EDUCATION OF SCIENCE AND COMPETITIVE ACTIVITIES

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Abstract

The presented research educational project is aimed on search of new forms of competitive activities that would support the interest in natural sciences as such. For school collectives there were suggested topics for the scientific competitive work in good accordance with their age group. Fundamentally the topics had to correspond with the pupil's and student's request to work on a serious scientific problems.
In the first year of the project there were involved 29 pupils from three primary schools, 38 secondary school pupils from four schools and 81 students attending high school in eleven different institutions. In the course of the first year of the project it has been proved that especially the pupils from primary and secondary schools are enthusiastic and eager to work and participate on the solution of some "semi-scientific problems". For this age group there were chosen two themes - "Water and Milk" (primary school) and "Honey, the Gods' Dish" (secondary school). First mentioned topic undoubtedly fulfilled all the requirements for the great experimental potential but the topic for secondary school involving experiments with honey has proved not to convey such variety of impressive experiments as it had been expected and calls for optimalisation.
High school students have already obtained sufficient knowledge from natural sciences. Moreover, teenagers want to be treated as adults and therefore they feel the need to work on "real" research topics. This kind of approach was offered by the finally chosen theme "Plants, medicinal plants, and drugs" which was very well received by the newly established groups of young scientists. The schools were offered the background support from the university, which was highly praised especially when the realization of more complicated experiments were required.
Key words: *competitive activities, natural sciences popularisation.*

Introduction

Recently, in the period of last 10-15 years, in the majority of economically developed countries, there can be observed the tendency to a decrease in the interest in the natural sciences and technical sciences within the young generation. Also the consequent interest in the career of scientist of research worker is decreased ("Europe needs," 2004). There are presented information about the increase of those who are interested in these sciences but this fact is caused by the growth in number of the university educated people. In the relative values, meaning the ratio of the university educated people with natural sciences specialization and the overall number of the university graduates, there can be observed a steep decrease and even in several branches like mathematics and physics in tens of per cents ("Evolution of Student Interest," 2006). However, there still exist branches, which are devoted exceptional increase in attention – these branches involve mainly computer sciences. This fact can be supported by the results of a research PISA ("Are Students Ready," 2006) that was performed in 2006 and which comprises the relationship of the respondents to information technologies. Comparable trends can be traced also in non-European countries, especially in the United States of America. The USA is a leader in the field of the development of new technologies and as such

considers the above-mentioned trend as honestly significant one. Therefore there was articulated an attempt, in order to advert the already existing negative trend, with a strong support of the project entitled American Competitive Initiative which is even supported by the current American president George Bush.

The crucial question, which is necessary to be formulated, is: What are the reasons for the decreasing tendency of the interest in the study of natural and technical sciences (NTS) in developed countries? The students are in choice of their future professional orientation influenced by their personal interest, which is basically formulated at their early education age. The fundamental interest is formulated latest at the age between 11 and 15 when the interest is firmly fixed. Unfortunately the attitude towards the NTS in this age group is strongly and negatively influenced by the theoretical approach to its education. This approach is among others caused by the strictly limiting legislation, which disables appropriate practical education especially at the primary and secondary schools ("Directive 1999/45/EC," 1999). Young people are also familiar with an ambiguous notion of the personality of a scientist or a technologist presented by the media. The society has generally acquired the notion of a scientist as a boring man wearing a white laboratory coat or a completely dirty technologist who behaves in a strange way.

At the high school is the boring theoretically aimed education of natural sciences in a real contrast with the humanities as e.g. management, sociology, psychology, which is then considered more interesting and at the higher level of education even preferred.

