

Biological Summer Course Arachne - Spider Web Connecting People and Different Branches of Science

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Abstract. *Biological Summer Course Arachne* is an optional training course for high ability secondary school students, held by the Arachne Association (Prague, Czech Republic) since 1998. The two weeks stay (designed for 30 - 35 participants) is organised by a team of enthusiastic university students in co-operation with the scientific staff of the Charles University, Faculty of Science and Academy of Science of the Czech Republic. Participants gain current knowledge in a broad spectrum of biological disciplines and practical skills as well. In addition these activities encourage them in further search for information and in critical thinking. The biological scientific program, occupying on average 4.5 h a day, consists of lectures, practical classes, short excursions and optional workshops. Each year, the scientific program has a different framework topic. Several sessions are reserved for teamwork on research projects. The scientific program is supplemented with a wide variety of activities, such as fine arts, dance, non-professional theatre, rhetorical training and team cooperation. All these activities promote further development of the students' abilities, namely creativity, communication and team cooperation. This complex approach is exceptional compared to similar courses in the Czech Republic.

Keywords. Biological Summer Course Arachne, gifted students, biology, extracurricular education, creativeness, students' projects

Introduction

In this contribution we would like to share our practical experience from nine years of organizing the Biological Summer Course Arachne (abbreviated as “*Arachne Course*” in further text) and to introduce our approach in the informal biological education. The Arachne Course is a bi-weekly residential extracurricular course for gifted and highly motivated secondary school pupils in the Czech Republic. In this

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course we combine theoretical and practical biological education with various non-scientific activities, which help to improve the pupils' creativity and social skills.

The symbolic name *Arachne* refers to the Ancient Greek mythology as well as to the animal kingdom: The Lydian princess Arachné exceeded Pallas Athena in the art of weaving. The goddess in a chafe tore to pieces the Arachné's marvellous work. The desperate weaver intended to take her own life, but Athena turned her into spider ("arachné" in Greek). The descendants of Arachné continue in weaving their admirable webs till present. The Arachne Courses aim to help the pupils to find connections between different pieces of biological knowledge into a meaningful complex, to cross the boundaries between different branches of science and to build bridges between young personalities.

1. View into the history of the Arachne Course

Good things often begin with coincidence of simple lucky chances. Indeed, the first Arachne Course (in fact without its symbolic name at the beginning) in 1998 was organised thanks to lucky chance. A handful of biology students from Charles University Prague were encouraged by the organisers of Summer Course in Mathematics and Physics (headed by Dr. Leoš Dvořák and Dr. Irena Koudelková) to join their course with a group of pupils interested in biology. After some hesitation and doubts they agreed. In rather limited time, they even got financial funding from the Open Society Fund and with a great deal of improvisation prepared a meaningful and diverse scientific program. In 1999, the organisers founded a small NGO - Arachne Association² (*Sdružení Arachne* in Czech) for the purpose of organising biological summer courses.

For the first four years, the mathematical-physical and biological courses successfully took place under the same roof. Each course had an independent scientific program, but they both had similar framework, the same time schedule and common non-scientific activities. After several years, the organisers had gradually realised, that even if the partnership between both groups had been mutually inspiring, their needs were essentially specific. In 2002 they decided to organise both courses independently.

2. Who are the weavers of the web?

Organisation of the Arachne Course depends on the team of *–eight to ten* organisers, who are present during the whole course. They prepare the schedule of the program, organise non-scientific activities, care for the participants' welfare and partly act also as lecturers and supervisors of the students' projects. Pre-gradual as well as post-gradual students of biology on Charles University Prague, Faculty of Science and their friends form the core of the Arachne team. They are volunteers, devoting great deal of their free time to the Arachne Course. Most of them are members of Arachne Association.

² More details about the Arachne Association and the Arachne Courses are available on www.natur.cuni.cz/~arachne.

