SECONDARY SCHOOL STUDENTS TASTE THE REAL SCIENCE: PROJECT METHODS USED IN THE "BIOLOGICAL SUMMER COURSE ARACHNE"

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Introduction

High ability secondary school students with deeper interests in natural science are eager to absorb many new facts, but usually possess *insufficient practical skills* necessary for their further scientific research. One of the causes is the education in the Czech secondary schools that emphasises memorising detailed and isolated facts with little focus on their synthesis and practical use. The project methods, stimulating the students' activity, are getting popular, but are still scarcely used in the secondary education of biology in the Czech Republic (e.g. Anonymous, 2004). There is still a lack of literature that can help them with integrating projects into regular school education (Švecová 2001, Anonymous 2000). This fact is of a great importance as regular teachers are hardly ever acquainted with these educational methods.

Furthermore, the ordinary Czech secondary schools give the interested students only a limited space to specialise themselves and extend their knowledge and skills in a particular subject beyond the common school curriculum.

Those, who have chosen biology as their future university subject, suffer most from this lack of complex practical training. Therefore, the students' expectations about their future career in a biological research are often rather unrealistic, without any personal experience in scientific methodology, and based merely on "the textbook knowledge". The talented individuals with deeper interest in biology thus have to rely mostly on their own activity. The best-known competition of student projects in the Czech Republic *The Secondary Schools Students Scientific Activity* (SOČ in orig.) gives the opportunity to work on an own scientific project during studies on the high school. However, this work involves extreme enthusiasm from the students and only a few of them have a chance to discuss the design of their projects and evaluation of data with specialists and to use convenient scientific equipment and up to date literature. Without this background, their enthusiastic work might not come to satisfactory results and they get discouraged.

They can also participate in student biological competitions, such as the *Biological Olympiad* (the Czech round and for the best participants the International Biological Olympiad) and *Ecological Olympiad*. However, these competitions do not involve the work on own students' projects (with the exception of the lower age levels of the *Biological Olympiad*).

In this contribution we would like to present our practical experience based on a "research training" of high ability secondary school students by project methods. These activities are an important part of the *Biological Summer Course Arachne (BSCA)*. The summer course with its friendly atmosphere offers more suitable conditions for promotion of the students' *creativity* and *critical thinking* compared to the school classroom (see Koukol, 2004).

What is the Biological Summer Course Arachne?

The *Biological Summer Course Arachne (BSCA)* has been held since 1998 by the Arachne Association (Prague, Czech Republic) in partnership with the Faculty of Science of the Charles University in Prague. It is organised as an optional summer camp designed for 25 - 35 high school students in the age of 14 - 20 years. There are no special criteria for the selection of participants, besides their interest in biology. Thus the course integrates students of different age and level of knowledge from various parts of the Czech Republic.

The whole organisation depends on a team of 8-10 enthusiastic university students (members of the Arachne Association). The educational biological program is arranged in co-operation with scientists and lecturers from the Faculty of Science of the Charles University and the Academy of the Sciences of the Czech Republic. The course lasts two weeks. Every year another locality of a high natural value is chosen to host the course.

The intensive educational biological program consisting of lectures, practical classes, terrain excursions, optional workshops and work on *research projects* occupies about 5 - 7 hours a day. The annual educational program has been focused on a different *unifying aspect* of biology since 2000:

2000 - Forest ecosystems from various aspects
2001 - A view inwards organisms
2002 - Ecology of organisms and communities
2003 - Evolution and developmental biology
2004 - Interactions among organisms

In each of the particular sessions the unifying aspect is dealt from the point of view of various biological discipline (e.g. botany, zoology, mycology, microbiology, genetics, physiology, etc.).

The biological programme is integrated with a wide variety of activities, such as creative art, traditional handworks, dance, non-professional theatre, mime, rhetorical training and team co-operation games. All these activities promote further development of the students` abilities, namely creativity, critical thinking, communication and teamwork. This complex approach is exceptional compared to similar biological courses in the Czech Republic. Similar approach is used for example by the organisers of *the Mathematical and Physical Summer Course* (Dvořák, 2003).

The background of students' research projects at the BSCA

One of the main aims of the *BSCA* has been to allow the participating students to experience the real scientific work in addition to attending the educational biological program. Therefore, the *research projects* have been an integral part of the program of all years of courses (with the exception of 1998 and 2002). The aims of this activity have been to get the participants acquainted with all phases of the biological research from planning of experiments, literature survey, observations and measurements to oral and written presentation of results and to experience the team-work, which is of a steadily increasing importance in the modern science.

