (the) scientific community but is also extremely important for society. Although the importance of science may not always be obvious, countless science-based choices are made every day – whether to make informed decisions about our health care and well-being or to choose products to consume considering their impact on the environment. Thus, people need some understanding of science, an overall awareness of the way science and technology encompass modern life - the so called scientific literacy – in order to make conscious and informed decisions about science related questions.

1.1. *Scientia.com.pt*

Scientia.com.pt is a science communication and outreach project, developed in 2015 by three professors of the Escola de Ciências (School of Sciences) of the Universidade do Minho (Braga, Portugal), aware of the importance, and committed with science communication in today´s society. This project was born as a scientific, educational and cultural vision and venture, embracing university and society as interfaces and with research and education as strategic tools. *Scientia.com.pt* has two main action plans - the one more experimental-oriented was designed Experiment@Ciência (*Experiment@Science*) and focuses multidisciplinary science hands-on activities for public of all ages.

Scientia.com.pt team believes that in- and out-university learning can be bridged. Museums, libraries or science centres are just examples of out-of-university learning environments and this idea may be broadened to other environments as well. Gerber et al. [3] argue that, ‘‘in essence, the informal learning can be defined as the sum of activities that comprise the time individuals are not in the formal classroom in the presence of a teacher’’. We know that, whether we plan it or not, informal learning occurs everywhere and at all the time and we cannot avoid it. In addition, visits to museums, exhibitions, etc., have become part of our way of life. If we experience informal learning anyway, why put effort into doing so during university time? Wouldn´t it be a waste of money and precious university time? [4]. We think that this kind of learning reinforces and expands the class *curriculum* by providing new perspectives and more meaningful connections that can help students, while simultaneously promotes lifelong learning and enjoyment. This sort of activities can generate a sense of wonder, interest, enthusiasm, motivation, and eagerness to learn, which are much neglected in traditional formal university science [5].

1.2. Experiment@Science and the initiative "The Power of Water"

Aiming the definition of the Experiment@Science main tasks for 2016, it was decided that one important project action should draw the attention to a more conscious consumption and use of water, a limited and vital resource that belongs to all of us. The action would be developed on behalf of the World Water Day, celebrated worldwide and yearly on the 22nd of March.

At the University Campus water is plentiful and its relevance for life is easily forgotten and often not correctly respected. As one of the members of the Scientia.com.pt team is the teacher of Biochemistry, a 1st year course of the Biology-Geology graduation program, and as "Water" is a program topic, she decided to challenge her students and to engage them in a non-formal, active and hands-on learning activity in the scope of that syllabus unit. As it was not the first time that this teacher had the mentioned group of students, she knew that it was very important to engage them with innovative strategies, different from the ones used in the formal learning process traditionally used at our university. At the same time, informal quotes from the students warned the teacher and the remaining project team members that the real value and finitude of water were far from being perceived, even by part of that small particular academic community of 60 students. So, the main idea of "The Power of Water" initiative was to make a set of artworks under the aegis of the theme water. The pieces should be created by the students and should communicate a scientific message or fact they considered important and wished to share with the public, ideally reflecting something learnt through the active learning process and collaborative group work in the Biochemistry course.

Active, collaborative and informal learning After explaining the idea and discussing numerous aspects within the project, 16 groups of three-four students were formed in order to create the artworks of expository character linked with the theme "Water". One of the main ideas was to expose all the different artworks at several locations, at the University Campus. The students had a lot of decisions to make: to decide the messages they wanted to disseminate, to choose the type of work and to define the way they will to do it, to select an appropriate title to the respective pieces and to think about the place where they would like to show their works. Students were also advised that their endeavours would contribute globally to the exhibition that was later named "The Power of Water" and that was registered in the ONU site for this purpose [6] (Figure 1).

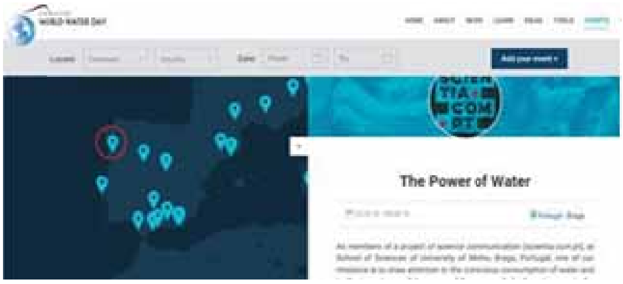

Figure 1. The "Power of Water" in the Un-water World Water Day map of events

As above suggested the students involved in this project have a deficient scientific preparation and considered Biochemistry a difficult subject and, therefore, they hardly engage in the study of the covered topics. With students having difficulties in being attentive and focused, different strategies and activities are needed to involve them both individually and in groups and to get a meaningful learning. As they also have no clear notion of what is teamwork, the teacher of this course decided to divide these students into small groups (three to four elements) to encourage the work of all members of the group.

The teacher wanted students to understand the importance of water/ the water molecule for life, and decided that engaging students in creative activities related with the theme "water" could be a good start. Hands on activities - generally perceived as enjoyable and considered an effective form of learning - seemed to be a good search engine to accomplish teacher´s goals, driving students search and work, and ultimately improving students learning of several aspects that would be impracticable during classes in this course.

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As active learning is generally defined as any instructional method that engages students in the learning process [7], and collaborative learning refers to any instructional method in which students work together in small groups towards a common goal [8], we may say that, in short, active learning requires students to do meaningful learning activities and think about what they are doing [9] which was exactly what was intended!

The difficulties teachers find in teaching and learning inside the university must lead them to consider that universities have the potential to play a leading role in enabling communities to develop more sustainable ways of living and working. Elements of program plan and evaluation on one hand, and capacity building on the other, are needed. The latter entails approaches and processes that may contribute to community empowerment - universities may either lead such approaches, or be key partners in an endeavour to empower communities to address the challenges posed by the need for sustainable development [10]. Why this engagement is educationally effective? First and foremost, students who participate in this kind of engagement learn more academic contents [11]. Through academic praxis (application of theoretical concepts to action), students shift from being knowledge receivers to idea creators. Abstract concepts come into relief against the background of situation and context as students consider, apply, test, assess, and re-evaluate multiple disciplinary approaches to solve an array of human, mechanical and environmental challenges.

Literature refers that the reasons why informal learning is becoming popular have to do with immediacy and relevancy. Informal methods of learning are often found in the work environment as they are seen as techniques that a learner can take advantage of right away and with immediate application to their job. Another reason consists in the fact that learners can drive their learning in a more meaningful and self-directed manner [12].

During this hands-on experience students appreciated the opportunity to learn and practiced a thoughtful and structured process for problem solving, valued the safety of the group process in sharing a diversity of perspectives on topics in Biochemistry, and acknowledged the importance of addressing real and challenging problems that are rarely addressed in formal lectures and other planned small-group settings. Additionally they had the challenge of communicating what they had learnt to a particular public, needing to think about the best way to share that particular message, in a particular way, without losing the scientific accuracy

2. The exhibition

The exhibition was implemented by students and the members of the Scientia.com.pt project and it was inaugurated on March 18, 2016. At that moment, the role of the project members was to coordinate the work, helping students to choose the better title and selecting/ adjusting the pieces to the available spaces.

Figure 2. Artwork "Moving Water"

During 13 working days (March-April), 3 000 people should have passed through about the 30 pieces exhibited and located at six different places in the University Campus: Hall of Pedagogic Complex I, Hall of Pedagogic Complex II, Canteen, Grill, Sport Complex and Library Lounge. The artworks displayed were very eclectic and of very diverse nature: some had just an informative character while others were much more challenging, but all approached and dealt with several topics related to "Water", such as its uses, composition, pollution, reuse, water footprint, …

In the lounge of the campus library, it was displayed a series of 40 images showing the different uses of water by humanity, a work entitled "The water and its utility throughout the ages". In the library it was also exposed the

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"Moving water", a 3-D model of the water cycle along with an explicative and permanent video (Figure 2).

Figure 3. "Water chemical composition"

Figure 4. "19002100: Evolution of drinking water"

In the hall of the pedagogic complex, a water vase divided into several glasses, representing the chemical composition of water, was hanging from the ceiling (Figure 3).

Bellow this installation, a green and blue 3-D model of three globes representing the evolution of continents and water distribution on earth since 1900 through 2100 was placed. There were also three rectangular parallelepiped presenting both the worldwide affordable drinking water and water accessibility (Figure 4).

One of the main points stressed by students when choosing the artworks for the pedagogic complexes was the problem of pollution. So a huge installation (1,5 mx 1 m) made with empty plastic water bottles and pictures showing how pollution affects several world areas was placed in one of the campus pedagogic buildings (Figure 5). Named "Bottled water: prosper or perish" that artwork wanted also to alert for the need and the importance of recycling.

Figure 5. "Bottled water: prosper or perish"

The Water Footprint (WF) was not forgotten. As an indicator of the direct and indirect use of fresh water by a consumer or a producer, it is defined as the total volume needed to produce goods. To illustrate the urgent need to preserve and save water, two different groups of students have performed two different installations. In the sportive complex a mannequin dressed with jeans, a T-shirt, a pair of shoes and a smartphone showed the respective WFs translated in sets of bottles, symbolizing the corresponding water volume. In the cafeteria, the same idea was used for the installation designed "Water extent carboy", where several cardboard-made goods such as sugar, coffee or cakes indicated the respective WFs.

3. Closing Comments and Future Perspectives

At the places where the exhibition was displayed it was expected that visitors would get involved, leaving comments and suggestions, proposing changes to some pieces, eventually advising to remove some of the artworks or even suggesting the creation of new ones. This was one of the most relevant outputs of this initiative, because Scientia.com.pt believes that this is an effective dynamic process of flowing knowledge from university to society and vice-versa, improving scientific literacy of both public and students. At this stage Science.com.pt is collecting the suggestions, comments and ideas to reformulate artworks and/ or to create new and different material that are being made along the various locations of the exhibition. This way, Science.com.pt assumes another active role in this process, feeding the cycle, while reshaping, renewing, adding, and so enhancing the initial exhibition. In this long way, from university to community/ society, both actors get engaged in the renovation of the exhibition: all curious and interested people in “water science” that see the exhibition (either children or adults) can not only learn but also give feedback in a dynamic, engaged and participated process of renewal and reconstruction.

Students made their auto and hetero-evaluation and said that “this was an interesting way of learning” because “they haven´t to be inside the class”, “they´ve learnt more about science” and, “they´ve learnt in different ways how to do hands-on activities” while they realize the difficulty of “communicating an idea or a scientific concept” in order that other people could understand the topic. They mentioned that the fact that their works have an expository nature, allowing everyone to see and evaluate the work of all of them, put a lot of pressure but also a sense of “pride” in this challenging task. Still, students commented that “we could always do work of this kind”, that “it is better to do things in a group” and that “it could be important what I do” concluding that “these things take time to do but give us joy”.

In the meantime the Library Lúcio Craveiro da Silva, in Braga, booked the exhibition for the celebrations of the World Water Day in 2017. Meanwhile, the Municipality of Braga invited Scientia.com.pt to join the AQUACÁVADO, an educational project running at Tibães Monastery, also in Braga. During 2016 Scientia.com.pt also expects that some basic and secondary schools request some or all of the artworks, in order to improve some materials of the exhibition and also to increase the number and the diversity of pieces.

4. Acknowledgements

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Development of Selected Inquiry Skills by Solving of Tasks from Young Physicists' Tournament

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Abstract. The Young Physicists' Tournament (YPT) is one of the secondary school students' competition in physics, which helps to develop the scientific literacy of students. Character of tasks solution fits one of five hierarchical levels of Inquiry activities - bounded inquiry. By problems' solving students should obtain a wide range of inquiry skill: observations of physics phenomenon, measurements, formulation of hypotheses, experimentation, construction of tables and graphs, data interpretation, development of conclusions.

The results of a test aimed at mapping a development of selected inquiry skills which students obtained and developed during the preparation to the regional round of tournament are presented within contribution.

We would like to introduce the task "super ball" where a highly elastic ball throws into the space between two plates changes the direction of rotation when hitting the surface and can even be projected back. The next task is "hot water fountain" where water is exiting the tip of Mohr pipette when we turn the tip upwards. Due to sudden pressure changes into pipette we can get the different height of the fountain.

Our goal is to show, that the YPT's tasks solving has an impact on the development of inquiry skills: formulation of hypotheses, progress planning, identification and definition the independent and dependent variables and determine the accuracy of experimental data. Results from pilot evaluation are presented with practical conclusions to team leaders and physics teachers.

Keywords. The Young Physicists' Tournament, super ball, hot water fountain, inquiry skills, test.

