The “GeneLab”– a gene and biotechnology outreach laboratory

Summary:
The GeneLab is an outreach lab for biotechnology and gene technology within the Centre for Math and Science Education (Z-MNU) under the direction of the Biology Education Department at the University of Bayreuth. The target groups are secondary school students, pre-service teachers (i.e., university students for biology education, in combination with chemistry or English language education), and biology and chemistry in-service teachers as well as teachers of other subjects like ethics. Second, guided by the university lecturer, they build up the equipment to all work areas for the eight student groups (maximum of 32 students). Third, they participate on three subsequent lab days together with the student groups from participating schools. During these days they undergo an a three-fold change starting from (a) the role of a school student (i.e., they participate in parallel to seven school student groups as eight group at this day and carry out all experiments), (b) on the second experimental day, they tutor two student work groups (tutor role) according to the assignment-assistance model of tutoring (Kersaint et al., 2011), and (c) on the third experimental day, they change to the teacher role (i.e., they teach one hands-on phase to the students, in the other ones: tutoring). A final reflection seminar wraps up the module. Accompanying explorative research has shown some effects on pre-service teachers’ PCK.

Aims:
Student modules: Students should gain specific knowledge regarding key questions of molecular biology and basic techniques therein. They should carry out authentic experiments on their own, unavailable at school due to resource as well as time limitations. Additionally, the modules should further other areas of genetic education and combine genetic education with an ethical reflection.

Pre-service teacher education: Pre-service teachers should develop pedagogical content knowledge (PCK; Shulman, 1986) regarding teaching microbiology, molecular biology, biotechnology, and gene technology. First, as one part of PCK, they should be able to prepare and to carry out experiments within these issues which they should implement later on as future teacher at school. Secondly, with regard to the student modules, they should exemplary reflect on their PCK of a specific issue which they develop by combining student modules with their teacher education. Additionally, pre-service teachers should also increase their content knowledge as well as parts of pedagogical knowledge. In-service teachers’ professional development (PD): In-service teachers should achieve a higher level of PD by participating both on the student courses and, especially, on specific lab days with regard to hands-on teaching biotechnology issues at school.

Main activities:
Students: day-long experimental modules: pre-service teachers: (a) term-long experimental courses, (b) outreach teacher education module: in-service teachers: day-long experimental courses.

Narrative:
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Methods of learning/training:
Pre-service teachers: evidence-based PCK development, in-service teachers: evidence-based PD development.

End user:
Pre-service and in-service teachers for biology education at two different stratification levels: the Gymnasium as a ‘university-preparatory secondary school’ (highest level, up to the 12th grade) and the Realschule as a ‘professionally oriented secondary school’, where students may receive the ‘intermediate secondary school-leaving certificate’ (intermediate level, up to the 10th grade. Bavarian Ministry of Education (BME), 2011, p. 11).

Involved actors:
Science education researchers with biology and chemistry teaching experiences for years at school.

Location:
Outreach laboratory at the University of Bayreuth.

Languages available:
German

Evaluation parameters:
Student modules: Since the program started, science education research in parallel has evaluated the modules regarding instructional efficiency of scientific learning. Results have been published in international peer-reviewed journals (e.g., Scharfenberg & Bogner, 2010).
Pre-service teacher education: (a) summative evaluation by the Faculty of Biology, Chemistry, and Geosciences; (b) explorative evaluation since the outreach teacher education module started.
In-service teacher PD: summative evaluation by the Ministerialbeauftragter in Oberfranken on behalf of the BME.


Duration:
Student modules: day-long; pre-service teacher modules: 6 day-long experimental courses; in-service teacher education module: six days; in-service teachers: day-long.

Optimum number of participants:
Pre-service teachers: twelve; in-service teachers: twenty.

Additional information or resources:
www.bayceer.uni-bayreuth.de/didaktik-bio/forschung/proj/ detail.php?id_obj=23987;

Teachers’ Competencies

1. subject matter/content knowledge
2. nature of science
3. Multidisciplinary
4. knowledge of contemporary science
5. variety of (especially student-centred) instructional strategies
6. Lifelong learning
7. self-reflection
8. teaching/learning processes within the domain
9. using laboratories, experiments, projects
10. common sense knowledge and learning difficulties
11. use of ICTs
12. Knowledge, planning and use of curricular materials
13. Information and Communication Technologies with Technological Pedagogical Content Knowledge
1. Building interest in natural science phenomena and explanations.