The stable Arachne team is accompanied with further 10 - 15 lecturers, who come to the Arachne Course for –one or two days to give specialized lectures or practical classes. The lecturers are recruited mostly among the students as well as among the scientific staff of Faculty of Science, Academy of Science of the Czech Republic and other research institutions. We are proud to say that several former participants already became Arachne organisers and lecturers. The comparatively small age gap between the organisers and the participants facilitates the effective flow of information and informal atmosphere. We believe, that younger lecturers are often able to better understand the needs and interests of secondary school students than are the professors and senior scientists. This advantage can even compensate their limited professional experience.

3. Who are the participants?

The first important decision we had to make was to choose the *target group of participants*. Since the beginning we rejected the way to set strict criteria, such as entrance tests, and choose “the best of the best”.³ Our aim has been to give chance not only to those, who are specialized and advanced in biology and who are expected to become outstanding scientists. We welcome also to highly motivated beginners and those, who like biology, but are not sure about their future specialization. Therefore we try to accept all applicants, if it is allowed by the limited capacity of the course.

Very soon we realised, this decision was right. The participants of our courses form a diverse assemblage of interesting young personalities, spending the days and nights not only sitting at the microscope or discussing the structure of DNA, but also observing stars, dancing, playing the guitar or writing profound letters to their friends.

Interestingly, there are significantly more applying women than men. If there are more applicants than we can accept, we select them according to *entrance questionnaires*. In the questionnaire each applicant has to describe his or her interests, hobbies and expectations about the Arachne Course. The questionnaire also helps to prevent the cases, when the less motivated applicant might be annoyed with the intensive scientific program or on the contrary by the non-scientific activities. One of the questions helps to assess the applicant’s creativeness, sense for humour and improvisation. The applicant usually has to answer the question: “What is in the picture?” and is encouraged to modify the picture, as he or she likes. The picture is usually a semi-realistic drawing with multivalent meaning. However, the questionnaires have a limited informative value and must be evaluated with caution:

- On average the boys of our target age (14 - 20) are usually more reserved than the girls. They often “ignore” personal questions and their answers are usually shorter and “superficial”. This does not necessarily mean, that they are less creative or motivated in biology.

³ In the Czech Republic already exists another biological summer course for gifted secondary school students, designed only for the winners of Biological Olympiad (www.biologickaolympiada.cz). The course as well as the Biological Olympiad itself, is organised each year by the National Institute for Children and Youth. It has a long tradition and capacity about 60 participants. Similar courses and competitions specialized e.g. on chemistry or humanities are held by the same institute as well.

- Creative but introvert people often hesitate to express themselves to unfamiliar (“anonymous”) organisers.

Another good decision was *to allow the participants to take part repeatedly*. The participants who already attended one or more previous years of the Arachne Course (on average, one half to two thirds of participants attended at least two courses) form a solid core and help to keep the tradition. On the other side the “newcomers” are always quickly integrated. The “solid core” has also a very motivating effect on the team of organisers and on the diversity of the program; no one lecture or game can be repeated in two or three successive years. We also try to find always a new locality for the course.

4. Capacity of the Course

There are usually more interested applicants than we are able to accept. Raising the capacity of the Arachne Course would bring not only technical problems (e.g. to find enough workspace and equipment in the labs), but would also damage the friendly intimate atmosphere. *Thirty to thirty-five participants* per course, divided into two groups for the lectures and practical classes, revealed a meaningful compromise. According to our experience, this number is the upper limit, when the organisers and lecturers are still able to keep an intensive contact with each participant.

The comparatively small capacity of the Arachne course is also positively reflected in the intensive contacts within the group of participants. At the beginning of each course, the participants are group of young people full of expectations; at the end a gang of good friends full of plans how find the possibilities to meet each other during the school year.