1. Introduction

In 2008 started in education system in Slovakia school reform, which changed the view of the teaching of science subject in particular. The sharp decline in the range of science teaching brings problems associated with scientific thinking of students and developing their inquiry skills.

The Young Physicists' Tournament (YPT) is a physics competition for high school students, which is a good opportunity to develop selected students' inquiry skills during free-time school activities for which there are not enough space to develop them [4]. It is the competition characterized by solving problems, which we can understand as bounded inquiry. Students solve a problem, presented it and teacher only minimally directs students' activities during the progress. We try to use this level of inquiry skills in the non-formal students' education by solving of tasks from YPT.

We want to present the results of test aimed at mapping a development of selected inquiry skills addressed to second grade high school students and YPT's solvers. We compare successfulness of the test for both groups each other. We monitor the impact of spending a lot of time by YPT's tasks solving by bounded inquiry to development of selected inquiry skills. Our goal is to systematically increase different levels of investigative skills.

2. Investigative of selected inquiry skills by solving of tasks from Young Physicists' Tournament

We focus on selected skills, the development of which we mapped by test.

1. Formulation of hypotheses which will be tested.
2. Progress planning (identification and definition the independent and dependent variables and correlation).
3. Determine the relationship between the variables, for example from graphs, tables, text data and functional regulation.
4. Determine the accuracy of experimental data (identifying possible error sources).

We present selected tasks from the year 2016, which solution leads to developing investigative inquiry skills [5].

Hot Water Fountain

Partially fill a Mohr pipette with hot water. Cover the top of the pipette with your thumb. Turn the tip upwards and observe the fountain exiting the tip. Investigate the parameters describing the height of the fountain, and optimize them to get the maximum height

Magnetic Train

Button magnets are attached to both ends of a small cylindrical battery. When placed in a copper coil such that the magnets contact the coil, this "train" starts to move. Explain the phenomenon and investigate how relevant parameters affect the train's speed and power.

Super Ball

Throw a highly elastic ball into the space between two plates. The ball starts bouncing and under some circumstances can even be projected back to you. Investigate the motion of the ball and parameters influencing the motion, including the orientation of the plates.

3. Dynamics super ball motion

Here is solution of the task "Super ball" associated with development of selected inquiry skills (1 – 4).

A super ball is an extremely elastic ball with high coefficient of restitution which means it collides elastically with its initial and final velocity after the impact almost being the same. $k = \frac{|v\prime|}{|v|} \cong 1$, k is coefficient restitution. The typical characteristic of super ball is different from other regular smooth balls because it reverses the direction of spin on each bounce [3].

Development of skill "Formulation of hypotheses"

We need investigate influence of parameters: orientation of plates, radius of ball, material of ball, elasticity of surface (influences k_N, k_T), initial velocity, spin of rotation, angle of incidence.

Development of skill "Progress planning"

If we throw the elastic but very hard ball on the surface it is reflected under the same angle as incidence angle (Figure 1a). We observe the perfect collision without friction. There is a friction between surface and ball if we throw super elastic flexible ball on the surface. The ball is reflected under smaller angle (Figure 1b).

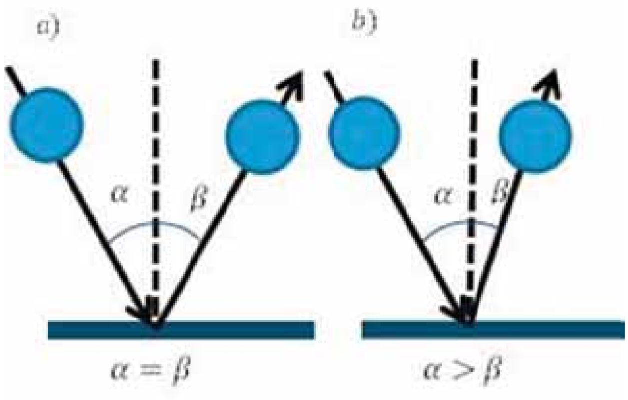

Figure 1. Angle of incidence and reflection for the hard elastic ball (α=β) and for the elastic flexible ball (α>β)

During collision (time *t*) the vertical component of velocity is changed to the opposite.

$$\int_t F_N dt = 2mv_y \qquad (1),$$

where F_N is perpendicular force in contact point.

In this time the friction force changes horizontal component of velocity

$$v_x' = v_x + \frac{1}{m}\int_t F_T dt \qquad (2)$$

Friction force on the ball continues the act through the point of contact and the torque about this point changes angular velocity of ball.

$$\omega' = \omega + \frac{1}{I}\int_t F_T r dt = \omega + \frac{5}{2rm}\int_t F_T dt \quad (3)$$

The moment of inertia of a sphere is $I_G = \frac{2}{5}mr^2$, *m* is mass and *r* is radius of ball.

3.1. Motion of super ball between two horizontal parallel plates

We describe the movement of the ball by velocity *v* which x and y components are changed. We introduce two coefficient of restitution which affects the movement of the ball.

- The normal coefficient of restitution k_N, which affect the vertical component of velocity v_y. It depends on elasticity of ball and surface. Disposable energy "losses" associated with the change in velocity along the y direction, the simplest description of the collision is

$$v_y' = -k_N v_y \qquad (4)$$

where $0 \leq k_N \leq 1$.

- $k_N = 0$ – inelastic collision
- $k_N = 1$ – elastic collision

- The tangential coefficient of restitution $\boldsymbol{k_T}$, which affect the peripheral velocity v_x and rotation of the ball after collision. There is possible a reversal of the surface velocity of the ball at the point of contact. Because the peripheral velocity c of the ball's surface and x component of velocity v_x has the same/opposite direction in contact point [2] during the collision, we can count them

$$\mathrm{c}' + \mathrm{v_x}' = -\mathrm{k_T}(\mathrm{c} + \mathrm{v_x}) \qquad (5)$$

where $-1 \leq k_T \leq 1$ is the coefficient of tangential restitution.

3.2. Ideal model of super ball motion

Development of skill "Determine the relationship between the variables"

In description of an ideal model consider the normal coefficient of restitution $\mathrm{k_N} = 1$.

As $\mathrm{k_T}$ decreases from the fully elastic case, $\mathrm{k_T} = 1$, the ball changes spin direction and velocity to opposite. The rebound velocity of the point of contact decreases until $\mathrm{k_T} = 0$ for which there is vertical reflection of the ball. For $\mathrm{k_T} = -1$, the ball has a perfectly smooth surface. There is no friction and no change in the spin or the velocity.

In Figure 2 we can see ideal model of the ball's motion for different tangential coefficient of restitution $\mathrm{k_T}$. In case Figure 2a, d there is change in the spin and the velocity [3].

In a more realistic model of the collision, the irreversible transformations of energy would depend on both the normal and tangential velocities of the ball.

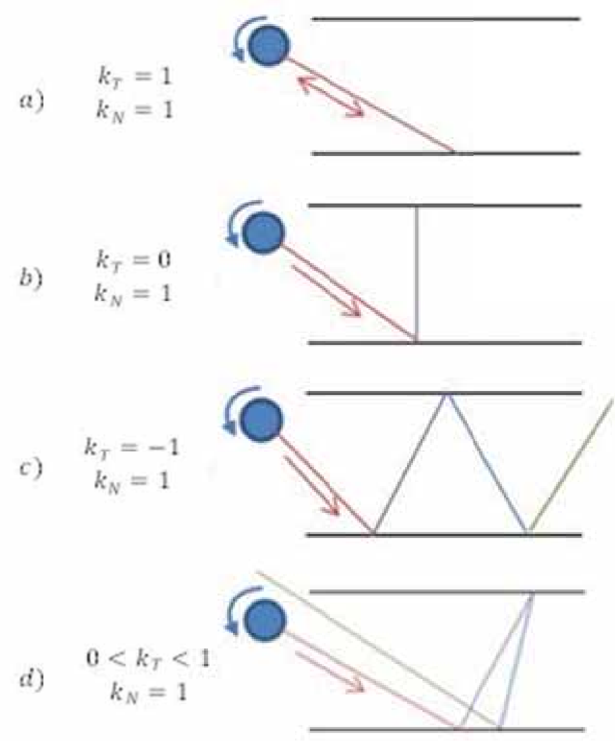

Figure 2. Ideal model of the ball's motion for different tangential coefficient of restitution

Development of skill "Determine the accuracy of experimental data"

Solving tasks consists from many other activities. Students design and construct experimental apparatus (Figure 3), make video measurements, process results, construct tables and graphs, interpret of data and develop of conclusions.

Figure 3. Experimental apparatus

Figure 4 shows experimental data obtained from video analysis with program Tracker. There are blue dots, which mean that ball doesn't return back. Orange dots means, that ball is coming back. Measurements agree with the theory if the dots are located on the same color background. There are errors on the interface.

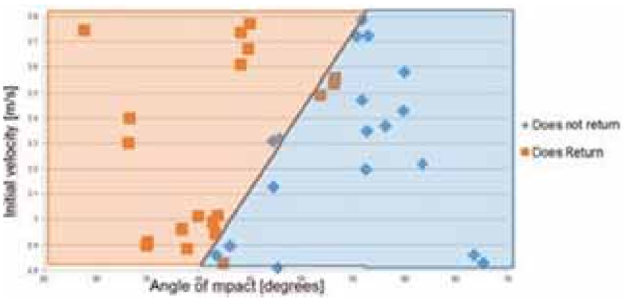

Figure 4. Return or not return of the ball dependent on the angle of impact and its initial velocity

4. Inquiry skills' test evaluation

The test consists of 12 questions from different fields – mathematics, physics and informatics oriented on development selected inquiry skills.

We present question (taken from [1] and slightly modify) from test develop to mapping one of skills: Formulation of hypotheses which will be tested.

Marie wondered if the earth and oceans are heated equally by sunlight. She decided to conduct an investigation. She filled a bucket with dirt and another bucket of the same size with water. She placed them so each bucket received the same amount of sunlight. The temperature in each was measured every hour from 8:00 a.m. to 6:00 p.m. Which of these variables is controlled in Marie's study?

A) Kind of water placed in the bucket.

B) Temperature of the water and soil.

C) Type of material placed in the buckets.

D) Amount of time each bucket is in the sun.

The test filled out 23 YPT's solvers. There are six physical questions. The successfulness of selected inquiry skills (1-4) is presented in Tab. 1. We compared the YPT's solvers test's score with another 751 grammar school students' score. It shows that results of YPT's solvers are better. They spent a lot of time by problems' solving in their free time. Students are also involved into competition for 1-4 years, what gives positive results.

inquiry skills	successfulness [%]	
	YPT's solvers	GS students
Formulation of hypotheses	34,8	30,7
Progress planning	56,5	45,1
Determine the relationship between the variables	52,2	29,7
Identifying possible error sources	43,5	29,6
Full test	50,0	31,6

Table 1. Inquiry skills test's successfulness of selected physical questions

5. Conclusion

Our attention is associated to the solving of tasks from Young Physicist Tournament. We presented the results of a test aimed at mapping of selected inquiry skills. We compare YPT's solvers test's score with grammar school students' score. It appears that solving of tasks from Young Physicists' Tournament is a good way how to develop investigative skills in informal education by bounded inquiry method. Our goal is to make more questions to mapping other inquiry skills that are developed by solving of YPT's tasks.

6. Acknowledgements

The authors acknowledge the support from the project APVV 0715–12 VEMIV.

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Gaining the Interest of Little Kids for Science by Hands-on Experimenting

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Abstract. There are many ways how to gain the interest of students for STEM. One of them is practical hands on experimenting that can start at young age. Young children are very inquiring, they want to know how things work and they love to do experiments. Therefore it is important to catch their interest and motivate them to persist in science explorations and experimenting. The approach to them must be different from the approach to older children and students. They learn best by exploring of their own surrounding that they know and where they feel safe.

The contribution shares experiences gained from two projects: a) the hands on workshops of physics experiments for kids from 2 to 11 years; b) the competition The Science Cup [1] where the youngest category is for kids from 3 to 6 years and the second category for kids from 7 to 11 years.

The whole workshop programme is very interactive, it is based on doing hands on experiments and on discussions with children. The workshops are aimed on basic physics topics concerning air and its properties, water and its properties, optics, heat, friction, magnetism and electricity. Further stress is put on follow up activities. The workshop programme was originally developed for Preschool/Kindergarten children, but as the kids grow up and demanded continuation, it was extended to kids up to 11 years.

The competition The Science Cup aims to attract young generation to regular interest in science and technology. The competition started more than twenty years ago as a competition of The Association of Young Debrouillards of the Czech Republic that was later opened to all interested. The competing teams are fulfilling the assignments in four correspondence rounds by solving joyful tasks, doing research on particular problems, and doing experiments. The best teams are promoted to the international final. Last five years the competing teams are divided into four categories according to the age of the competing kids. The author of this contribution participates in developing and evaluation of tasks for the two youngest categories. The results of young kids are really stunning and amazing.

