

VIENNA OPEN LAB - THE ROLE OF HANDS-ON LABORATORIES IN MODERN SCIENCE EDUCATION

Karin GARBER^{a,b,1}

^a *dialog<>gentechnik (Vienna Open Lab), Vienna, Austria*

Abstract. This report is based on my experiences, which I gained as a project leader of the Vienna Open Lab within the last two years. This hands-on laboratory for pupils and the interested public is the first of its kind throughout Austria.

Keywords. Hands-on laboratory, science education,

Introduction

Almost daily it comes to new achievements and discoveries in the field of modern Life Sciences. Biotechnological applications are established in almost all areas of life, from medicine over agriculture and food production up to environmental protection. At the same time the need for understandable information and public participation in an open discourse about applications, chances, risks and ethical aspects within these complex and partly controversially debated ranges grows.

The kind of education pupils get at school has an important share in the discourse mentioned above and it contributes to a fundamental genetic literacy. Nevertheless teachers are sometimes overtaxed if one expects that they can fulfill this task alone.

During the last nine years of its existence, the independent Austrian society dialog<>gentechnik took different approaches to fostering the dialogue between science and the public. Beside its main function as a competent information office on life sciences, dialog<>gentechnik organized numerous projects, some of them specifically intended for schools, i.e. teachers and students. The establishment of the Vienna Open Lab – an initiative of dialog<>gentechnik and the Institute of Molecular Biotechnology – is one of the latest projects realized. Some other initiatives, such as the School Kit Gene Technology and the GEN-AU Summer School as well as the increasing demand on the part of teachers and learners to visit a laboratory, have paved the way for this hands-on laboratory. In contrast to the United States, where hands-on laboratories have a long tradition, no such institution existed in Austria so far.

¹ Corresponding Author: Karin Garber, Vienna Open Lab, Dr. Bohr-Gasse 3, 1030 Vienna, Austria; E-mail: garber@viennaopenlab.at

1 Selected Projects that Support Traditional Science Education at School

1.1 School Kit Gene Technology - The Laboratory in the Classroom

An important preliminary project of the Vienna Open Lab is the “School Kit Gene Technology”. Equipment, materials and exact instruction manuals for simple experiments in gene technology are contained in a protected carrying case that can be borrowed from dialog<>gentechnik. At special seminars, teachers get an introductory training in handling the kit. Care was taken that the experiments need no approbation according to the Austrian gene technology law, so they can be carried out at schools in the classroom.

Even though the manuals are very detailed, performing experiments and discussing the sometimes unexpected results with their students turned out to be a challenge that some teachers are not willing to meet. Of course this does not apply to all teachers, but most educators feel more comfortable when a real scientist is available. Students on the other hand seem to enjoy school much more when it takes place somewhere else than in the classroom. The Vienna Open Lab meets both needs.

1.2 Vienna Open Lab – The class in the Laboratory

(A joint initiative of dialog<>genetechnik & the Institute of Molecular Biotechnology)

At the end of 2004 dialog<>gentechnik started planning and constructing a new project – the Vienna Open Lab. On May 23rd, 2006 this fully equipped molecular-biological laboratory opened its doors for the public. Visitors - above all school groups - are actively involved through hands-on activities

Objectives

A visit at the Vienna Open Lab should give an overall impression about the work of researchers. It should encourage the elemental curiosity – especially that of younger pupils – to discover things. Visitors should get the opportunity to conduct their own investigation, thus getting an insight into the day to day work of scientists. The pupils are to receive views of selected topics of research in modern life sciences and to concomitantly acquire understanding for scientific thinking and working. They are to understand, which significance and limitations scientific experiments do possess. Furthermore this project is intended to contribute to:

- a genetically literate public
- informed opinion leaders
- the next generation of research biologists

Even though school-groups represent the main portion of visitors, families, journalists and the interested public are among the target groups of the Vienna Open Lab as well.

Location

Located at the Campus Vienna Biocenter – a Life Sciences cluster of research institutes and small biotechnology companies – the Vienna Open Lab benefits from its surrounding. Young scientist are recruited as tutors, senior scientists can be enlisted as speakers and new experiments can be developed together with research groups, thus linking the experiments to actual scientific problems.

Programme

The Vienna Open Lab offers hands-on laboratory experiments for children from 6 years, teachers, students, and the interested public. During the trial phase even a kindergarten group visited the lab. As a matter of course the activities have to be specifically adapted to the different age groups. Training programmes last from two hours up to six hours. Special programmes (e.g. teachers workshops) take one day and longer.

Experiments and techniques offered in the Vienna Open Lab so far include:

- DNA extraction from fruits, vegetables, plants and food products
- DNA isolator from saline mouthwash
- Analysis of DNA with restriction endonucleases and gel electrophoresis
- Making a cell model
- Transformation of bacterial cells with plasmid DNA
- Detection of genetically modified food by PCR
- Predict bitter tasting ability by PCR
- Genotyping of transgenic plants

In the course of the workshops visitors get to know more about:

- Basic principles of genetics and molecular biology
- Key concepts of genetic modification
- Traits and how they are inherited from parents to their offspring
- The structure and function of DNA
- The structure and function of cells
- Plasmids and restriction enzymes and their importance as basic tools for recombinant DNA techniques
- How and why foreign DNA is introduced into an organism
- How scientists investigate the function of certain genes

1.3 e-Learning

In cooperation with the Austrian Federal Ministry of Education, Science and Culture, dialog<>gentechnik tried to strike another path in science education. Advised and coordinated by dialog<>gentechnik, school teams from all over Austria developed and designed computer based training units. Therefore students had to collect, select, arrange and summarize information about scientific certain topics.

eLearning Project „Stem Cells and Cloning“ (school year 2004/05)

In this pilot project pupils have created a unique and extensive e-learning course about the different aspects of research on stem cells, cloning of humans and animals and related ethical questions. The e-content is available as a CD-ROM version and is widely used as teaching material.