5. Finance and equipment

Since the early beginnings, the Arachne Course has been supported by the biological division of the Charles University Prague, Faculty of Science. Our *alma mater* kindly provides us not only with financial support, but its particular departments borrow us laboratory, field and didactical equipment, such as: scientific microscopes, dissecting microscopes, field glasses, data-projectors and literature. The encouragement and advice by senior colleagues are also essential for us. Arachne Association itself possesses only minor equipment and small library. An important deal of the equipment (e.g. computers) and literature is private property and is regularly borrowed by particular organisers and lecturers.

The advantage of the Arachne Association as NGO is the possibility to apply for grants by different public and private institutions. During the last four years we got financial support from the *Ministry of Education, Youth and Sports of the Czech Republic*, the *Ministry of Culture of CR* and *Tomáš Baťa's Foundation*. On average, approximately one half of the expenses are covered with the support from the biological division and with different grants, the rest is covered with the participant fees.

6. Scientific program

One of the keystones of the Arachne Course is, that we prefer active pupils' work to passive reception of information. Besides the current biological knowledge the participants shall get acquainted with elementary laboratory and field methods and learn from direct observation of living objects or fixed material. Therefore we include not only lectures, but also practical classes and field excursions as much as possible. Several sessions are reserved for teamwork on students' research projects, representing an integral part of the course.

The scientific program extends beyond the secondary school curriculum. We try to focus on the topics, which are either neglected or insufficiently represented in the biology classes on Czech high schools.

The biological scientific program occupies daily on average 4.5 hours. It is divided into 3 hours morning block and 1.5 hours afternoon block. Ordinary lectures last 1.5 hours; less often 3 hours sessions are reserved for time-consuming practical classes.

For the scientific program (except for the projects) the participants are divided into two parallel groups according to their age, experience and attendance of previous Arachne Courses. The scientific content of the program is the same for both groups, but the level is adjusted.

Table 1. Framework topics of the previous years of the Arachne Course 2002 – 2006 and examples of topics of particular lectures and practical classes.

Year	Framework topic	Examples of specific topics	
		Lectures	Practical classes and field trips
2002	Ecology of Organisms and Communities	Macroecology Role of water in living organisms	Analysis of sounds Identifying insects in the field
2003	Evolution and Developmental Biology	Microevolutionary processes Endosymbiotal origin of plastids and mitochondria	Identification of insect larvae Fertilisation and embryogenesis in amphibians
2004	Interactions among organisms	Sounds and auditory organs in animal kingdom Parasitism Influence of invasive organisms on ecosystems	Comparison of mimics in different bumblebee species Identification of soil fauna Practical course of photography
2005	Biodiversity and Biogeography	Historical sources of biodiversity in Central Europe	Preparation of chromosomes
2006	Function and Structure in Living Organisms	Photosynthesis Physiology of Insects Molecular genetics	Differential staining of plant tissues Human anatomy Histology of nervous system and sensory organs

6.1. Annual framework topics

Biology actually represents an extremely wide spectrum of disciplines and topics. The two-weeks course is too short to introduce all branches to the participants. Thus, after first two “crowded years” we decided to focus each year's course on a different *framework topic* (see Table 1). The topic shall be comparatively broad, attractive and

cross the boundaries of different biological disciplines. Relevant *specific topics* of particular lectures and practical classes are selected within various biological disciplines such as botany, microbiology, zoology, genetics, etc. They shall exhibit various scientific approaches and contributions of different disciplines to the framework topic.

6.2. Lectures

Our intention is to stress not only the biological information itself, but also to explain its relation to other scientific branches. Therefore we regularly include also lectures on biophysics, such as the role of water in living organisms or sound and function of auditory organs. Lecture about the philosophy of ancient Greece as one of the roots of European culture met also surprising success. Several evenings are usually reserved for optional informal lectures or slide shows from different expeditions.

The lectures are interactive and the participants are continuously encouraged to ask questions or to interrupt the lecturers whenever they do not understand. Topics of different lectures together form rather a mosaic than a compact whole. We believe that it is more important to keep high diversity of the program and to give the participants stimuli for further study than to exhaust each topic.