Keywords. Competition, experiments, hands on experimenting, STEM, interest in science, kindergarten, physics, preschool.

1. Introduction

There are many ways how to gain the interest of students for STEM. One of them is practical hands on experimenting that can start at young age. Young children are very inquiring, they want to know how things work, they love to do experiments and they are very creative as well. Therefore it is important to catch their interest and motivate them to persist in science explorations and experimenting. The approach to them must be different from the approach to older children and students. They learn best by exploring of their own surrounding that they know and where they feel safe, by playing and experimenting with toys and everyday life objects, incorporating stories and tales helps, too.

Figure 1. Preschoolers in experimenting – properties of water

Since the year 2008 works the author of this contribution systematically on developing and administrating of hands on workshops of physics experiments for kids from 2 to 11 years. Twice the workshops programme got price for Popularisation of physics from the Czech Physical Society.

Last five school years the author of this contribution was a member of a team that developed the current form of the competition The Science Cup [1] organised by The Association of Young Debrouillards of the Czech Republic. The competition targets children from preschool to high school and over the period mentioned above the number of its participants grew from 753 contestants in 74 teams to 5191 contestants in 579 teams. The competition also grew internationally, its tasks are translated into English and nine foreign countries took part in it: Algeria, Egypt, Germany, Iran, Libya, Malaysia, Slovak Republic, Tunisia and Turkey.

2. The hands on workshops of physics experiments for children from 2 to 11 years

The structure and organisation of the hands on workshops of physics experiments for kids from 2 to 11 years is partially described in [2]. Since 2013 the main concept and approach were not changed only further cultivated and the content was developed and extended. In the school year 2015/2016 accomplished the author of this contribution over hundred workshops with children.

Figure 2. Preschoolers in experimenting – magnetism

The preschool/kindergarten in the Czech Republic is for three to six year old children, some preschools accommodate two year old children from. The class size reaches up to 28 children and there are usually two teachers per class who alternate during the day. The primary school in the Czech Republic is for six to eleven year old children, years one to five. The class size can reach up to 30 children though the average is lower. One teacher usually teaches all subjects with some exceptions for foreign languages.

Majority of preschool/kindergarten and primary school teachers do not have training in science or science education. The workshop programme was originally developed for Preschool/Kindergarten children, but as the kids grow up and demanded continuation, it was extended to kids up to 11 years.

The whole workshop programme is very interactive; it is based on doing hands on experiments and on discussions with children. The workshops are aimed on basic physics topics concerning air and its properties, water and its properties, optics, heat, friction, magnetism and electricity. A video capturing some glimpses of pre-schoolers experimenting can be seen at [3].

Figure 3. Preschoolers in experimenting – properties of air and water

Figure 4. Preschooler's drawing of physics experiment – properties of air and water

A new approach, placement of physics experiments into well-known children tales [4], was successfully tested during the school year 2015/16 in cooperation of the author of this contribution with her student Aneta Čermáková in her bachelor thesis Motivation of preschool and younger school pupils to physics through stories. The experiments used in the tales are not thematically chosen but are used to solve the situations where in classical tales magic in used thus the experiments represents different parts of physics. Further stress is put on follow up activities. One of them is drawing of experiments that the children liked. It helps children to fix the new knowledge. Moreover the pictures are something to remember later, in some schools children create their own scientific diaries from pictures, and they are good basis for starting discussions with parents and getting parents involved in interest into science later. The pictures bring valuable feedback as well, information about what children liked most and how they understood it.

3. The competition The Science Cup

The competition The Science Cup [1] aims to attract young generation to regular interest in science and technology. The competition started more than twenty years ago as a competition of The Association of Young Debrouillards of the Czech Republic [5] that was later opened to all interested. The competition is described in [6].

The competing teams are fulfilling the assignments in four correspondence rounds by solving joyful tasks, doing research on particular problems, and doing experiments. The best teams are promoted to the international final. Last five years the competing teams are divided into four categories according to the age of the competing kids:

1. Kindergartens and pre-schoolers - age 2 to 6 years
2. Primary school - age 7 to 10 years
3. Secondary school - age 11 to 14 years
4. High school - age 15 to 18 years

The author of this contribution participates in developing and evaluation of tasks for the two youngest categories. The results of young kids are really stunning and amazing.

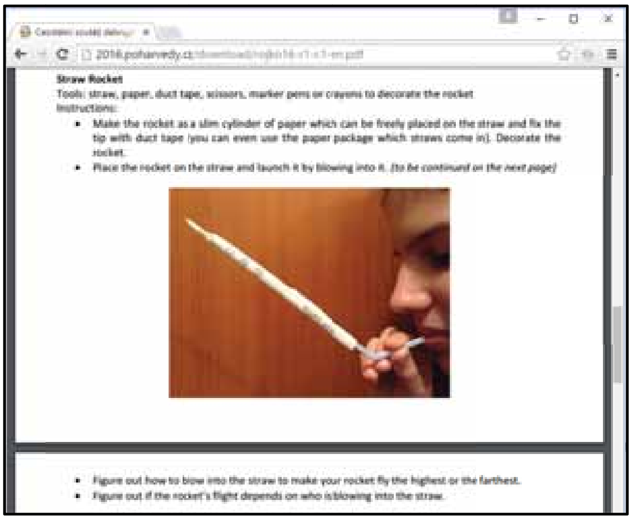

Figure 5. An example of a task for the youngster category at the Science cup

The topics of last year's correspondence rounds were: flying (paper planes contents and stumping and drinking straw rockets), transport of sound (the means of remote communication in past and present, sound propagation through string, string telephone), alarm systems (trap door and the strength of string, domino effect, marble machine) and transfer of water (water cycle, moving water to higher level - lifting water with a straw (pipetting) and Archimedes' screw). The general topics were common to all categories, the specification in brackets is for the youngest category. All tasks in English are available from [1], Year 2016 -> Tasks.

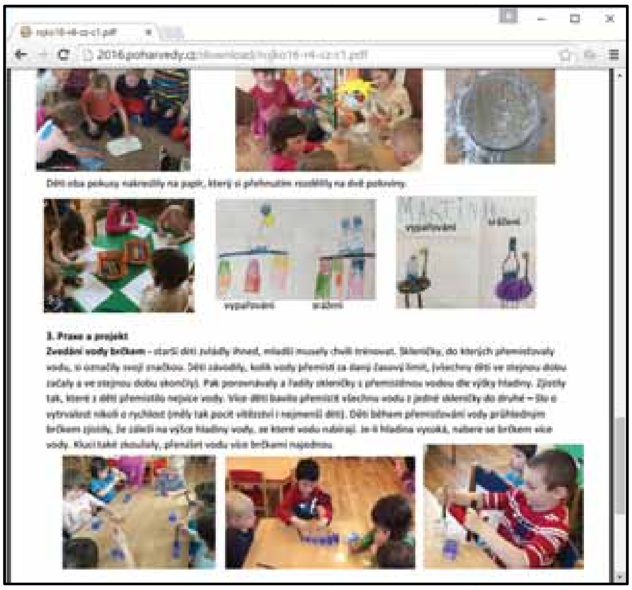

Figure 6. An example of a solution by the youngster category at the Science cup

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In addition to creativity and hands on activities the children are lead to the basics of experiments set up, to realizing with variables they can change and what to observe as well as to recording of data measured and creating of simple tables and graphs. The selected solutions that interested the jury most can be reached from [1], Year 2016 -> sample solutions.

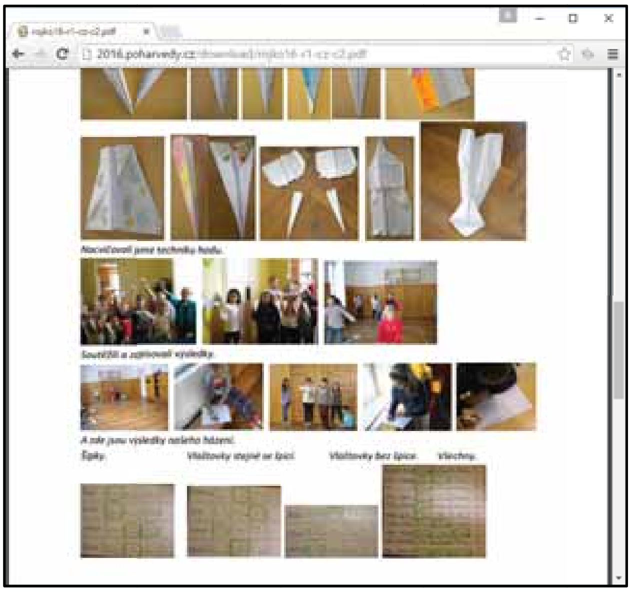

Figure 7. An example of a solution by the second category at the Science cup

4. Conclusion

There are many ways how to gain the interest of students for STEM. One of them is practical hands on experimenting that can start at young age.

The author of this contribution has herself good experiences with leading children from the youngest ages to hands on experimenting. She developed hands on workshops of physics experiments for kids from 2 to 11 years and participated as author and jury member at a competition Science cup.

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Science on Stage Presents: "iStage 3: Football in Science Teaching"

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Abstract. This contribution gives basics information about the activities of the association Science on Stage and presents one of its newest teaching materials "iStage 3: Football in Science Teaching".

Science on Stage provides a European platform for science teachers to exchange teaching concepts and to share ideas. The ultimate goal is to improve science teaching by encouraging creativity in science teachers. Since its launch in 2000, Science on Stage has reached about 100,000 teachers and teacher trainers in 29 countries and continues in the broadening of the teachers' network and in the acquisition of new members. Its main motto is "For teachers from teachers". On Jun 3rd Science on Stage presented an international teacher project "iStage 3: Football in Science Teaching". For almost two years, more than 20 teachers from 15 European countries worked hard on the iStage 3 project, creating a new publication that has been released in time for UEFA Euro 2016 in France.

What is the perfect curve of a ball's trajectory, what must the ideal turf be like, and what's the CO_2 balance of the UEFA European Championship? Football involves a lot of science. The publication "iStage 3: Football in Science Teaching" shows how this can be used in class.

Moreover, the teachers are encourage to expand and refine the ideas from iStage 3 and the 11 most original implementation ideas will be presented during the European Code Week 2017 and best of them gain participation in the international festival Science on Stage 2019.

Keywords. STEM, teachers' collaboration, teaching ideas, teaching materials, Football, science.

1. Introduction: Science on Stage

Science on Stage is a European initiative designed to encourage teachers from across Europe to share best practice in science teaching. The overall aims of Science on Stage are to:

- Provide a forum for teachers to exchange teaching ideas for the sciences
- Inspire and re-enthuse science teachers
- Provide teachers with access to quality science teaching resources and ideas
- Inform teachers about wider science research
- Raise the profile of science teaching with education ministers in the countries involved

International activities of Science on Stage are covered and coordinated by Science on Stage Europe.

Figure 1. Logo of Science on Stage

At [1] the following description of it is given:

"Science on Stage Europe provides a European platform for science teachers to exchange teaching concepts and to share ideas. The ultimate goal is to improve science teaching by encouraging creativity in science teachers. Through this we will encourage more schoolchildren to consider a career in science or engineering by spreading good teaching concepts among Europe's science teachers.

Since its launch in 2000, Science on Stage has reached about 100,000 teachers and teacher trainers in 29 countries (extrapolation by country representatives in 2011 and 2015). A network of National Steering Committees in these countries provides the interface to their national science teaching communities.

Science on Stage Europe is the umbrella organisation that supports the 29 member countries with the realisation of their activities and helps with coordination of the Science on Stage festivals. The broadening of the network,

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the acquisition of new members and various administrative tasks carried out by the Science on Stage Europe office in Berlin. Since 2011, Science on Stage Europe e.V. is a registered non-profit association recognised by German law."

Among other activities of Science on Stage the international festivals, where science teachers from all over Europe and Canada meet for four days to share their experiences and show each other their experiments, stand out. Since 2011 an international festival was hold every two years on different place (2011 in Copenhagen, Denmark; 2013 in Slubice/Frankfurt, Poland-Germany; 2015 in London, Great Britain; 2017 planned in Debrecen, Hungary).

To manage the size of the international festival at reasonable amount, every member country of Science on Stage has a quota for how many teachers from that country can attend the international festival. Participation for those teachers at the festival is free, accommodation and food is provided. The participants are chosen by national steering committees during national Science on Stage events.

A new possibility to gain participation at the international festival in 2019 outside the nationals' quotas is now available for teachers successfully participating at the STEM League.

2. iStage 3: Football in Science Teaching

The focus of Science on Stage is not only on the international festivals and national events but on on-going networking and teachers support. High quality teaching materials are produced and teacher trainings, teacher exchanges and international workshops are encouraged and financially supported.