“eContent + Biosciences“ – eLearning II (in progress)

The project „eContent + Biosciences“ is an e-learning project, with the aim to encourage the teamwork between scientists and school teams all over Austria. The high school students are introduced to the current research topic of a scientist and present its content as e-learning sequences. The teaching units will be pooled and presented on a web-portal „Biosciences in Austria – by Pupils for Pupils“ and will be available for all schools in Austria.

2 Learning Science in the Laboratory

Although the Austrian government put a strong emphasis on scientific literacy and modern life sciences within the high school biology curriculum, there is (almost) no hands-on instruction in genetics and biotechnology at the pre-university level.

Only a handful high schools are equipped with some basic apparatuses for DNA analysis, like PCR machines or gel electrophoresis systems. Furthermore the Austrian law system is very restrictive regarding the manipulation of organisms on a molecular level. So there are just a few experiments one can accomplish at school and outside of a registered laboratory.

At this point the Vienna Open Lab comes into play, because it offers the opportunity to add a practical element to the very theoretical classes at school by providing experiences that can not be duplicated in the classroom. A real laboratory situated in a research institute produces a unique informal learning environment. Young scientists as tutors and a limited number of participants (each instructor advises a maximum of ten students) ensure a very intense interaction between the researchers and the students and drop one’s inhibitions to ask questions or participate in a discussion.

2.1 Defining Realistic Goals

Addressing the advantages of an informal laboratory environment that provides high school students with opportunities to “learn by doing”, one has to consider temporal limitations as well. The laboratory courses offered by the Vienna Open Lab last from two to five hours. Thus one has to concentrate on the objectives one can achieve within this limited period of time and adapt the goals to the available resources.

Objectives do also differ concerning the age of the target group. Activities for

highschool students are not only restricted to learning certain scientific technologies and procedures, but should also impart how scientists ask questions or raise a problem, hypothesize possible solutions and design and conduct experiments to proof their hypothesis. In addition techniques that were outlined theoretically at school can be tested practical. In doing so, the students internalize the learning matter much easier.

A study which was accomplished by Waarlo and Smeenk showed that in case of primary school students emphasis should be on an observational base for heredity and on introducing simple genetic vocabulary. More complex topics like DNA structure and genes should wait until students understand molecules, otherwise children struggle with the amount of abstract information [1]. In case of very young visitors the tutors focus on the laboratory as a working place. Among other things, they discuss the kind of work clothes scientists have to wear and the machines they are working with

2.2 Effects of Laboratory Learning Environment

It has already been in the 1980s that the laboratory has been given an important role in science education. Science educators have expressed the view that uniqueness of the laboratory lies principally in providing students with opportunities to engage in processes of investigation and inquiry [2]. Additionally laboratory work is an important medium for stimulating interest and enjoyment, and motivating students to learn science.

In the Vienna Open Lab students are working together in small groups. Such cooperative laboratory activities have the potential to enhance constructive social relationships and the more informal atmosphere encourages the interaction among students. The groups conduct the same experiment with different probes, and at the end of the course the results of all groups are collected and compared. The different groups have to integrate their individual results into the overall question. Thus the students should get an understanding of the nature of the scientific community, where different research groups cooperate with each other.

2.3 Important Features of Successful Laboratory Courses

During the test run and in the discussion with teachers and pupils, we already gained some useful experiences for optimizing the structure of the programme. The following list gives a small overview of important points that must be considered in order to obtain the desired effect:

Design of the Lab protocol

In order to make up a optimal manual, hand-outs need to comprise:

- the central question of the experiment,
- an instruction sheet containing the procedures,
- enough space for observations, results and discussion.

In addition clear guidance should be provided about the relevant information that has

to be noted.

General structuring

- Take ones time
- Be careful not to overtaxing the students with complex technical and scientific details
- Point out the general and specific aims and purposes of the lab in a prelab introduction
- Encourage questions
- Take ones time to reflect and discuss the results and ask the students for their own hypothesis and interpretations during a postlab discussion

3 Conclusion and Future Perspectives

The Vienna Open Lab is the first institution throughout Austria that meets the need of the teachers for a more practical education on modern Life Sciences. To learn science in a real laboratory outside of school and to get in contact with real scientists provides the pupils with memorable experiences and stimulates their interest in science.

To optimize the project, one has to adhere to certain standards and aim for regular improvement. For that purpose the Vienna Open Lab will evaluate the feedback of the visitors via a questionnaire. Besides an advisory committee will be established consistent of scientists from different fields, like sociologists, pedagogues, ethicists, etc.

In 2007 the Vienna Open Lab will accomplish a week-long “Science Summer Camp” for teenagers. In case the project proofs to be successful (which is to be assumed) we will consider an expansion by setting up a second laboratory and a computer room.

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