Fig. 1. Example of a practical class in Arachne 2004: comparing mimicry of different bumblebee species.

6.3. Practical Classes and Field Excursions

Approximately one half of the sessions are dedicated to practical classes and short walks in the nature, during which various organisms and ecosystems are demonstrated. There is usually also one whole day excursion to an interesting natural locality. The practical classes and excursions shall (at least to some extent) fill the gap, which arises due to the restriction of practical education in biology in secondary schools' curricula. The participants practice basic laboratory and field methods, such as light microscopy, aseptic cultivation of microorganisms, staining of plant tissues and dissection or identification of different organisms.

6.4. Students' Projects

Students' expectations about their future career in biological research are rather unrealistic, based largely on high quantity of theoretical knowledge. Therefore, one of the main aims of the Arachne Course is to allow these students to experience real scientific work for at least the limited time of several days. There are three to five sessions reserved for students' projects during the two-weeks course. Supervised by lecturers, research teams of two to four students work on different topics, proposed at the beginning of the course by the organisers. Particular topics cover variety of disciplines including faunistic or floristic survey, ecological observations, microbiological laboratory experiments or morphological studies (see Tab. 2). Teams are supplied with standard scientific laboratory and field equipment and necessary literature. The supervisors are ready for advice and help in any difficulties, but the participants are encouraged to plan the experiments and observations and collect data by themselves, as much as possible. The work ends up on a "*scientific conference*" where each team presents and discusses its results. The students are expected to write a short report for the "conference proceedings".

The work on projects promotes the students' thinking about the pros and cons of scientific career before deciding for it. Those who are interested in project methods used in Arachne Course can find more information in [1].

Table 2. Selected students' projects realized during previous years of the *Arachne Course*.

Topic	Year	Acquired methods	Outputs
Nature trail	2000 2004	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, ethological observation of focal animal, questionnaire among the residents and cottagers in the village	Description and map of the habitats preferred for breeding, feeding and other activities
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
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
Quality of recycled paper	2004	Hand preparation of recycled paper, physical measurements and quality testing	Comparison of various parameters of different sorts of self-prepared recycled paper
Photosynthesis	2006	Planning, conducting and evaluation of biological experiment	Comparison of intensity of photosynthesis in different abiotic conditions.
Sounds of Orthoptera (grasshoppers)	2006	Identification of different species of Orthoptera, recording and computer analysis of animal sounds	Comparison of sonograms of several orthopteran species



Fig. 2. Work on a students' project, Arachne Course 2004: observing predatory soil mites.

7. Non-scientific program

The scientific program is integrated with a wide variety of activities, such as fine arts, dance, non-professional theatre, challenging outdoor games, rhetorical training and solving model problem situations in the teams. They serve not only as leisure program to recharge batteries after exhausting lectures. All these activities promote further development of the students' abilities, namely: creativity, communication and team cooperation. This combination of scientific and non-scientific program is exceptional compared to similar biological courses in the Czech Republic.



Fig. 3. Example of non-scientific activities, Arachne 2004: marionette theatre produced by the participants.

Each year, the non-scientific activities are framed with different *annual libretto*. We usually choose an inspiring period of the Czech or world history (see Tab. 3) or “virtual travel” to foreign cultures. Particular activities may be inspired by important historical events, traditional handicrafts or local customs. Before the course, the participants as well as the organisers and lecturers are expected to prepare their own

traditional dress and to wear it during festive occasions during the course (e.g. dinners and evening councils). The organisers also prepare *annual songbook*, distributed to each participant. Annual libretto, traditional dress and songbook are essential to achieve unique atmosphere of the Arachne Courses and help to motivate the participants. Another effective mean how to motivate the participants is to introduce the activities with short scenes played by the organisers.