It is questionable if the above-mentioned problems can be solved just by a pure integration of the natural sciences at the primary and mainly secondary schools as indicated by professor Bilek (2006) in his essay considering Czech models of natural sciences integration. Nevertheless there were, in the range of the research of the young people's attitudes, published ambiguous results from different researches pointing out at the complicated relations between the youngsters' attitudes and factors influencing these attitudes (Lavonen, Juuti, Uitto, Meisalo, Meisalo, 2005; "Pupils' Perceptions of Science," 2005; Jenkins, 2006). These controversies have been quite clearly exposed by an international study performed within the project ROSE and lead by Sjøberg (Sjøberg, Schreiner, 2005). This project has proved that even despite of the positive opinion on the importance of science within the society the majority of the young people in the developed countries (in contrast to the undeveloped countries) refuse their personal participation in science and research. This incoherence could be solved by an extensive international study performed during the year 2006 within the project PISA ("Assessing Scientific," 2006). The main target of this project was to find a complex view on the opinions of young people on science, their attitudes to it, the relation between science and society etc.

The team of STM-Morava project, from Palacky University in Olomouc, has devoted the attention to the aim of reversing this already existing trend in the loss of interest in the natural sciences using the method of competition simulating the scientific research. The following part of this paper presents the first results of the performed research.

Methodology of Research

The fundamental aim of the presented project was to enhance the interest of the pupils and students in the natural sciences due to the practical activities imitating the procedures of a real scientific research also including the crucial competitive parameter. In the course of the project there were established "scientific clubs" at the primary and secondary schools. The scientific meetings of the clubs involved programs with thematically clear contents and were even more motivated by the competition for the "best scientific group".

In the first phase of the competition development there were, for the purpose of the fundamental procedures verification, addressed several schools where there was an intention to establish "scientific clubs". Those mentioned "chosen" schools were selected from the schools in the region because at these schools, based on the previous experience, could have been expected an active and systematic approach in the development and optimalization of the aborning competitive activities. There were chosen three school collectives at the primary schools (involving the youngest children) and four school collectives from the secondary schools. From the very beginning the "scientific clubs" were

devoted sufficient pupil's attention and therefore the coordinators limited the number of pupils involved in the first year of the project was by number 10 of eagerly working young people. Overall there were involved 29 pupils from the primary school and 38 pupils from the secondary school.

In the project there were also involved teenagers at the high schools (grammar schools offering general education) and colleges (grammar schools with professional specialization). From the high schools there was chosen a sample of eight schools and from those specialized colleges there were addressed and later adjoined three. The chosen colleges were addressed because their specialization correspond with the thematic plans and programs of the organized "scientific clubs" – pharmaceutical, health care education college, and milk industry specialized college. In this field, probably because of the specialization, there was observed less interest and the clubs even involved less eager young scientists, especially in comparison to the primary and secondary schools. The number of participants at the scientific meetings was approximately five with several exceptions; the largest "scientific clubs" comprised 10 students. However, there were involved 81 students into the first year of the project at this level of education.

The unavoidable presumption for the realization of this part of the project was an active cooperation with the sciences teacher from the chosen schools. The teacher played the undeniable role not only in the terms of the "scientific club" realization but also in the final paper elaboration. Regarding the thematically specified contents of the scientific meetings one member of the project organization team was always available to assist. This help was required and needed especially at the primary schools while the secondary school teachers proved to be more independent. Unfortunately the technical equipment at the secondary schools did not allow to perform all of the experiment that would correspond with the pupils´ acquired knowledge and skills. Therefore the more complex and complicated experiments were performed with the kind assistance of Palacky University where was organized one of the scientific meetings. This approach was chosen not only with regards to the development of the pupils´ skills but had also a motivation character – the pupils could visit different scientific stations where a real research is performed.

All the activities were planned for a term and included not only active work of different kinds of experiments and theoretical preparation but also approximately two months were devoted to elaboration of a final paper which should have corresponded with the work performed at the scientific meetings.