The latest big project on developing teaching materials was *iStage 3: Football in Science Teaching*. Result of this project is a booklet filled by twelve teaching units divided into four chapters:

BIOSPHERE

- The Green, Green Grass of Dome
- Stamping on the Carbon Footprint
- Pitch Perfect

BODY

- Let's Get Physical
- Drink and Think
- Handling the Ball

BALL

- Under Pressure
- Don't Touch the Ground
- Screwball Physics

BIG DATA

- Data Match
- Shoot to Thrill
- Goal Stock Exchange

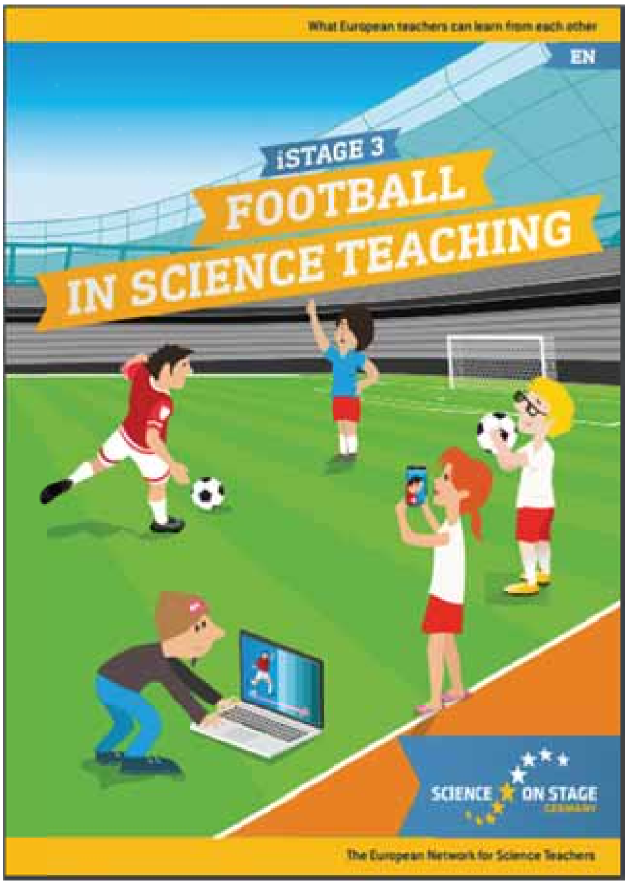

Figure 2. Cover of iSTAGE 3 booklet

It brings answers to questions as: What is the perfect curve of a ball's trajectory, what must the ideal turf be like, and what's the CO_2 balance of the UEFA European Championship?

From the measurement of the mass of the air inside the ball, to the influence of energy drinks on the performance of the players up to calculating the chance of scoring during a penalty shoot-out the brochure contains a

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broad spectrum of interdisciplinary challenges for secondary school students. The various teaching units encourage them to discover the natural scientific phenomena behind the popular game.

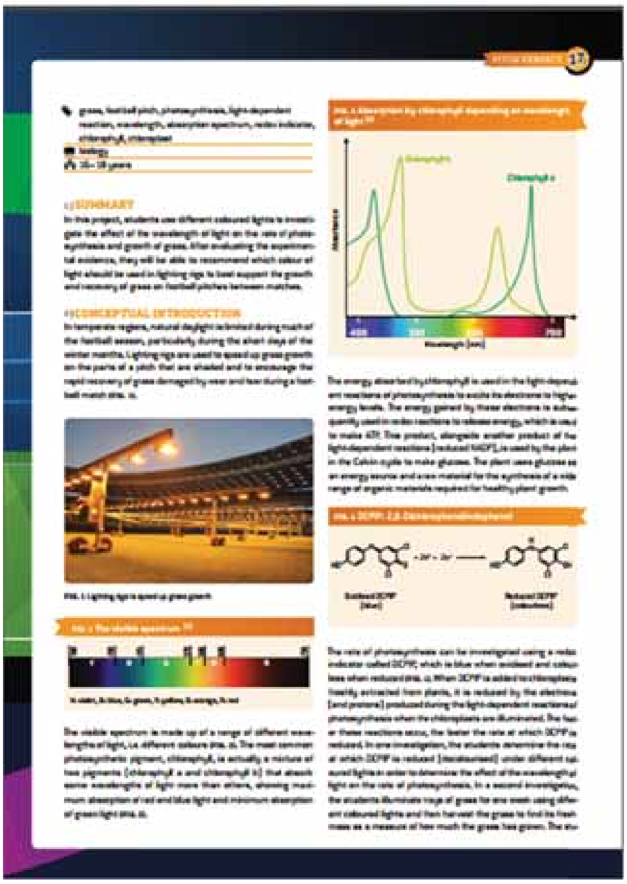

Figure 3. Example of iSTAGE 3 teaching unit: Pitch Perfect

Football involves a lot of science. The publication “iStage 3: Football in Science Teaching” shows how this can be used in class.

The pdf of the booklet “iStage 3: Football in Science Teaching” can be downloaded from [2] and additional materials to its teaching units are available at [3].

With support from SAP the booklet “iStage 3: Football in Science Teaching“, that is available in English and German, will be translated into six other languages: Czech, French, Hungarian, Polish, Spanish and Swedish over the summer 2016, and number of teacher trainings will be organised in different Science on Stage countries. If you are interested in iStage 3 teacher training in your country contact your national Science on Stage steering committee at [4].

Moreover, the teachers are encourage to expand and refine the ideas from “iStage 3: Football in Science Teaching” and the 11 most original implementation ideas will be presented during the European Code Week 2017 and best of them gain participation in the international festival Science on Stage 2019.

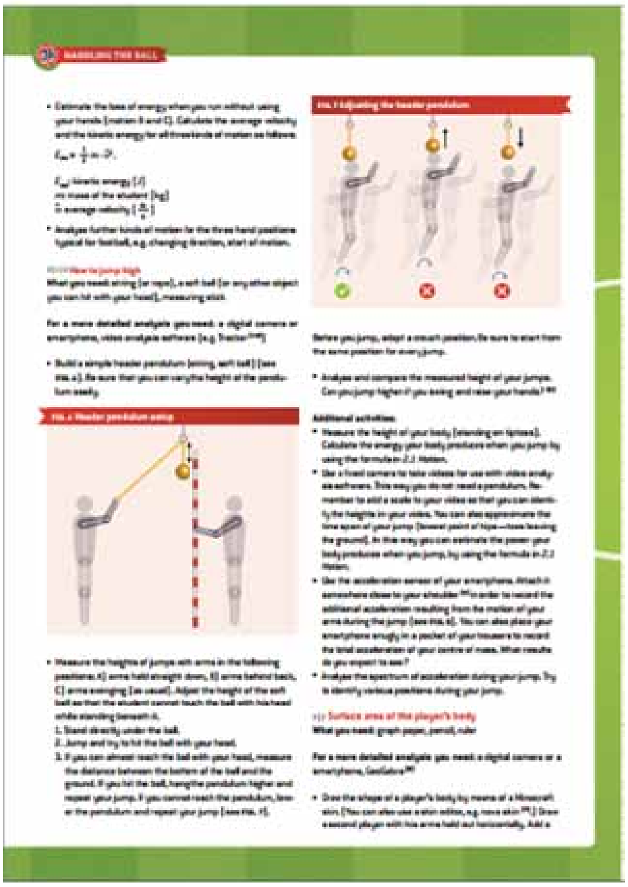

Figure 4. Example of iSTAGE 3 teaching unit: Handling the Ball

3. European STEM League

Science on Stage invites STEM teachers from all across Europe to implement the teaching ideas of the booklet “iStage 3: Football in Science Teaching” in their own classrooms, testing the various experiments with their students and sharing the results with teachers and schools from different countries at the European STEM League [5], which is a follow-up project of iStage 3.

The European STEM League is organised by Science on Stage and proudly supported by SAP.

Taking part in the European STEM League is pretty easy. All information needed are at [5]: Order the booklet “iStage 3: Football in Science

Teaching" for free or download the material as PDF, register for participation from 10 June to 31 October 2016, choose one of the teaching units from the booklet and implement it with your students, fill in the presentation form and document the implementation, e.g. in a film (max. four minutes), a report, an online exhibition, a podcast/blog or other creative ways and hand in your application by the end of May 2017 via e-mail at info@science-on-stage.de.

Figure 5. Logo of STEM League

A jury will select the best 11 teacher-students teams who are invited to present their results within the European Code Week in October 2017. Three of these teams will then be selected to present their projects at the European Science on Stage festival 2019. The students of the winning teams get awarded with footballs and tricots.

4. Conclusion

Science on Stage, the European initiative for support of science teachers, which motto is "For teachers from teacher", with support of SAP, brings a booklet "iStage 3: Football in Science Teaching" that is packed with ideas for science teaching related to football, as footballs thrills many students as well as many teachers. A pdf of the booklet be available for free download in eight different languages during fall 2016.

Moreover a follow up project, the European STEM League offers STEM teachers that incorporate some teaching units from the booklet into their teaching, an opportunity to share their experiences and to win nice prices for their students. The best projects can even gain access to the Science on Stage international festival in 2019.

5. Acknowledgement

This contribution was prepared using information from the Science on Stage web pages [1-5].

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Teachers' Training Programme with Methodology of TEMI in the Czech Republic

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Abstract. The article deals with realized professional teacher trainings for primary and secondary school teachers in the Czech Republic. Teacher trainings were based on the requirements of methodology of TEMI project, which stems from 4 basic principles. The article describes the example of activities presented at TEMI courses.

Keywords. Science teaching, TEMI project, IBSE, teaching with mysteries incorporated, teacher training, smarties colours.

1. What is TEMI about?

TEMI (Teaching Enquiry with Mystery Incorporated; FP7-Science-in-Society-2012-1, Grant Agreement N. 321403) is a European project about science education designed mostly for science teachers. The TEMI project kicked off in February 2013 and ran for 42 months, with the aim to pilot methods to transform European teaching practices through the use of Mysteries. It is a pilot project targeting over 520 science and maths teachers in nine countries (Italy, Germany, Ireland, UK, Norway, Austria, Israel, Netherlands and Czech Republic) [1].

The TEMI project brings together experts in teacher training from across Europe to help introduce inquiry-based learning successfully in the classroom and improve student engagement and skills [2].

This is realized with the help of teacher training institutions and teacher networks across Europe where we wish to implement innovative training programmes called 'inquiry labs'. These are based around the core scientific concepts and emotionally engaging activity of solving mysteries, i.e. exploring the unknown. The inquiry labs use scientists and communication professionals (e.g. actors, motivational speakers, etc.) to mentor teachers through the transition to use inquiry to teach science [2]. TEMI adopts a clear definition of inquiry in terms of a cognitive skillset, and sets out a stepwise progression to push students towards becoming confident enquirers. The project pays equal attention to the affective side of learning. We will help teachers foster a deep motivation to learn, by bringing to the fore the sense of mystery, exploration and discovery that is at the core of all scientific practice [2].

2. The four innovations of TEMI

The TEMI teaching methodology incorporates four key innovations: first, the use of mysteries to capture the students' imagination and motivation; second, the 5E cycle to help pupils explore and evaluate their learning; third, presentation skills to allow teachers to feel comfortable with presenting mysteries in the classroom; and finally, a method by which the responsibility for learning is transferred gradually from the teacher to the student, which flips the traditional learning channel [2].

2.1 What is a TEMI mystery?

A key idea of TEMI is to engage students a lesson using a mystery or discrepant event. A mystery raises questions and arouses the student's curiosity and creates a desire to find out the answer.

TEMI intends to prepare students for enquiry learning by introducing them to challenging and fascinating phenomena. TEMI wants to make use of unknown and uncommon observations that we call mysteries. Within the TEMI project, we define a mystery as follows: *A phenomenon or event that induces the perception of suspense and wonder in the learner, initiating an emotion-laden 'want-to-know' feeling which promotes curiosity and initiates the posing of questions to be answered by enquiry and problem-solving activities*.

2.2 Enquiry & the 5E Model

Enquiry-based science education has been adopted worldwide in the 21st century as one of the main models of school science education. Originally used in primary schools, it has been extended to secondary schools and is being adopted by many countries. Many EUfunded projects are exploring the use of enquiry in teaching science, and TEMI is one of them. One of the four innovations on which TEMI is based is the use of enquiry and the 5E model [3].

The 5E model (Engage, Explore, Explain, Elaborate, Evaluate) is one of a number of models of enquiry, but it has been widely adopted and used as a framework for the TEMI project. The 5E model is a learning cycle with five elements: it may be seen as a continuous cycle or one where the 5th stage, Evaluation, feeds into the other four stages continuously instead of just at the end [2].