Evaluation research (Scharfenberg, 2005) has shown that the lab day furthers the students’ emotional component of interest (Krippa et al., 1992; i.e., measured as affective rating of acceptance) which is based primarily on the hands-on activities. However, the lab day did not further the epistemic component of interest.


2. Building up informed citizens: Students understanding the nature of Science & Science in society.

Nature of science. Within the module Genetic Fingerprinting, students and pre-service teachers are confronted with key concepts describing the nature of science, for instance, the concept tentativeness. Parts of DNA which ten years ago has been assigned as junk DNA are now coupled with regulatory functions. In this case, a preserved regulatory element within an intron is associated with the brown/blue eye color in humans (Eisberg et al., 2008).

Science in society. Within the module Genetic Fingerprinting, students and pre-service teachers discuss the role of science in society. In this case, they discuss and value the pre-implantation diagnostics (PID) and its ethic-moral consequences. PID is of particular relevance in Germany due to the current changes in the law.


3. Understanding students’ concepts and learning style about of science phenomena:

Pre-service teachers have different chances to understand students’ concepts with regard to the subject domain, i.e., eight students) hold and with different learning styles of the work group members.


4. Understanding students’ concepts and learning style about of science phenomena:

The experiments conducted do not always reach the results expected by the teachers. One of the most important learning tools in this course is the ‘error’ if treated in an adequate way. The error is addressed and analyzed by tutors and participants not only so that teachers can reflect on what did not work, but also in order to develop awareness of science as a continuing process.


5. Activities for gaining knowledge, not for entertainment, nor for simple imitating of results.

The students’ experiments are embedded in a framework of minds-on hands-on units, consisting of a theoretical minds-on phase (during which the teacher introduces the theoretical background of each experiment) as well as an associated experimental hands-on phase. Before they begin, the teacher introduces the students to the work area during an initial pre-lab phase. Before they begin, the teacher introduces the students to the work area during an initial pre-lab phase. At the end comes a final interpretation phase and discussion of the actual results. All experiments are authentic, representing the ordinary day-to-day actions of the community of the practitioners. The pre-service teachers have the chance to develop their PCK by working with new student groups on the three subsequent days. The tutor role provides the chance to counter against the self-experienced difficulties during the hands-on phases. Finally, the teacher role allows to include the own experiences from the two days before into a own instructional strategy. Moreover, university students also increase other elements of PCK in their first seminar (e.g., knowledge about the current syllabuses). Independently, they also increase their content knowledge as well as parts of pedagogical knowledge (e.g., regarding cooperative learning).


6. Understanding science as a process not as stable facts. Using up-to-date information of science and education.

Since the programs have been started we evaluate both the student and the pre-service teacher modules.

Student modules: In total, we have published eight papers in peer-reviewed journals and two doctorate theses up to now (2005 to 2011). Pre-service teacher modules. In parallel to implementing the module into teacher education, we started an explorative evaluation. First results have shown effects on pre-service teachers’ PCK. For instance, pre-service teachers differently assessed students’ learning difficulties before and after the teacher education module.

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Both the students and the pre-service teachers take part on their specific module in order to do science, including experimenting, analyzing, interpreting, and redefining explanations. The students attend an experimental lab day. The pre-service teachers do science both in the role of the school student (1st lab day) and in the role of the tutor (2nd and 3rd lab day of their module; for details, see above 3rd paragraph of the section content).


Assessment: formative – of students’ learning and the summative – of their progress. The experiments conducted do not always reach the results expected by the teachers. One of the most important learning tools in this course is the ‘error’ if treated in an adequate way. The error is addressed and analyzed by tutors and participants not only so that teachers can reflect on what did not work, but also in order to develop awareness of science as a continuing process.


The GeneLab courses for in-service teachers’ PD bring together teachers from different schools in the area around Bayreuth. Due to complexity of some new experimental approaches, cooperation between the teachers may arise. Independently, they come in contact with science education researchers at UBT, and, content-dependently, with UBT experts in different fields of biology and/or chemistry research.