The thematic content of the "scientific clubs" was carefully selected in order to fulfil the following criteria: it should have taken into account the acquired level of the pupil's and student's knowledge and the chosen topic should have attract their attention. Considering these criteria there was chosen the topic "Water and Milk" for the primary school children and "Honey, the Gods' Dish" for secondary schools. For the purpose of the "scientific clubs" the topics were elaborated into competitive, experimental, and theoretical contents of each scientific meetings. This elaboration was needed mainly because at this education level there was not expected any high scientific efficiency of the involved primary and secondary school teachers in that sense they would be able to develop the given topic at all those mentioned levels. On contrary the thematic specialization was subordinated to the above-mentioned high scientific efficiency of the high school and college teachers who were considered to be sufficiently skilled and experienced. This age group, meaning teenagers, was given an attractive topic entitled "Plants, Medicinal Plants, and Drugs" and they were just offered an elaborated exemplary procedures of the experimental work. In the next phase the students collaborated with their teacher and with one of the coordinators of the project team. Their activities were extended according their knowledge, gained data, and even their imagination. All of the above-mentioned topics will be discussed in the following part of this contribution.

All the scientific activities were crowned with a final scientific conference where were the gained results and experimental skills presented either in the form of short oral contributions or graphically attractive form of colourful posters. Based on the evaluation of the committee members there were announced three best final works from the section of the high school and college students. In the category of primary and secondary school pupils, especially considering the fixed program of the scientific meetings and number or participants, there were not announced the winners in this category. All of those final papers were praised according to some parameter and also the originality was highlighted.

Currently a sociological research takes place at the involved schools with the aim to complete and monitor the impact of the presented research activities not only on the auricular participants but also on their class-mates and the changes of the overall climate at the schools which is involving also opinions of other pedagogical workers. The results of this research will be available during autumn 2007.

Results of Research

Regarding the results and summary of the first phase of the research it is necessary to pay attention primarily to the content of the competition topics and to the variation and originality noted among the "scientific clubs" from different schools.

The topic for the primary school entitled "Water and Milk" has proved to be the right one for this age group. The pupils were impressed by their own new observations and findings they acquired although still working with such ordinary substances as water or milk. The pupils were allowed to perform previously prepared experiments and this way to gain some new data and information about the commonly treated substances – e.g. they were allowed to determine pH of water, milk, and other solutions (squashes, vinegar solution, salt solution etc.) colorimetrically, to determine water hardness (also using the colorimetric method) and with it connected content of minerals in water. They studied surface tension of water and its changes with the surfactant addition. They measured density and miscibility of several liquids (honey, oil, treacle etc.) with water. One of the fundamental experiments with milk involved the determination of fat in milk (skimmed milk, half-fat milk, whole milk, or cream) and separation of these fat particles from milk. According to the level of their knowledge, or may be according to the teacher's level of knowledge, were these basic experiments supplied by additional experiments – e.g. observation of phase changes of evaporating water and backward condensation of vapor, observation of changes in conductivity when common salt is dissolved, observation of tiny water creatures and plants under a microscope. At one of the scientific meetings the pupils were even able to prepare ice-cream or yoghurt, at another one they prepared cracking beverages and also observed function of the hydrodynamic oscillator. Additionally the was included initiative activity in one of the "scientific clubs" which left the natural sciences behind and made a short sociological research on the topic: "Can and Do You Save Water?" which was performed on the randomly chosen group of respondents visiting one of the town supermarkets.

Records of the performed experiments were taken down and completed by the young scientists themselves into the pre-prepared forms and were accompanied by sketches and results of the experiments and experimental adjustment (Figure 1). The completed experimental forms supplied with theoretical introduction into the topic milk and water served as the final paper illustrating the activities of the scientific group and were introduced at the 1st Conference of Young Scientists which was held in mid-May 2007. It is typical for this age group that in the final papers elaborated by the "scientific clubs" the eagerness and hunger for new information, knowledge, and skills is drawn as a thin red line.