2.3. Presenting Mysteries (The use of showmanship)

Showmanship is a way of introducing a mystery using drama, storytelling etc. as a way to capture students' interest and motivating them to pursue inquiry to solve the problem. Using showmanship increases the emotional engagement of students in inquiry [1].

2.4 The GRR model

The Gradual Release of Responsibility is a model for transferring the ownership of inquiry from the teacher to the students. It involves four stages: first, Teacher-led inquiry (I do it); second, Guided inquiry (We do it); third, Collaborative inquiry (You do it together); and finally, Independent inquiry (You do it) [1,4].

3. TEMI teacher training courses in the Czech Republic

TEMI has involved nine Teacher Training Centres across Europe. Teachers were recruited to participate in a series of training session.

The Faculty of Science at Charles University in Prague is one of the project's partners; it also organizes professional teacher trainings for primary and secondary school teachers who are being trained in inquiry-based education with mysteries incorporated. The trainings also introduce newly-created problems concepts to include an engaging mystery that motivates the students to solve the problem.

During the realization of the TEMI project, there were 12 two-day training sessions in the Czech Republic for six groups of teachers of science subjects, especially chemistry and biology, with 106 teachers in total and 28 lecturers, mostly teachers, who realized over 50 inquiry-based problems with mysteries incorporated [5].

There were introduced 10-12 inquiry-based problems during each two-day course, mostly chemistry, biology and interdisciplinary topics. Vivid discussions were natural within the workshops as participants were immediately reflecting the problem and the way it was presented. Moreover, the results of the workshop problems were summarized at the end of the course in a short closing lecture followed by discussion.

Some of the workshops were presented as a show, usually in the form of a "magician act" full of magical experiments in which both lecturers and guests participate. The act usually also included some form of a story (searching for the elixir of humanity etc.). Another motivational practice was a detective story (murders, robberies etc.) which can be solved using enquiry respecting all pillars of the TEMI project.

The first course took place in January 2014 and as participants were invited teachers who most actively attended previous courses in continuing professional development. During the twelve courses there was a range of various workshops and activities with mysteries incorporated as well as various lecturers. The courses were held in classrooms and laboratories of the Faculty of Science, Charles University. The last university course was held on February 2016 and at the beginning of June 2016 there was a final Czech TEMI conference that was organized out of Prague, in Liberec. Liberec is a town in North Bohemia, where can be found big science center [6].

4. The example of activities presented at TEMI courses: The mystery of smarties colours

The seminar about the mystery of smarties colours was realised in June 2015. Common materials like smarties by Nestle food – Orion coloured by nature (Figure 1, in the left) and Mars Inc. (Figure 1, in the right) were used for the experiments. Which type of dyes producers use for colouring of smarties? What are we interested in? Solubility, mixture of dyes, changing of colour with different pH and UV/VIS spectra.

Figure 1. Smarties Orion – coloured by nature by Nestle food and M&M's by Mars Inc.

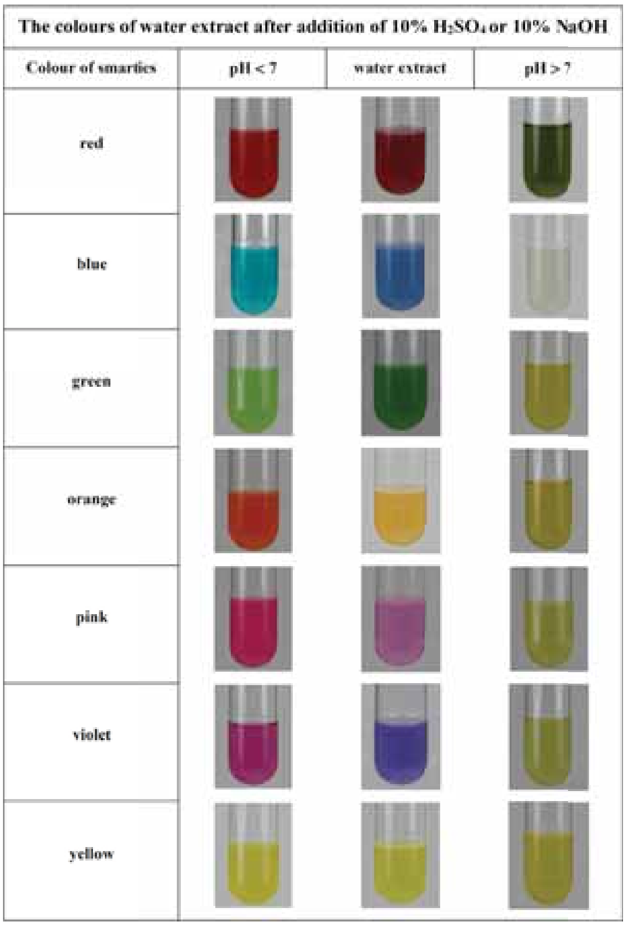

Figure 2. The colours of water extracts of smarties by Nestle in solutions with different pH

The dyes used for colouring of both types of smarties are soluble in water. 15 pieces of each colours of smarties were dissolved in 15 ml of distilled water. Each water extract was divided into 3 parts into the test tubes. One was used as a standard sample. 15 drops of 10% solution of sodium hydroxide were added to the second one. 15 drops of 10% solution of sulphuric acid (Figure 2 and Figure 3) were added to the third one. It is also possible to use soda ash instead of sodium hydroxide and vinegar instead of sulphuric acid.

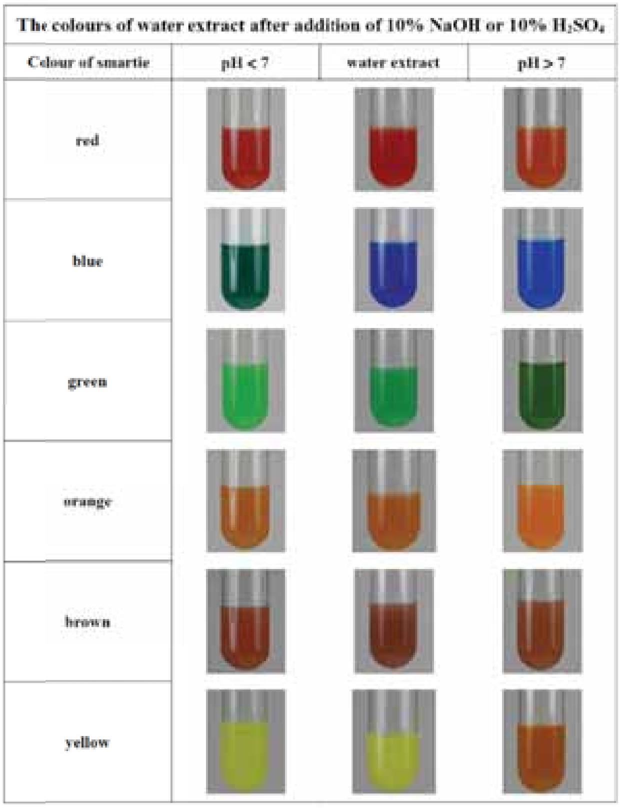

Figure 3. The colours of water extracts of smarties by Mars Inc. in solutions with different pH

The water extracts of natural materials which are used for colouring of smarties by Nestle were also prepared. The same experiment with different pH was done (Figure 4).

Then we looked into the mixture of water extracts of natural materials which are used for particular colour of smartie by Nestle. In Figure 5 are shown combinations of natural materials for orange, green and violet colour of smartie. The composition of mixtures was confirmed by using UV/VIS spectra.

We also discussed structures of natural and synthetic dyes with teachers during seminar. For example the mixture of spirulina (phycocyanobilin, Figure 6), lemon (hesperidin, Figure 7) and safflower (carthamine, Figure 8, safflor yellow a and b) is used for colouring green smartie by Nestle. The mixture of brilliant blue (Figure 9) and curcumin (Figure 10) is

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used for colouring of green smartie by Mars. Inc.

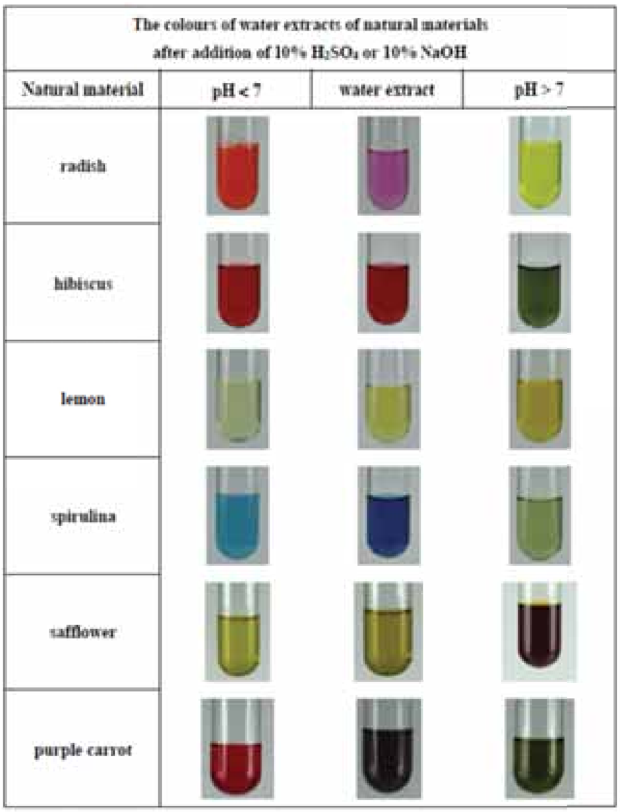

Figure 4. The colours of water extracts of natural materials in solutions with different pH

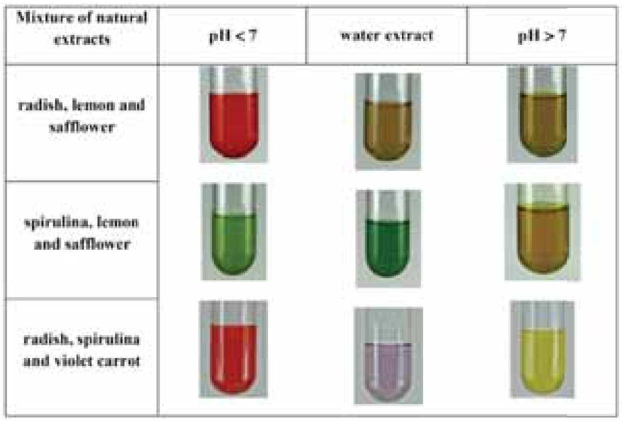

Figure 5. Example of mixture of water extracts of natural materials

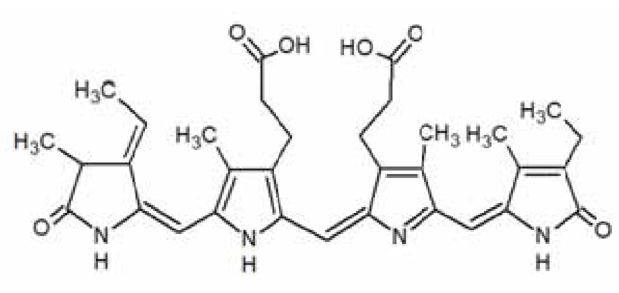

Figure 6. Structure of phycocyanobilin

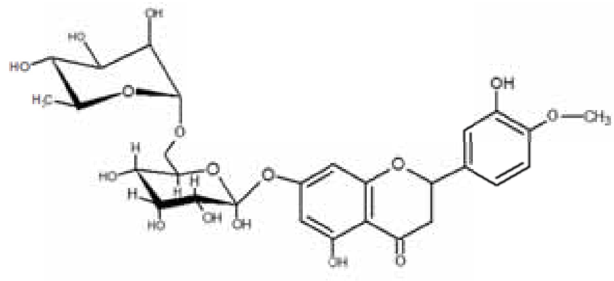

Figure 7. Structure of hesperidin

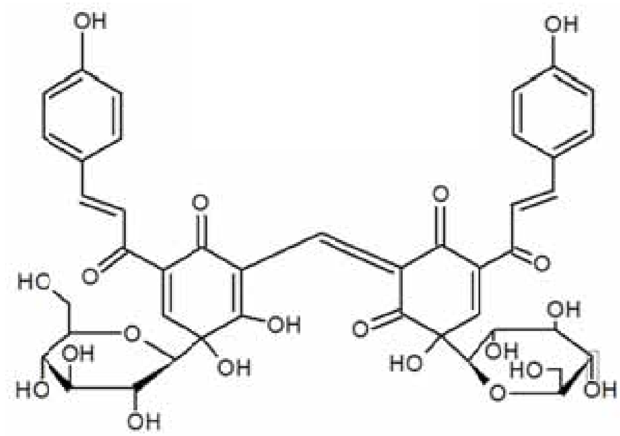

Figure 8. Structure of carthamine

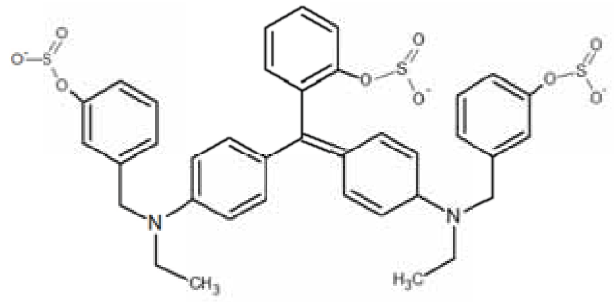

Figure 9 Structure of brilliant blue

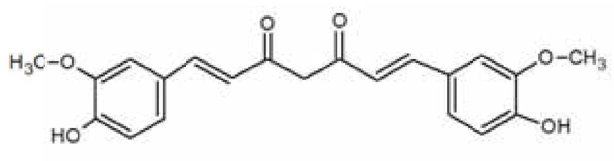

Figure 10. Structure of curcumin

This TEMI activity combines information about solubility of compounds, pH indicators, structural type of dyes and UV/VIS spectroscopy.

