Understanding Root Symbioses through Multi-perspective Inquiry-based Learning in a Plant Science Laboratory

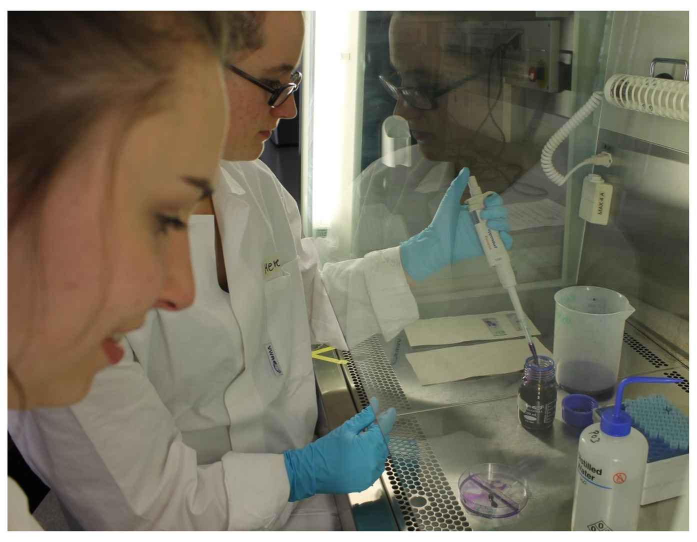
Rita Gazdag[1,2] • Martin Willmann[2] • Jörg Großschedl[1] • Marcel Bucher[2]

[1]Institute for Biology Education, University of Cologne

[2]Botanical Institute, Cluster of Excellence on Plant Sciences, University of Cologne

rgazdag@uni-koeln.de

Theoretical Background

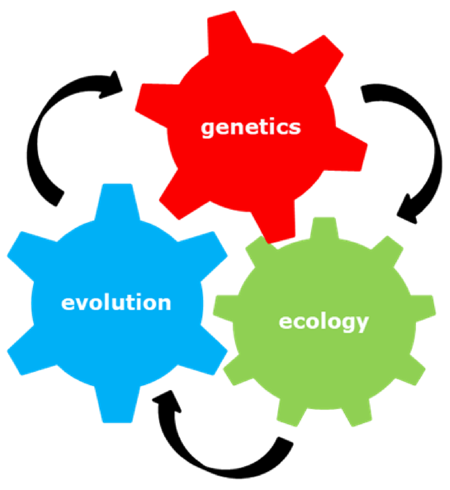


Students' conceptions have an accelerating and/or hindering long-term effect on subsequent learning processes [1, 2]. Learners' active participation in planning and executing contributes to their own learning [3]. **Inquiry-based learning** provides students with authentic scientific experience, promotes cooperation between students, fosters interdisciplinary linkages to other school subjects and highlights autonomous learning [4].

Strongly-guided "cookbook"-like experimenting should be avoided as this approach is contradictory to the essence of any fast-evolving, collaborative, scientific inquiry [5]. Moreover, students find it difficult to build and follow-up their own research activity, to argue for and back-up their own hypothesis [6]. Therefore planned instructions together with an open-ended scientific inquiry and the consideration of students' conceptions are the keys to the promotion of knowledge construction [7].

Teaching biology should always be planned from the viewpoint of evolution in all school forms [8]. This is important particularly, when it comes to the different content themes in biology like molecular and cellular processes, biodiversity or ecological aspects of plant breeding. This **multi-perspectivity** could help students to better understand the inter-connectedness of biological disciplines.

Mycorrhiza fungi and nitrogen-fixing bacteria create two forms of mutualistic symbiosis (mycorrhiza and nodulation) with roots in soil. These symbiotic interactions are beneficial for both partners, serve essential ecosystem functions and played a major role in evolution. In this study we investigate the three concepts on secondary students' learning on the example of mycorrhiza and nodulation symbiosis.



Key Objectives

The aims of the project are:

- to evaluate the implementation of the three major design principles identified above:
  - **students' conceptions of plant root symbiosis**
  - **instructional strategies fostering inquiry-based learning**
  - **multi-perspectivity of 3 disciplines: *genetics, evolution, ecology***
- to develop a learning material on mutualistic symbioses in the root for high school students (level Sek. II).