Totally, 3-5 sessions (approximately 10 - 20 hours in total) are reserved for the work on the projects during the *BSCA*. The students work in *teams* of 2-4 members on their project based on a *research topic*. Particular topics cover variety of disciplines including faunistic or floristic survey, ecological observations, microbiological laboratory experiments or morphological studies. The teams are supplied with basic scientific laboratory and field equipment and literature. Each team has also its own *supervisor*, who is ready for advice and help continuously during the course.

The role of the supervisor begins months before the *BSCA*. A new set of *research topics* is arranged for each course, according to the local natural conditions and the main

focus of the program. The team of organisers, who are consecutively supervisors of the projects, carefully select topics for projects according to the following criteria: (1) projects are expected to be solved within the rather short time, (2) shall be interesting for the participants, (3) participants shall learn more about unusual methods and (4) the supervisors themselves must be well experienced in the subject. The topics usually originate from regular research projects, but their level is reduced. A *list of selected projects* carried out within previous years together with main students' acquisitions is presented in Table 1.

After the topics are selected, each of the supervisors has to write a short introduction to the project and a list of recommended methods, possible hypothesis and aims of the project. Furthermore, he/she has to obtain instruments and literature needed for the work. Due to the partnership with the Faculty of Science, the course is supplied with scientific instruments used in a regular biological research. Later, at the beginning of the course, suitable space is selected within available rooms (in the accommodating facility) to serve as a laboratory, study room and library.

Six steps of the students' work

The whole process of the student' work may be divided into following six steps:

1. *Choice of research topics*. At the beginning of the course the students are supplied with a list of the *research topics*. The students are allowed to choose among the topics offered. Their choice may reflect their previous experience. Those, who decided for the same topic, form a *research team*.

2. *Planning the work*. Before starting the work, the teams may adjust the aims of their project or formulate new ones and suggest *hypotheses* to be tested. Their supervisors' first milestone is to get them briefly acquainted with appropriate methods and necessary literature. They also co-operate with their teams on the time schedule of the work.

3. *Collection of data*. Sufficient time is reserved for *data collection*. This part may be achieved within one session (in a single collection of sufficient amount of material), in several sessions based on a precise time schedule (e.g. cultivation and counting of bacteria and yeasts) or continuously during the course (e.g. collection of plants during the sessions and the terrain excursions). Exceptionally, students may collect further data in their leisure time. The students are encouraged to plan the experiments and observations and collect data by themselves as much as possible.

4. *Analysis of data and their interpretation*. Collected data, measurements and observations are sorted; statistical analysis may be carried on a computer with standard statistical software. Observations are documented using photos, drawings, schemes or maps of distribution. This part is connected with the most intensive contact with the supervisor. The supervisor has to check the accuracy of the data set and recommend further steps in their processing. As the final step of the work, hypothesis are confirmed and included into discussion and conclusions. A raw report summarising the project is completed.

5. *Presentation.* After the project has been successfully concluded, it is in short presented to the rest of the students and the lecturers on a *scientific conference*. All members of the team are encouraged to participate on the presentation. It should reach approximately 10 – 15 minutes and students may use an overhead projector or let their outputs circulate among the other students. At the end of the presentation, the teams' supervisor comments the results, emphasizes the main points, evaluates the teamwork and opens a discussion.

6. *Short communication in conference proceedings.* After the presentation students discuss again problematic parts of their project with their supervisor and are expected to write a full text of their project into the proceedings. Their work on this contribution follows throughout the year and collected and further "revised" papers are arranged into *conference proceedings*.

Specific aspects of the project on the *BSCA*

The intensive work on the projects during the course gives the students opportunity to acquaint themselves with the scientific research. However, several phases of the regular project methods have to be adapted to the conditions of the course. Firstly, the *research topics* are prepared by the organisers and the students have to choose from the annual offer. This suppresses student's own ideas. On the other hand, the students are not well acquainted with local natural conditions and possibilities of the course. Making up students' own topics of projects might result in loss of time with unrealistic projects.