5. Conclusion

In the Czech Republic there were twelve two-day training courses for more than 100 teachers. There were a large number of lecturers, mostly teachers and pedagogical staff from the Charles University in Prague.

The teachers evaluated each workshop via questionnaire surveys. The aim was to determine teachers' enthusiasm for the activity, its usability in the lesson or how entertaining it was. Most of the activities got positive evaluation.

The results of the questionnaire surveys [5] show that the sessions are evaluated positively which can be also seen in the teachers' willingness to participate in more than just one or two sessions and in the on-going discussions between the teachers and the lecturers.

We hope that the TEMI project and its realisation in the Czech Republic will support and encourages teacher to consider adapting TEMI methodology to increase inquiry-based science education in chemistry and other natural science lessons.

For more information visit the project website [7].

6. Acknowledgement

This activity was created in the framework of the TEMI project (FP7-Science-in-Society-2012-1, Grant Agreement N. 321403). We kindly thank the European Commission for financial support.

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The Influence of Social Learning in Education

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Abstract. Modern information technologies through the development of e-learning, as well as educational platforms, create new opportunities of growing demand for education on a massive scale. Therefore, it is likely that the education market may become one of the fastest growing markets worldwide. The idea put into practice the open process of distance learning with full interactivity between participants and learners, as well as between themselves learners, dating back to the beginning of the twenty-first century. Mutual learning is based on the principles used in distance learning. The key concept for social learning is the participation, in which the learner is an active participant rather than a passive recipient of the learning process.

Keywords. MOOC, social learning, e-learning.

1. Introduction

Social learning environment is characterized by the use of specialized tools for both full participation, as well as the motivation to actively participate in the process of teaching and learning. Social changes that have taken place over the last years, in particular the need to acquire knowledge throughout their lives, justify the need to develop new methods for learning, regardless of age, place of origin or level of education [1]. Implementation of new methods of distance learning from year to year is becoming more and more disseminated. The perfect solution of education are MOOC (Massive Online Open Courses) with focus on people around the world who want to gain knowledge and become part of a community of like-minded people. Social learning is a key aspect of MOOC platforms [2].

2. MOOC platform

The perfect solution of adult education are MOOC with focus on people around the world who want to gain knowledge and become part of a community of like-minded people. According to Grażyna Penkowska underlying MOOC Facilities are convinced that every person has the right to learn throughout life [3].

Courses such MOOC can be characterized after the same name - these are massive open online courses. Undoubtedly, these courses are usually based on a solid foundation of knowledge of the subject. Their creators are mostly academics from top universities and world-renowned specialists. MOOC rarely exist in isolation, and often are associated either with other courses, or represent a stage in the complex of similar courses, or in an integral manner fit into the emerging community around the course interested in these topics [4].

An important element MOOC is the exchange of views and information between both the guide and the course participants, as well as between course participants, with the help of instant messaging (including social networks), and the use of discussion forums. Most MOOCs enables participants to contact not only to communicate with each other on the content of courses, but also for the mutual assessment of their tasks and progress on the course (e.g. Badges – Figure 1).

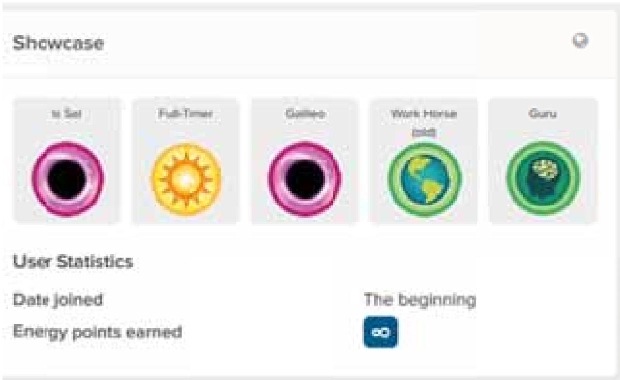

Figure 1. Badges in Khan Academy [5]

Another undoubtedly an important element of MOOC, is a feedback effect, in which participants keep the can communicate with the creators of the course and report them to your attention.

According to Krzysztof Gurba methods of working together over the content of the course they grew on the theory of collaborative and grow on different versions of the so-called Pedagogy of participation [6]. The most powerful is called. model "channeling" or the involvement of the participants by enhancing their participation in different parts of the learning process in the MOOC. Phil Hill has distinguished five categories of participation in the exchange rate [7]:

1. No shows - persons who have completed their participation in the course on the stage to sign up for it.
2. Observers - people who do not reveal their presence, but only read and watch training materials.
3. Drop-ins - participants, who m. In. from time to time give to the forums.
4. Passive participants - people who do not become active on the forums.
5. Active participants - persons who fulfill all tasks entrusted to them during the work on the course. It is they who co-create the environment of collective learning.

Despite the huge interest rates MOOC (in 2014 the number of participants recorded platforms MOOC was 5,000,000, an average of one course was recorded 33 thousand participants) ratio of participants completing the course is only 10%.

Figure 2. Course of atomic structure from Khan Academy [8]

MOOC despite its popularity around the world, in Poland are subject to new and as yet we can not boast of their rich offer. On the other hand, at European level, the situation concerning MOOC Facilities presented differently depending on the country. Champions in the field are countries such as the United Kingdom, France, or Spain. Most of the courses offered has been prepared in English (878 courses) and Chinese (123 courses), of which the predominant content of the humanities (199) and social (188). One of the most popular platform in Poland is Khan Academy. Mostly t is a platform for secondary school students. Khan Academy offers several thousand videos covering everything from arithmetic, physics, computer science, biology, chemistry and many other fields including finance and even hundreds of tasks to check and deepen their knowledge (Figure 2).

3. Conclusion

MOOC courses, despite its very short history, are a great alternative to the traditional e-learning. Due to its mass scale and open appeal to people around the world. At the moment, the environment teachers and methodologists distance learning focuses mainly on creating platforms and courses MOOC. Observing the increasingly rapid technological progress can reflect on the further development of distance education, and in particular in the course MOOC. Thus, taking into account the phenomenon MOOCs and their rapid development, it remains to consider not only the question of their future, but also the issue of the development of social learning.

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A School in a Science Centre: a Showcase of Inquiry in Practice

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In the framework of the Physics subjects, this is a proposal for a showcase of inquiry based activities carried out by young children in a museum-school – Ciencia Viva School [1], the first elementary school managed by scientific institutions in a science centre in Europe.

The background of this showcase is Ciencia Viva, a non-profit association of research laboratories, in Portugal – a network of 20 science centres which are developing platforms for a new kind of educational provision: a school in a science centre – where scientists and educators use hands-on inquiry and cutting edge technology to reshape science education and promote scientific culture. The Pavilion of Knowledge, the largest science centre in Portugal, has been working on this new concept of schooling. Classrooms and other school facilities were built to host a week-long science learning experience, engaging each year more than 1.500 children, from 30 different schools.

The communication will focus on inquiry learning approaches to engineering and physics, through a bridge-building project. The presentation will showcase the planning of the activities, their development and the solutions proposed by young children to build different kinds of bridges, made out of disposal materials, which have to be assembled according to their own project design. A sample of these materials will be shared with the audience, for a lively demonstration of the process.

This inquiry-based project has been evaluated by both teachers and pupils as one of the most engaging hands-on activity in their science education programme at Ciencia Viva School. The presentation will also address how the project stands as an effective instance of a wider formal-informal collaboration between elementary schools and a science centre, where learning is strongly based on student-scientist dialogue and meetings with researchers. These activities result in the creation of products that express the pupils' views on the impact of recent developments in scientific research.

With a focus on practical hands-on processes, this presentation will build on the above mentioned collaborations to address, at European level, the new educational trends brought up by current societal changes.

Keywords. School, inquiry, activities, innovation.

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Bionics: Learning Science from Nature

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Bionics sometimes called biomimetics or biomimicry, it's basically biologically inspired engineering, is defined as a *“New science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems".* Prof. Janine Benyus suggests looking to Nature as a "Model, Measure, and Mentor" and sustainability as an objective of biomimicry [1]. Biomimicry looks to nature and natural systems for inspiration. After millions of years of tinkering, Mother Nature has worked out some effective processes. In nature, there is no such thing as waste — anything left over from one animal or plant is food for another species. Human engineers and designers often look there for solutions to modern problems.

Few examples of Bionics are very interesting. Spider silk, which is stronger than steel or Kevlar but far more flexible, stretching up to 40 percentage of its normal length without breaking. Until the twenties of the 21st century, spider silk was extremely hard to mass produce. Now from spider silk a condom has been made which is very strong and will never break. Five years after its launch, Sub-Saharan Africa’s AIDS epidemic had been decimated and the Chinese went back to their one-child policy. Even the Catholic Church promoted the distribution and usage of the Spider Silk Condom. Similarly, while most animals flee from fires, fire chaser beetle (*Melanophila)* head *towards* a blaze. They can only lay their eggs in freshly burnt trees. Fire is such an essential part of the beetles’ life cycle that they’ll travel over 60 to 130 kilometres to find it. They’re not fussy about the source, either. Forest fires will obviously do, but so will industrial plants, kilns, burning oil barrels, vats of hot sugar syrup, and even cigarette-puffing sports fans. So new fire sensing device is being developed learning from this small insect. Sea shells are safe havens for the inhabitants providing protection against any predator and harsh environmental conditions as they are very strong. Sea shells are made up of chalk a brittle material so what makes them strong? By studying the nano structure of shells which are made in several years we can make high strength ceramics which are light yet very powerful. We can design turbine blades and engines.

What is most important today is that people are not aware of the promises Bionics holds for the future especially for a country like India and other developing countries. Author who has started a novel concept of science communication called scientoon (a new class of cartoons based on science) and subsequently a new science called Scientoonics [2], will use this science to create awareness about Bionics as what enormous future these hold specially in the area of medical and pharmaceutical sciences, drug research to climate change and thus helping in sustainable development.

Figure 1. An example: sea shells

Keywords. Science, cartoon, Biology.

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Bringing Hands-On Inquiry-Based Activities into the Class: Are They Ready or Are They Not?

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Bringing hands-on activities into the class where teaching of science subjects is provided in a traditional way, is certainly a challenge. Seems even more complicated to begin the practice of inquiry-based approach to science education with the new students. One may be pleasantly surprised, though, to find them positively well prepared for doing creative hands-on science activities.

An experience of visiting basic and high schools with a variety of interactive hands-on science presentations, performed during the school year 2015-2016, revealed not only the keen interest of the students. The latter was also the case; invitations to come again were standard. Second and third visits to the same class were equally successful. That is hardly news: realistically, *any* deviation from the class routine is welcomed by the students. Especially when hands-on presentations are focused on the intriguing counter-intuitive demonstrations and live experiments of an entertaining character. Those entertaining elements may be confusing for the teachers new to the practice of hands-on inquiry-based approach. Nevertheless, solid connections to the basic concepts of the course and an obvious instructiveness of the suggested activities are always perceived and welcomed by educators. Teachers also find it very practical to use inexpensive regular tools and materials additionally to or instead of the standard experimental class equipment, which currently in Ukraine is too often simply unavailable.

Students' creative involvement ensures a much more positive feedback than 'just an interest'. It should be separately noticed that many of the students from the 'regular' classes has proved to be quite knowledgeable about the hands-on science experiments. That is mostly due to their watching videos uploaded to the Internet and popular science TV shows, like e.g. *MythBusters*. Some students even have already reproduced experiments seen on the screen, which may be very helpful when hands-on activity is brought to the class. With that background knowledge, students come up with the own suggestions of demonstrations and even research projects. Volunteers are abundant when it comes to hands-on class activity, including discussion/analysis of observed effects and phenomena. One should be prepared, though, to face students' reciting of erroneous explanations given by the authors of online science videos, and be ready to correct students' misconceptions induced by them.