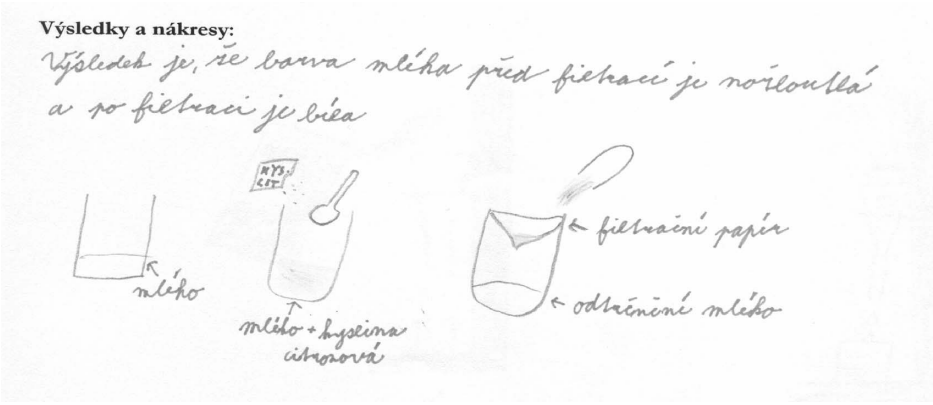

Figure 1. The sketches of the experiment of the fat droplets separation from milk. It was taken from one of the final papers of the primary school "scientific clubs".

On contrary the finally chosen topic "Honey, the Gods' Dish", for the secondary school pupils, has proved to be so attractive. The interesting physical properties of honey have not proved to be so impressive as chemical experiments. Unfortunately majority of the interesting and attractive experiments were listed only as demonstrative and not devoted to the pupils´ work because there were several dangerous chemical reagents involved (e.g. concentrated sulphuric acid). This was the main reason why the teachers and co-ordinators escaped to the kingdom of impressive experiments and did not fulfil the primarily stated experimental and theoretical topic. However, one of the "scientific club" teachers was able to extend the content of the "honey-meetings" by organization of a field trip into bee-hiving club and final pre-Christmas gingerbread baking. The pre-Christmas baking attracted attention not only of the members of the "scientific club" but also of other pupils and even of the headmaster. Although this topic was well elaborated and experimentally rich it has not proved to be sufficiently attractive and some of the scientific meetings had to be completed by experimental improvisation in order to keep the attention of the participants. Nonetheless, from the scientific point of view the topic "Honey, the Gods' Dish" gave enough experimental space to the density measurements, measurements of the electric conductivity or viscosity. From the chemical properties of honey point of view the pupils paid attention to its constitution. Apart from water they determined also presence of carbon and hydrogen, reducing sugars, in some samples they revealed even traces of proteins and starch (probably the sample containing starch was obtained from the already baked ginger bread which would throw light on its presence).

However, it is necessary to praise the work of one of the teachers who showed a potential in experimental improvisation when she was able to involve honey into all of those attractive experiments. Thanks to this attitude the pupils could compare how are the "Pharaoh's snakes" different when there are used two sorts of mixtures – mixture of bicarbonate and sucrose and bicarbonate and honey. Those that were raised from the firstly mentioned mixture grew into enormous sizes while those that were prepared in assistance of honey did not raise at all. On the other hand honey could create a beautiful volcano with its cone (Figure 2). Also the experiment with the aim of dehydration of honey and sucrose with sulphuric acid was highly praised but unfortunately had to be performed by the teacher (from the safety reasons). Nevertheless all the pupils could try to caramelise both sucrose and honey and could taste the difference and judge how lovely can the caramelised honey taste. Thanks to this innovative approach of this teacher all the scientific meetings were devoted not only to the impressive experiments but additionally also to honey in connection with these experiments. However, all of the involved "scientific clubs" at all of those secondary schools have completed the research and elaborated the final research paper. Interestingly those final papers give us evidence that pupils from this age group have acquired additional skills like work with new information and their search on the Internet with ability to form a conclusion. At the end, even after all of the above listed experimental and thematic problems, all of the participants expressed their likeliness to be involved into this project in its second year.

