Teaching Laboratory Classes in the Natural Sciences

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Introduction

Laboratory classes are the practical-experimental part of many study programmes, where students learn the methods of empirical natural sciences. Students acquire experimental competencies, and experience that the process of gaining knowledge is rarely linear or immediate, but requires a complex sequence of tasks or procedures. Working on lab experiments includes experimental design and strategic thinking, formulating hypotheses, at times lengthy trial-and-error experiences, reasoning and argumentation, discussing measurement errors, handling laboratory safety issues, and teamwork.[1]

1. Roles and responsibilities

At the University of Vienna, teaching laboratory classes is often characterised by a cooperation between course instructors and teaching assistants (TAs, often predoc assistants). Their responsibilities and leeway in designing classes differ as follows:

■ **Course instructors:**

- ☐ Plan the basics of the lab class (taking into account the provisions of the curriculum, particularly the student learning outcomes), experiment selection, as well as assessment;
- ☐ Make sure that the content of the lab exercises and the lectures are well coordinated, and that the lab exercises are well integrated in the modules or study programmes (as preparation for subsequent lab classes);
- ☐ Can also take on all responsibilities of teaching assistants (see below).

■ **Teaching assistants:**

- ☐ Communicate with students and instruct them on site;
- ☐ Plan experiments in detail;
- ☐ Make sure that all students understand and follow safety procedures;
- ☐ Assess student work – often according to criteria specified by the course instructor and used by other TAs.

2. Learning potential of hands-on laboratory classes

Hands-on laboratory classes provide students with various learning opportunities, thus leading to a long list of potential student learning outcomes. Teachers should set deliberate priorities to prevent students from getting lost in competing learning outcomes. Experts in lab teaching call this practice "**targeted labwork.**"[2]

The learning potential of lab classes includes the following:

■ **Conceptual learning outcomes (combining theory and practice):**

- ☐ Direct observation of phenomena helps better understanding of scientific concepts (*inductive learning*);
- ☐ Expert knowledge is applied to practical tasks (*deductive learning*).

■ **Procedural learning outcomes (experimental skills in all stages of an experiment):**

- ☐ Proper use of apparatus and materials;
- ☐ Planning experiments and justifying the selection of experiments;
- ☐ Data analysis: Ability to assess statistical errors and recognise systematic errors, including mathematical competencies.

■ **Epistemological learning outcomes:**

- ☐ Understanding the role of experimental empirical research in the natural sciences; Understanding data and its epistemological uncertainty.

- **Language and writing-related learning outcomes**: Proper use of oral as well as written academic and discipline-specific language (e.g. laboratory protocol), documentation and presentation of results.

- **Social competencies**: Teamwork.

Teaching lab classes entails specific challenges and opportunities that are different from other course settings. Introductory laboratory classes are often criticised for not providing the foundations required for subsequent lab courses, or for writing final papers based on experiments.[3] The following entries (/en/start-page/course-types-disciplines/teaching-laboratory-classes-in-the-natural-sciences/2-during-the-laboratory-class/) on laboratory classes highlight what matters most in teaching in order to inspire student learning.

Continue reading

Laboratory work (1): Planning Laboratory Classes (/en/start-page/course-types-disciplines/teaching-laboratory-classes-in-the-natural-sciences/1-planning-laboratory-classes/)

References

[1] Nilson, Linda B, "Problem Solving in the Sciences," in *Teaching at Its Best: A Research-Based Resource for College Instructors*, 3rd edition, 199-207. San Francisco: Jossey-Bass, 2010; here: p. 207.

[2] Séré, Marie-Geneviève, "Towards Renewed Research Questions from the Outcomes of the European Project," in *Labwork in Science Education*. *Science Education* 86, No. 5 (2002): 624-644; here: p. 626.

[3] Mühlenbruch, Tobias, and Volkhard Nordmeier, "Optimierung naturwissenschaftlicher Experimentalpraktika." In Heterogenität und Diversität – Vielfalt der Voraussetzungen im naturwissenschaftlichen Unterricht, edited by S. Bernholt, 414-416. Gesellschaft der Didaktik der Chemie und Physik, Jahrestagung in Bremen 2014, Kiel: IPN, 2015.

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