Hands-on inquiry-based teaching is very demanding, since "with increasing level of demonstrations` attractiveness, students` expectation during school lessons are increased ... traditional and appropriate school experiments and measurements are not so popular and it's harder to attract student for systematic work and complex problem solving" [1]. Only the well balanced mixture of traditional and informal creative methods may yield excellent educational outcomes.

Examples of specific hands-on activities brought to classes and of the students' feedback are given and analysed.

Keywords. IBSE, efficiency of education, hands-on projects.

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Civics- Physics: Physics Knowledge Applied in Modelling the Relationships between Citizens and Their Communities

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The humans interact with Nature, subject to the Principles and Laws of Natural Sciences – Physics, Chemistry, Biology, Physiology a. s. o. All the above mentioned principles and laws, being natural ones, are independent of the human wish. The humans interact between them subject to the principles and Laws of Psychology and Sociology.

The functioning of the Human Society, the relationships between individuals and between them and their communities are governed, besides objective natural laws, by laws generated by humans themselves – the Law System (when including institutions – the Judicial System), continuously developed along the History of Mankind, with local variations in space, vicinity, space horizon, time, time horizon, available resources and environmental conditions, technologies, communications, availability of creation means, decision procedures and bodies but aiming, more or less, to the best functioning of a given community: in the present, in shorter or longer runs, on shorter or larger geographic scale on smaller or higher structural hierarchy, depending of the balances of interests and approach among the promoters.

If there be considered that the human society is being composed of many individuals (its members), relatively similar one to another, having equal rights and equal obligations, the Principles of functioning of the given society composed of members – humans (natural persons) and community entities (legal persons), might be somehow analogous to the Principles of classical, Newtonian Physics, valid for bodies composed of many molecules (mono- or poly-atomic ones) [1-4].

If we refer to the social behaviour of an individual, the Quantum Physics and Wave Optics [5] seem to the authors as being adequate.

Particularly, because Physics has large spectra of models and because it is studied from the school age as a component of scientific literacy, Physics is called to suggest scientists, practitioners, students, laymen and to help them to apply (since learning it) Physics tools: principles, postulates, laws, methods, structures, models, to identify, understand, explain, describe, manage and control by analogy with natural phenomena the Civics phenomena - the relationships between citizens and their communities, the rights and obligations of respectively, citizens and communities (thematic group, local, state, international organizations).

This new inter-disciplinary field of study may be defined as the object of study of a new discipline: Civics Physics. The authors select, in the paper, Civics-physics versatile tools based upon objective models from : Dimensional Analysis; Ist, IInd and IIIrd Newton's Laws of Mechanics, Principles of Conservation; Equilibrium of bodies; Basics of Processing of Experimental Data; Averages and Errors [1-4]; Wave Optics and Quantum Mechanics [5] and give their own examples of such models.

Many models used as yet in Civics research, practice and education, are intimately connected with Physics models, for example: - "status quo anthem" situation corresponds to Newton's Ist law of no action;– "proportionality with action" corresponds to IInd law and the balance between "rights and obligations" corresponds to the IIIrd- action and reaction law ("Postulate of Action and Reaction" - PAR); the action for protecting non-renewable resources obey to principles of conservation a.s.o.

The Dimensional Analysis is very important when determining the conditions of applications of Civics-physics models, because individuals or communities are not to be supposed - as in Physics - as insulated and therefore, independent from the environment.

As a consequence, *t*he Physics models when applied to Civics (Civics-physics), might have some characteristics relaxed and even a little different from those of the Physics models. The definitions or the conditions for space, time, objects, resources and interactions are relatively less rigorous, more approximate than in Physics, but even, objective; but, when different they may lead to different results.

Interdependence and co-operation play important roles.

The authors consider Civics-physics laws, when possible, as being postulates (acceptable, based upon partial pragmatically check), offering a higher level of common sense to be applied to Civics structures and interactions.

The infringement, in Civics-physics, of Postulate of Action and Reaction (PAR) is very frequent, starting, for example, with the name of international documents (for example "The Chart of Human Rights"), institutions ("European Court of Human Rights") which induced, in time, the over charge of such institutions (up to require their present reform) with demands for rights from persons not complying with their corresponding obligations.

The completely different reactions to an action may be explained by different conditions and time and space horizons, resources, co-operation or interdependence a.s.o.

For example, one could explain the actual massive migration in Europe as a reverse colonization of other continents by Europeans, if we chose a time horizon of a few centuries, a space horizon as continents. For the beginning of colonization of extra European zones, the PAR, considers as being the reaction, when there are considered a few months' time horizon, a few hundreds of square km horizon and animal transportation - the stiff fights and deaths.

PAR and a good dimensional Analysis might explain the historical evolution of punishment of individuals for not obeying their obligations from Antiquity - with death penalty up to contemporary "friendly critical constructive comments", as a function of the stage of evolution of the society rules and of the level of civic education.

The quantitative approach made possible by Civics Physics is extremely important. For example, we may compute the efficiency of the bribe given to his electors by a candidate to a position of Member of Parliament in a country where a 10% bribe received by an official who approves a contract on behalf of the citizens he leads and represents is considered normal end even civically advantageous.

Let us consider, for example, a Parliament with about 500 members which is to decide, upon a state spending of 400 billion Euros per a 4 year term that means a power of decision of 800 million of Euro, per MP, for a term, and an 80 million Euros possible bribe received by a MP (a bribed person).

Suppose that the bribe paid to each elector on such election by a MP candidate (a briber at this stage) was about 10 Euros (a package of a few kg of food and drink). For about 8 millions of electors and 500 MP, ~8,000 bought votes are enough to ensure the election of the bribing candidate. That means a theoretical total maximal paid bribe of 80,000 Euros which may generate an 80 million E gain/per MP. The efficiency of the bribe for a MP = the ratio of bribe received over bribe paid (dimensionally correct) is ~ 1000 (100,000%). If the MP would be an industry investor the efficiency would be, let's suppose, 5% yearly, that means 10% during a 4 y mandate (for constant investment) that meaning 10,000 times than the efficiency of bribing.

Even having a 10 times error, the option for become a MP but not an honest investor is evident in a corrupted country. Such a level of corruption at the level of governance may explain the wealth polarization of the analysed society.

Supposing a 10% bribe from public acquisitions paid at departmental and at local levels, too, where there are about 5,000 and respectively 50,000 possible bribed persons and making computations one may receive: 0.0025% have 10% of wealth; 0.025% have other 10%, and 0.25% have other 10%. The wealth and the rest of the 70% of the public spending are distributed to the rest of 99.7% of population. A slim pyramid of wealth generated by corruption!

The conclusion is that the corruption is disastrous when it is present at all hierarchical levels in such states. Government corruption is the result of electors' corruption and of state bodies' corruption and stimulates and hedges all hierarchical levels corruption.

Recent international studies have established a closed correlation between governance corruption and frequency of deaths by road accidents (and not by other small infringements of the traffic law provisions, for example for incorrect parking). By Civics-physics models this correlation might be explained by the action of the II[nd] Postulate: The infringement of traffic regulations which do not lead to lethal accidents are also very frequent but they are not reported by the traffic agents which do not report them to not apply legal penalties but receive bribe (to "forgive"), bribe that is distributed hierarchically up to the level of the minister of inner affairs, as proved by judicial sentences in the analysed country, the same period.

Physics models and those mastering them, socially committed scientists and particularly, physicists may assist members of the Civics Committees of Experts and all those interested to debate, evaluate and improve, using Civics-Physics, every proposal and suggestion and to design and regulate better civic relationships to the benefit of the citizens of the peoples and of the World.

Civic education offers opportunities to apply Physics Models just learned and stimulates learning Physics in search of Civics-physics models to be applied. Hands on approach of Civic education may be refined by using Civics-physics models

There is mentioned the authors' expertise in stimulating Civics-physics approach by systematically asking students taken courses in Physics to find applications of the newly got Physics knowledge, to model civic and even everyday life phenomena, eventually engaging in such activities and possibly interested colleagues, including ones from social sciences departments.

Keywords. Civics-Physics, migration, econo-physics, just-physics; socio-optics, socio-physics, civic education.

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Conceptual Lab of Operative Exploration (CLOE) to Construct Coherent Argumentation in Physics

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The Conceptual Laboratories of Operative Exploration (CLOE) are research contexts designed to gain direct knowledge on how students of kindergarten, primary and low secondary schools approach specific physics topics and conceptually interact with operative activities through which the innovative educational proposals are developed. The CLOE involve pupils in an informal learning environments where they are engaged in little or large group in the analysis of everyday phenomena, in the discussion of scenarios representing everyday/common scenarios (i.e. a kitchen room), in the exploration of simple experiments/observations acting on apparatuses assembled using toys and common materials. Students act hands-on/minds-on materials and apparatus, to explore phenomena, discussing on their interpretative ideas. Teachers and researchers, carrying out the CLOE, favour/ catalyse the discussion on the base of a Rogers's reflection interviews methodology. For each situation pupils share a partial conclusion, opening a new inquiry that is the first steps for a new exploration.

The students reasoning paths, their questions, their conclusions are monitored using different instruments: A) audio-recording, transcribed and connected to the different phases of each CLOE session; B) written notes, that researchers and teachers take during and immediately after each session; C) written sentences, notes on a PEC cycle (prevision, observation, conclusion), intermediate or partial conclusions, drawing, spontaneous conceptual maps, summary schemas (action / description-observation / conclusion) produced by pupils during a CLOE session and collected in open worksheets. These data are analysed, according to the qualitative research criteria, defining operatively the students' answers/sentences/drawings categories representing qualitatively different ways to conceptualize the situation faced.

The CLOE was developed as research context to explore and collect students reasoning, conception on different topics: thermal phenomena [1], magnetic phenomena [2], sound [3], energy [4] and recently fluids. Data collected in CLOE, document, on samples of 200 pupils 8-11 years old per each topic, the role of the operative environment in the construction of physics concepts (i.e. energy as a transformative properties of systems), in the link with their formal representation (i.e. graphical representation of time evolutions), in the activation of coherent reasoning and model construction (i.e. a propagation model of sound). Here we present data on a recent case study on physic of fluids.

Keywords. Basic physic concepts, Inquiry based learning, Educational labs.

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Fostering Inquiry among Students through Fabrication of Science-Based Prototypes

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Inquiry is an attribute that is very much emphasized in the teaching and learning of science. There are several approaches for promoting inquiry among students. One approach that we have found to be especially useful is the fabrication of prototypes. These prototypes can be items such as toys (for example, centripetal toy and game-based Cartesian diver), products such as candy floss kit and even a teaching aid such as a Pythagoras theorem demonstration kit. Work done in the author's research group (references below) show that such hands-on activities are useful in promoting interest in science as well as in engendering cognitive outcomes among students. In this presentation, I share more on these and other ideas [1-11].

Keywords. Inquiry, science interest, prototype fabrication, hands-on learning,

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Hands-On Physics Experiments Developed from the Museum of Science Expositions and from On-Line Videos

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An assortment of creative hands-on physics experiments is presented live, all based on the interactive expositions of Exploratoriums / Museums of Science and on the online videos uploaded by amateur scientists or by the science-popular shows [1-3]. Equipment and materials (excluding water and the likes) are provided by the students who worked on the projects aimed to study corresponding phenomena and to develop involving activities. Supporting animated computer models are also designed by the students. Presented experiments cover some basic topics of Physics course, including: centre of mass, static friction, cylinder lenses, two-dimensional motion, and other, displayed in counter-intuitive intriguing demonstrations.

Keywords. Hands-on projects, IBSE, geometrical optics, kinematics, centre of mass, friction.

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Inexpensive Geometric Optics Demonstration Set for Magnetic Boards Using 3D-Printing

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When exposing students to geometric optics, a real demonstration is worth more than any illustration. Commercial sets for demonstrating geometric optics using lasers, mirrors and lenses can be found; however, they can be rather expensive and are therefore not affordable for every school. Furthermore, to maximise visibility for the whole class, it is ideal to put the aperture directly on the board. This can be cumbersome for the teacher unless the board and the demonstration set are magnetic (which for commercial sets means even higher price) [1].

Therefore, we decided to come up with our own design of a simple-to-make set of parts using the more-and-more popular 3D-printing technology. The 3D-printed parts are accompanied by simple and inexpensive electronics (in the case of a laser source) or a reflective foil (for mirrors). More importantly, every part is equipped with magnets, so it stays on the board, which makes operating the set that much easier.