Obrázek 5: *faraónovi hadi z cukru a medu*

Figure 2. The photograph of the experiment called "Pharaoh's snakes" performed in one of the "scientific clubs" at the secondary school dealing with the theme "Honey, the God's dish".

The high school "scientific clubs" we offered, in comparison with the primary and secondary schools, just thematic frame programme. For the first year of this project there was chosen a topic entitled "Plants, Medical Plants, and Drugs" which fulfilled the requirements given by the students themselves. This topic is sufficiently impressive, popular and up-to-date for nowadays teenagers. The realization team of the project just foreshadowed the direction, which should have been followed and offered just handful of introductory experiments of basic characteristic. Consequently the "scientific clubs" set out on their own way according to the skills and experience of its members and of the teacher leading the scientific meetings. This phase relatively faithfully simulate the introductory part of the research when there is known just the topic including the basic direction and is developed with the realization and understanding of the studied issue.

From the primarily performed experiments aimed on chromatography separation of plant pigments isolated from spinach extracts, separation and study of the properties of flavonoid located in lime-blossom or study of peppermint oil itself the work at the scientific meetings has ramified into distinctively different directions. At this point we would like to mention the most interesting experiments and also those that were frequently performed. Probably the most frequently performed experiment was isolation and determination of caffeine or nicotine from plant material or experiments with ethanol flammability. One of the most authentic experiments was approval of the tar substances in smoke of one cigarette, which was performed thanks to the set up apparatus called "artificial lung" imitating the function of a real lung (fig. 3). This experiment was followed by thematically joined experiment enabling the smoker revelation via the colourful reaction of iron and rhodanide ions that are present in the smoker's saliva in triple amount in comparison the non-smoking person. The other "scientific club" followed entirely different direction. They studied plant pigments used as pH indicators or flavonoides that give an impressive fluorescence under UV lamp. The essential substances obtaining was then extended to further plant materials and also to the preparation of their synthetic imitates. However, also the experiment demonstrating the difference between methanol and ethanol in the course of combustion of their esters with borate acid has fulfilled its role and was treated as interesting. In this age group there were already visible results of the humanistic education influence and therefore all of the elaborated papers included a sociological research aimed on the drug doping. These researches have proved alarming facts previously proclaimed and published in different professional researches. In the age group from 14 to 18 there are about 20% of smokers, 30% of these teenagers drink regularly alcoholic beverages (and 67% of them have already once tasted it). Striking finding is that approximately 3,5% of them regularly dope one of the variety of drugs and at least 35% of the respondents in this research have tried some kind of a drug. Therefore side by side with the experimental work and theoretical part of the final papers are filled with interesting, alarming and shocking information about nowadays teenagers. However, the man is a part of nature and as such should be judged therefore also the sociological attempt should be highly praised and appreciated. Nevertheless the "scientific clubs" could also leave the ordinary high school laboratories and enjoy one planned field trip, which ended at Palacky University (the guarantee of the project) and even they were given the opportunity to perform some of the experiments there using the scientific experimental devices. This contact with reality in the form of the laboratories at Palacky University was highly praised by the teenage participants and considered as one of the best occasions of the half-year duration of the "scientific clubs".

sestavená aparatura

Figure 3. The photograph of the experiment aimed on the determination of the tar substances in smoke of one cigarette, which was performed with the improvised apparatus called as "artificial lung" by the members of one of the "scientific clubs" established at the high schools.

Conclusions and Discussion

The conclusions from the first year of the research of competitive popularisation of natural sciences at the primary, secondary, and high schools are currently preclusive. The detailed analysis of all the obtained information and data is being in progress. Simultaneously there is being prepared a sociological research, which should map the impact of the realized activities not only on the research participants but also on the closest surrounding – on the classmates, teacher, and parents. Nevertheless even in this introductory phase it is possible to formulate at least some conclusions considering the methodology of the research.