One of the general aspects of the course is the *co-operation within the team*. As the members of the team are in a direct contact almost constantly during the stay, they have to be very tolerant and get on well during the course. The friendly atmosphere at the course, relatively low difference in the age between the participants and the supervisors and the supervisors' helpful attitude prevent antipathies in the teams.

The most limiting factor is the time. Particular phases of the work follow immediately after each other within as few as 3 – 5 sessions. The *time management* must be carefully concerned from the preparation of the topics till the final conference. Students usually prefer the data collection to the finalisation of the project. Therefore, the finalising of the projects is negatively influenced with the lack of the time and participants' stress. The supervisors pay special attention to this point. They have to monitor the students' work continuously and to recommend them to stop a particular phase of the project and go to the next ones, if the time is insufficient.

Among all, a great attention is paid to the final completion of the projects. Especially the part *discussion* in the final report requires an intensive co-operation of the participants with their supervisor. According to our experience, to formulate final conclusions and to discuss the facts represent the most difficult parts of the work. Students usually fail to see their results within a wider extent and have difficulties to compare them with literature. They also fail to select the most important facts into their final presentation. They cannot sell them out well during their presentation and sometimes an original result or a surprising conclusion vanishes in a plenty of unimportant facts. The role of the supervisors' care is important, as these skills are crucial for any kind of further students' individual work. Training of these skills is emphasized besides the particular scientific results of the project.

To conclude, we believe that the *research projects* carried out during the *Biological Summer Course Arachne* significantly help the talented students in their future scientific career. The course promotes the students` thinking about the pros and cons of a scientific career before deciding for it. No matter if they choose biology or any other university subject, the course can serve as a valuable source of experience. The skills that are trained during the course such as the teamwork, critical and analytical thinking and the presentation skill will help the students in any further studies.

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Table 1: Selected students' projects realized during the six years of the *Biological Summer Course Arachne*.

Topic	Year	Acquired methods	Outputs
Nature trail	2000	Field survey of natural objects of interests, compilation of information from the literature, popularisation of scientific information	Proposal for a nature trail with the text of information panels
Habitat preferences of the House Sparrow	2003	Description of habitats, categorisation of bird activities, precise field observation, ethological observation of focal animal, questionnaire among the residents and cottagers in the village	Description of the habitats preferred for breeding, feeding and other activities, map with localisation of the activities in the village
Habitat preferences of the wood tick	2003	Standard methods of monitoring of ticks, description of habitats, determination of ontogenetic stages	Description of the habitats preferred by ticks, frequency of different ontogenetic stages and sex ratio of adults
Amphibians and reptilians of the region	2003	Faunistic mapping, determination of larvae and adults of amphibians, a description of habitats of recorded species	Check list, maps of occurrences and description of habitats of individual species, photographs of specimens
Water molluscs of the region	2003	Faunistic mapping, collection techniques of water invertebrates, determination of water gastropods and bivalves	Check list of water molluscs, interpretation of differences in species spectra
Micro-organisms around us	1999	Techniques of extraction, cultivation, counting and staining of bacteria, yeasts and filamentous fungi, performing the Enterotest	Comparison of quantity of micro organisms in different habitats, detection of potential pathogens
Resistance of bacteria against different sorts of tooth paste	2003	Techniques of extraction, cultivation and counting of bacteria, preparing the design of an experiment	Comparison of antibacterial effect of different sorts of tooth paste on two model species of bacteria
Diagnostic characters of filamentous fungi	2003	Micro-morphological study, documentation by drawings and photos, taxonomic evaluation of characters	Delimitation of 3 species of microscopic fungi based on their morphology
Trichomes of various plant species	2003	Determination of plant species, micro morphological study, documentation by drawings and photos	Drawings of trichomes of different plant species, interpretation of functional differences
Dyes extracted from plant tissues and their suitability for staining of cloth	2003	Different techniques of extraction of plant dyes and different methods of staining of cloth	Colour card of different cloth stained with different plant dyes, evaluation of colour stability
Galls and similar structures caused by phytoparasitic invertebrates	2000	Determination of galls and host plants, documentation by drawings	Lists of phytoparasitic invertebrates hosted by different plants, drawings of galls and similar structures
Differences in natural forest vegetation along the gradient of abiotic factors	2000	Phytosociological survey, determination of plant species, measuring of abiotic parameters, categorisation of plant associations	Description and interpretation of differences in species composition of vegetation along the slope of a narrow valley