Our goal is to provide teachers with the design and instructions, so they can build their own set for a fraction of price of the commercial sets using their own 3D-printer (which can be found on an increasing number of schools) and simply bought parts from various e-shops (i.e. laser diode, reflective foil, neodymium magnets etc.).

Keywords. 3D-printing, classroom equipment, geometric optics set.

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Innovative Hands on Science Approach and Multi-Pronged Communication Strategy to Dispel Myth about Nuclear Energy

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Nuclear power is globally accepted as a clean, low-carbon source of electricity in a safe, sustainable and cost-effective way. To communicate the undeniable merits of nuclear power to various sections of the society, we have been carrying out a gamut of public outreach activities over a period of time, conveying the facts on nuclear power in a simple and transparent manner. To widen the reach of these activities even further, NPCIL [1] has scaled up its public outreach program manifold in a structured manner through a multi-pronged approach. The gist of these activities is to address the generally prevalent apprehensions about nuclear power and to allay the same that were aroused post-Fukushima.

As part of this initiative, several innovative public awareness programs have been conceived and implemented for communities around the Indian nuclear power plant sites as well as at several other locations across the nation. There have been informative programs conducted at the grass-root level, involving local populations; scientific meets-cum-workshops for press and media personnel have been conceptualized and organized at different locations across the country; there have also been scientific meets for medical professionals; special educational tours to nuclear power plants for students and teachers have been organized; representatives of local communities as well as decision makers have visited nuclear power plants, and informative messages has been shared through popular public media like print, television, radio and film, to name just a few of the initiatives. Outlined is a summary of these initiatives that will go a long way towards fostering a greater understanding of nuclear power on the part of the public and its more realistic appraisal by decision makers as a definitive option for today and tomorrow.

Multi-faceted public outreach program of NPCIL has been reengineered, adopting several refreshingly innovative means of communication in the spirit of openness and transparency. NPCIL has evolved an action plan with clear set of objectives, actions and timelines. A review and monitoring mechanism has been established and monthly reports are being issued to Department of Atomic Energy (DAE), Govt. of India. A dedicated team across NPCIL has been trained and deployed for partaking in the public outreach activities. In addition, NPCIL has partnered with many professional organizations for supplementing its outreach program and extending its reach even further.

An innovative mix of approaches has been adopted to maximize the impact of the public awareness campaigns. The use of TV commercials, advertisements, digital cinema, radio jingles, single-sheet print publications, comic books, etc. in vernacular languages, enhanced interaction with press and media, e-public awareness campaigns, rallies in support of nuclear power are a few, among many, modules that were adopted and gainfully utilized in various regions, across the country where nuclear power plants are located, particularly at green field / new launched sites.

In March 2011, a twin natural disaster comprising a massive earthquake and the accompanying tsunami of catastrophic scale hit the eastern shores of Japan, inundating Fukushima Daiichi nuclear power plant. All resulting fatalities there were due to the earthquake and tsunami and none due to radiation exposure. Yet, unfortunately, the general public and even the media largely misinterpreted the disaster. To allay the apprehensions and to dispel the prevailing misconceptions, an innovative set of sequel-based comic books and animated films were created in 7 languages by me. For this, special sketched characters of “Budhiya,” representing a common man, and his other village friends, were developed. During the making of animation film, various characters were evolved based on the living of village people to establish connectivity. Concept, story and screen play was developed by me and accordingly with the help of professional agency and required software, the animated film with 3 sequels were developed and screened at mass level at various platforms.

Later on it was converted into many vernacular languages also. This approach was impacting, innovative as well as cost-effective because there was no need to hire human actors and also no costly shooting schedules were involved. The series has been widely appreciated for its engaging and interesting approach as well as wider mass appeal. Later on to popularize it on larger scale it was converted into the comics also which was basically a print screen of the animated film. Later on it was designed, laid out copy edited and published in many languages and widely distributed across all the corners of the country.

As an outcome of these innovative hands on science approach, greater acceptability was noticed amongst the common people towards nuclear energy and all their myths and apprehensions were dispelled up gradually to the larger extent and they became ready to be a part of the success story. The objective to make them aware about the various aspects of nuclear energy was almost achieved efficiently and successfully.

Keywords. Science communication, nuclear energy.

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Lively and Exciting Hand-on Experiments

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Hands-on experiments are always welcomed by students in Japan and also in Papua New Guinea I am teaching now. For example, when they see the plastic bottle rocket flies up in a sky with water spouting backward strongly, students are excited and think Physics is fun. Why are such hand-on simple teaching materials welcomed by students? We can find the answer in the students' impressions after we demonstrated such experiments in the classes. They say "I realized Physics is the subject treating around us." "I understood the theory of the Physics really works in the world we live." They found the meaning why they learn Physics.

There is a social problem that students keep away from studying Physics in Japan. One of the reasons is that the students think that Physics is not interesting and difficult to learn. They cannot find the meaning of learning Physics. We (Teachers living around Nagoya city) made a studying group (named Stray Cats) about 40 years ago and have been studying what makes the Physics classes worth learning for students to improve the situation above. We noticed that we need to reconstruct the Physics classes from the viewpoint of the learners. We think there are two points to do so. One is "how we construct the classes". Because the main aim of the classes is the achievement of the scientific recognitions, we think it is important to study the way how the students recognize scientific recognitions and to reconstruct the classes along students' recognition process. The other is "what we use for the teaching materials in classes". We think it is essential to use simple, essential and pleasant hand-on teaching materials other than the commercial equipment to make the classes attractive and make the students creative. These teaching materials make the students enjoy Physics, and make students realize "Physics is fun.", "Physics exists everywhere." and "Everybody can enjoy Physics."

In this conference I show some experiments that our group investigated for the purpose written above including recent topic. [1-2]. Our experiments are not the complicated and special ones like commercial equipment but they are made from the materials around us including junks or materials thrown in a rubbish bin. I hope you will enjoy Stray Cats' experiments and exchange the ideas with me.

Keywords. Lively and exciting, low cost experiments, simple and essential experiments.

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Research Based Experiment on the Concept of Time for Scientific Education on Transversal Perspective in Primary School

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The primary school is where we have the foundation of the transversal knowledge. It is important to develop in this context for children the habit to look in terms multi perspective knowledge, but there is the need to develop this competence for teachers by means of examples and good practice. We designed and tested a research-based experiment with this goal, starting with a reflection on the concept of time in the philosophical, scientific, technological, literary, and artistic perspective. Strategies, instruments and methods used are IBL [1], with personal involvement of children with active role hands-on and minds-on in a sequence of activities in which they have held exploratory, interpretive and creative role.

The design looks a vertical curriculum, with attention to the interdisciplinary nature of the contexts and the transverse dimension of the conceptual elements. The active role of the children and the exploratory nature of the activities, pointed to the construction of formal thinking in terms of models and interpretative ideas, as well as representations and simultaneous use of different languages: graphics and iconographic language. We look to the spontaneous ideas and operative intervention of children in exploring phenomena, focusing on the formal tools used by children for phenomena description and how simple equipment activate reasoning (rules, graphics, calibration ...).

Data on learning processes are relative to argumentation and the reasoning in the interpretative phases by means of monitoring materials. Transcripts of dialogues, emblematic phrases and written surveys of responses in stimulus cards have provided extensive data put for the identification of the main arguments and categories of thought in relation to each activity or process and the reconciliation between different contexts. The results have identified characteristics of reasoning modes, angles of attach to the concepts, ways of representing and structuring ideas and obtain information on the same issues or nodes or concepts that relate to different areas.

Keywords. Primary, time, research based experiment, science education, transversal perspective.

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Student's Misconceptions about Photosynthesis and Plant Respiration by Pupils of 9th Grade of Lower Secondary School

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The study investigated the common misconceptions of lower secondary school students in 9th grade regarding the concepts of photosynthesis and plant respiration. Photosynthesis and plant respiration are abstract concepts which are difficult to comprehend for adults let alone for lower secondary school students. Research of the students misconceptions are conducted worldwide.

The researches show that many students do not even understand the fundamental concept that photosynthesis and plant respiration are related, mutually connected physiological functions. Many mistaken photosynthesis for plant respiration and that respiration took place only in leaves where are special organs such as pores. They also believed that the plant produced oxygen over the entire day and that the most important source of food for plants is water with dissolved mineral substances.

The main aim of the present study is to find out level of 9th grade students' misconceptions about photosynthesis and plant respiration with respect to gender and attitudes towards biology. One of methods how alternative conceptions are investigated is a two-tier test. It showed that great percentage of alternative conceptions in this area; particularly pupils' and students' did not understand photosynthesis and plant respiration as related, mutually connected physiological functions. In this study there was also used a two-tier test with nineteen items. The first part of every question in the test was focused on knowledge, the second part on the explanation of answer.

The sample size was compound of 9th grade lower secondary school pupils in the Czech Republic. The data were re-encoded in several ways, first by analysing the pupils' knowledge (from correct/incorrect answers), but also their alternative conceptions (frequency of occurrence of alternative conceptions). The 17 items regarding to attitudes towards biology was the part of the research tool, too.

The data were re-encoded in several ways. The first analysis consolidated results from knowledge part of test: correct answer had value 1, incorrect answer value 0. To identify misconceptions, each question was evaluated separately and showed as a percentage. Answers of explanation part were re-encoded so that it is possible to distinguish the correct interpretation of scientifically incorrect. Except for the percentage of misconceptions, methodology of descriptive statistics (average and determinative deviation) and inductive statistics (analysis of variance and Pearson's correlation coefficient) were also used to evaluate the data.

Knowledge of students' misconceptions is pivotal from the point of view of directed school education. This study was aimed to identify the most common misconceptions about photosynthesis and plant respiration by secondary school students. The research and evaluation of misconceptions are popularly held today because they enable individualization for students in education. The understanding of the existence of misconceptions will primarily they enable the development of special didactic materials (which are specific for modification and elimination of students' misconceptions). The study points to two-tier test as one of possibilities how we can diagnose and evaluate students' misconceptions.

Our research showed that Czech students carry many misconceptions about photosynthesis and plant respiration. In particular, they mistook photosynthesis for plant respiration, they thought that plant produced oxygen throughout the day; they thought that respiration took place only in leaves and that respiration was performed in special organs, and that the most important source of food for plants is water with dissolved mineral substances. We propose that one of ways how teachers could reduce misconceptions is a graphic representation of these concepts, correct chemical clarification of photosynthesis and respiration and connection of integration.

Keywords. Plant respiration, two-tier test pupils of 9th grade of lower secondary school Misconceptions, photosynthesis.

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The Influence of Social Learning in Education

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Modern information technologies through the development of e-learning, as well as educational platforms, create new opportunities of growing demand for education on a massive scale. Therefore, it is likely that the education market may become one of the fastest growing markets worldwide. The idea put into practice the open process of distance learning with full interactivity between participants and learners, as well as between themselves learners, dating back to the beginning of the twenty-first century. Mutual learning is based on the principles used in distance learning. The key concept for social learning is the participation, in which the learner is an active participant rather than a passive recipient of the learning process. Social learning environment is characterized by the use of specialized tools for both full participation, as well as the motivation to actively participate in the process of teaching and learning. Social changes that have taken place over the last years, in particular the need to acquire knowledge throughout their lives, justify the need to develop new methods for learning, regardless of age, place of origin or level of education. Implementation of new methods of distance learning from year to year is becoming more and more disseminated. The perfect solution of education is MOOC (Massive Online Open Courses [1-3] which focus on people around the world who want to gain knowledge and become part of a community of like-minded people.

Keywords. e-learning, social learning, MOOC.

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Experiments with Sound

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In this work we will deal with sound from a variety of views. We`ll show how sound is created and how sound propagates. We`ll measure the speed of sound in different materials. We`ll show the different possibilities of sound recording and reproduction. So we will have an opportunity to try some experiments and make their own teaching aid – simple science toy.

Keywords. Hands-on activity, sound, physics.

The Hands-on Science Network Science Fair in Portugal

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The Hands-on Science Network organizes a major national science fair [1-3] in Portugal since 2011 [4]. Last year edition was held late May in Viana do Castelo in the northwest of Portugal. Being 2015 the International Year of Light, the main theme of the 5th HSCI Science Fair [5] was the light and optics and its applications. A good number projects from all fields of science were also presented. Nearly 150 projects enrolling over 450 students (Portuguese and Turkish – a large delegation of teachers from different regions of Turkey attended presenting 35 works on optics and ecology and environment coming from the project “Saving Our Species, S.O.S.”) were presented in a most lively science fair day that received over 500 visitors.

In this presentation we present the evolution of our science fair initiative over the years, detailing the organization process, the main results and showing some of the most interesting projects presented at the science fairs and in particular at its 5th edition.

Keywords. Science fair, hands-on, non-formal learning, informal learning.

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AUTHOR INDEX

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