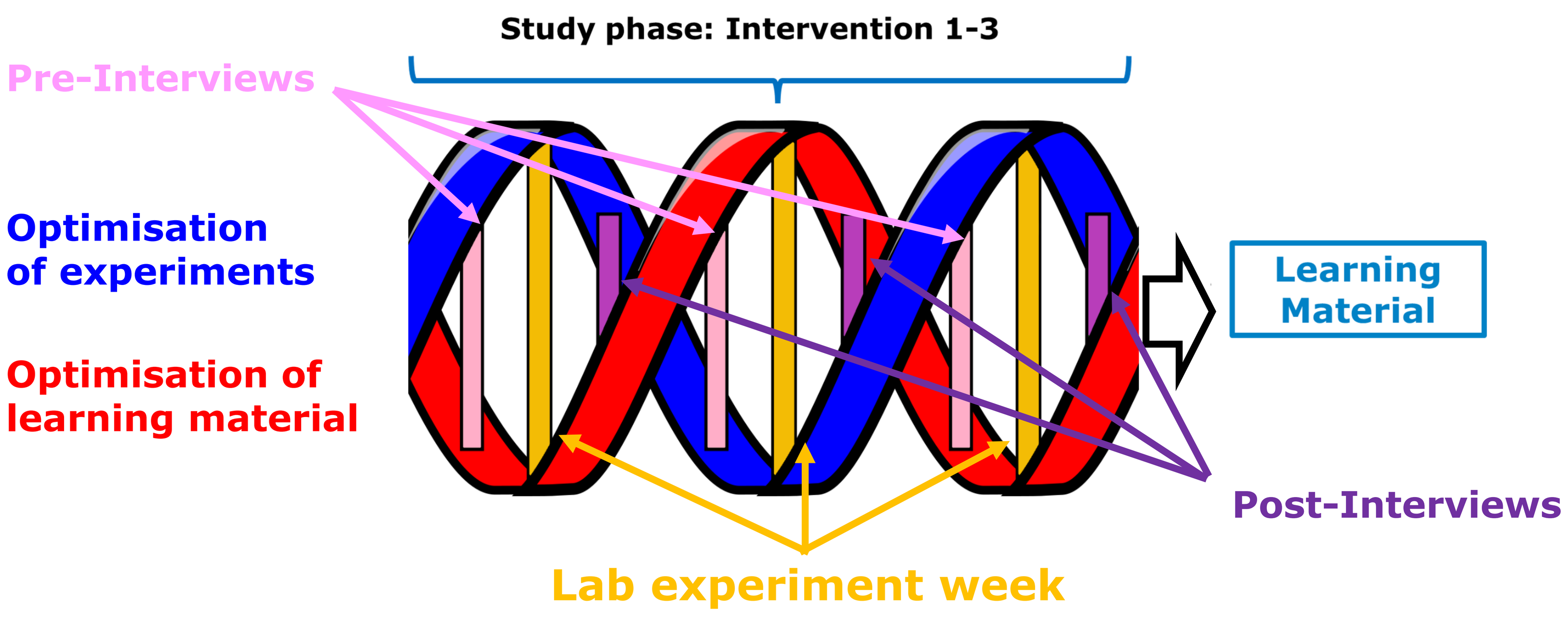


Fig. 1: Cycles of the optimisation process

Research Design and Methodology

The **model of educational reconstruction** [9, 10, 11] and the **design-based research approach** [12] form the design of this study. It includes 3 cycles of the optimisation process. Each cycle consists of an experiment week, pre- and post-interviewing to analyse students' conceptions.

During the interviews the students are questioned about interactions between the plant, plant root and other living organisms, especially microorganisms. Both pre and post-interviews are coded with qualitative data analysis [13].

Based on these results, follows the updating of the learning material. It includes the Predict-Observe-Explain (POE) prompting approach [14] to support students' experimentation process.

In 2018 two similar cycles including video assessments will be conducted to follow students' learning material use. Finally, we will evaluate the **successive combination of these three design principles** with respect to the **learning process of students and the development of the learning material**.

Findings and Discussion

We have so far conducted the first intervention phase. In pre-interviews, students first shared the typical misconceptions of microorganisms [15, 16] being detrimental. In the post-interviews they could already differentiate between beneficial and parasitic plant-microbe interactions. By then we further experienced a significant conceptual change of students' understanding of the evolution, the formation and genetic mechanism underlying both forms of symbiosis.

It has become clear for students that symbiotic interactions may take different forms, and outcomes are dependent on environmental factors present in the soil. Regarding the question about the role of evolution in plant-microbe interactions, pupils contemplated on its beneficial impact on both partners throughout evolution.

They also concluded that this interaction would change agricultural practices in the future. We can therefore already suggest that the multi-perspective teaching and learning of a rather complex topic like symbiosis contributes to students' holistic understanding of plant growth, its nutrient cycles and microbe interactions.

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