The first argument, which was verified, is that: there is a connection between the undeniable role of the teacher and the formation of new pupil's and student's attitudes towards natural sciences, their notions about the research work and the position and importance of the researchers. If the developed society relies only on the enthusiasm of several individuals eagerly working with children and teenagers the problem with the decreased interest in natural sciences will not be solved and will not disappear by a wave. The difficulties that are brought by the natural sciences popularisation are though balanced by the already mentioned pupil's and student's adventures from understanding and joy but it can be considered the only prize for the teacher. Nevertheless the approaches considering positive attitude or even love to natural sciences must be first acquainted and only the people who have acquired it can pass them forward. However, the teacher who is not supported by his/her headmaster and also by the Ministry of Education cannot perform this kind of activity.

The following conclusions are in connection with the younger participants of the research and their abilities, knowledge, and interests. It is really typical, and it has been proved by the results of this project, that the youngest participants enjoy eagerly every experimental activity. However, the experiments are in this age group highly welcome and praised especially when accompanied by effective and impressive colour or sound changes unless the eagerness and motivation quickly diminish. The results of the experiments and the conclusion formulation is only of a low importance in comparison to the way leading to it. With the higher age the children and later teenagers have acquired sufficient knowledge but unfortunately they are influenced by the surrounding in the sense of pure memorizing. Therefore the high school students are diligently collecting supportive materials and pieces of information sometimes even not exactly knowing the real meaning. On the other hand in this age group there can be observed a tendency to analytical thinking and activity. That is also reflected in the choice of their experiments when the sensual percept is not the most important. There are far more important the gained information about the properties of the studied system. These changes in the way of thinking is definitely connected with the deeper knowledge in the field of humanities, which is then reflected by the effort to understand the other people's thinking and behaviour. Therefore in the final papers there could be found at least hints of sociological researches or opinion polls. Similar approaches were found in the final papers of the primary and secondary schools only rarely.

Last but not least the results of the first year of the research has proved that there is a lack of experimental work especially at the primary and secondary schools although they are so desperately needed for good understanding of the discussed topics within the natural sciences lessons. We are likely to agree with the argument of the absurdity to integrate all the natural sciences into one universal subject (Bilek, 2006), however, it is necessary to add that the experimental work and also the optional activities (in our case represented by the establishment of the "scientific clubs") enable this kind of integration which is then highly appreciated. It is not possible to establish the integration only according to a law, which would be laid down by the Education authorities. The integration of natural sciences should foreshadow the direction of future development in this sphere in the sense of limitation of the amount of theoretical knowledge and shift towards the experimental work with the aim of better understanding. This particular conclusion is so far the most important result, which naturally derived from the first year of this research immediately after the completion of the practical part of the project. This statement could be also supported by the following quotation taken from the victorious final high school paper (it was formulated by the participants themselves as the final dot of their competitive paper):

This is an absolute end of our „masterpiece". The work we have devoted more than half a year of our lives is concluded and we can now only hope that it has somehow attracted your attention and did not sink into the average. We have learned a lesson that a man should study as far as he/she can and that the way of experiment is the most pleasant and the most effective one. This project has unlocked the imaginary "Doorway of Wisdom" behind that were hidden words like anthocyane, flavonide or fluorescence. These terms are probably not so impressive still the opportunity to work with them is not given or offered to everybody. We are dared to say that some of us were influenced so far that the membership in the "scientific club" will lead our steps in our future lives. Therefore we would like to thank the organizers who are responsible for the project realization. No matter which verdict will be announced in May and which paper will be considered the best one we do appreciate the opportunity to participate in the project. At once we have learned that not only geniuses but also skilled, able, and talented chemists can work in research.

The detailed information about this project can be found on the website http://www.vedajeza-bava.upol.cz but currently only in Czech language. English version will be available soon.

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