The non-scientific program is scheduled in afternoons and evenings. There are also two to three night outdoor games during the course. Most of the activities are collective. The participants are usually divided into five to six small groups, less often into pairs. Only part of the games during the Arachne Course are typical competitions, with clear winners and losers. Most of them, especially the creative activities, do not have any winners and losers, or more precisely formulated, “all are the winners”. The current society, as well as the science, is too much “competition oriented”, therefore we support rather the *positive feeling from the team cooperation*, than the prestige gained by beating the competitors. The participants should feel at least some satisfaction, even if their team lost. New teams are established for each activity to prevent negative feelings between the members of different teams and negotiations among the fellows within the team.

Table 3. Annual librettos of the non-scientific program in Arachne Courses 2002 - 2006.

Year	Annual libretto
2002	Czech National Revival
2003	Ancient Greece
2004	Middle Ages in Bohemia
2005	World Congress of Nations
2006	The 1960ies

Table 4. Examples of particular non-scientific activities in Arachne Course 2003 (Ancient Greece). Abbreviations: ind - individual activity; coll - collective activity in groups; p - activity in pairs

Name of the activity	Nature of the activity
Olympic games	- physical competitions (ind)
Ancient tragedy	- amateur theatre respecting the rules of antic drama (coll)
Battle of Salamis	- ritualised reconstruction of a naval battle (coll)
Pottery	- training of work with foot-operated throw (ind)
Sophists	- rhetorical training, disputation between two speakers (p)

8. Daily rituals

During the years of Arachne Courses we introduced several regular customs or *rituals*. They are nice tradition and improve communication between the organisers and participants and among the participants themselves:

Daily evening Council: This is the everyday friendly meeting (0.5 - 1 hour) of all participants, organisers and the lecturers. The council provides space for announcements regarding the program, evaluation of non-scientific activities,

participants' wishes and opinions and for collective singing. During the Council everybody is wearing the traditional dress and is sitting on floor in circle.

Sharing the feelings: Usually at the end of the Council, the participants have space to share their feelings (usually connected with the days' program) with the others. This ritual has different forms according to the annual libretto of the non-scientific program. E.g. in 2006 we strewed together the *mandala*. After several minutes of silent meditation with music, the people were encouraged to express themselves and to strew one field of mandala.

Internal post: Everybody has a chance to send letters to other participants or organisers via the internal post. The letters are dropped into a special post box and later distributed by the postman or postwoman (one of the participants) during each evening Council to the addressees.

9. Participants' feedback

The participants' feedback helps to improve the program of future Arachne Courses. First is the *immediate response* of participants during the activities. The lecturers and organisers, however, do not always perceive it, because of concentration on the lecture. Some of the psychologically oriented games are followed by *common analysis*, serving primarily the participants, but also inform about the success of the game. At the end of the course the participants fill two *questionnaires* - one about the scientific program and the second about the non-scientific activities. They evaluate particular lectures and other activities with school marks and add their comments and suggestions. Last, but not least positive feedback, is that many of the participants want to attend the Arachne Course repeatedly and recommend it to their friends.

10. Beyond the Arachne Course

It is difficult to distinguish the direct influence of the Arachne Course on the participants' personalities from their previous experience and abilities. We did not attempt to make any statistics yet, but we have direct as well as indirect positive evidence: (i) After attending the Arachne Course, the pupils often decide to participate in different biological competitions and are successful. (ii) Many of the participants visit each other during the school year and organise informal meetings. This means, they became real friends. (iii) Former Arachne participants are usually successful in entrance exams on different universities. (iv) In Charles University Faculty of Science, former participants often belong to the best students, measured not only with their results in exams, but also with their activity during the semesters (e.g. asking questions during the lectures).

11. References

- [1] Mourek J., Koukol O., Fišerová J. and Hrabáková M., Secondary school students taste the real science: project methods used in the "Biological Summer Course Arachne". 9th Conference of the European Council for High Ability, Pamplona, Navarra, Spain, September 10 - 13, 2004. Proceedings (on CD), 2004.