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What Do Legionella, EHEC and Botox have in common? An Interdisciplinary Science Camp on Biomembrane Research and the Nature of Science

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Abstract

Nine students aged 16 to 19 took part in a XLAB science camp in Göttingen (Germany) in October 2019 entitled 'What do Legionella, EHEC and Botox have in common?'. In order to answer this question, the underlying scientific concepts such as the transport mechanism across biomembranes and as the basis of that the self-assembly of lipids to bilayers were developed during the five days of the camp based on the heterogeneous prior knowledge of the participants. Using specific developed experiments and information materials, the students acquired both the scientific principles and the important research method of fluorescence microscopy independently. Therefore, the phenomena of color and fluorescence were systematically investigated from a chemical and physical point of view. On the last day, the learned contents were applied to the pathogens Legionella pneumophila, EHEC (enterohemorrhagic Escherichia coli) and Botulinum toxin (Botox) by comparing adapted primary literature on current research on SNARE-mediated exocytosis at the presynapse with a newspaper article on medical research on Botox. By analysis of scientific communication, an authentic insight into the work of a scientist is given in addition to the experiments. An accompanying questionnaire study examined the changes in the participants' understanding of the nature of science.

Keywords: *adapted primary literature, nature of science, science camp, biomembrane.*

1. Introduction

When do students come into contact with science? According to PISA 2015, only a minority of students are involved in science outside school activities [1]. As a result, science education is of particular importance for the teaching of scientific literacy and at the same time stuck in a dilemma: In a short time and with few resources, students should be trained to become "reflective citizens" being able to "engage with science-related issues, and with the ideas of science" [1, p. 50]. In addition to the teaching of scientific knowledge, knowledge about the nature of science is necessary in order to be able to discuss current scientific results [2]. In education and in the media, however, current results from fundamental scientific research are rarely discussed [3]. In fact, scientific knowledge is generally presented rather in an explanatory, narrative, absolute and simplified way. In addition, it's difficult for teachers to integrate current research into the classroom for several reasons, as we outlined previously [3].

With this background, the science outreach project of the Collaborative Research Center 803 (CRC 803) at the University of Göttingen aims to prepare current complex basic research in the interdisciplinary field of biomembranes and to transport it to the general public [4]. The cooperation of the scientists and science educators led to the development of numerous experiments and teaching units (e.g. 'From Surfactants to Biomembranes' [5]), whose contents are related to the research done in CRC 803. In addition to the dissemination of scientific knowledge and the state-of-the-art methods at CRC 803, an authentic insight into the work of a scientist is given. In this article the concept of a science camp entitled 'What do Legionella, EHEC and Botox have in common?' is described, which attempts both to impart scientific knowledge and how scientific knowledge is gained.

2. Educational Framework of the Science Camp

Science Camps offer the possibility to teach knowledge, free of normative restrictions to interested students over several days and provide more time and resources compared to classroom teaching. Therefore, it is possible to discuss current research in such a format. The course took place in the

XLAB, an experimental laboratory for students located in Göttingen, Germany [6], which is also characterized by its proximity to the University of Göttingen and its research.
With the heterogeneous prior knowledge of the participants in mind, the camp focuses on the independent processing of the contents. The participants have to achieve different learning goals and can choose from a total of 40 experiments, various information materials and tasks from the developed script as well as the possibility of searching for more information on the internet or in textbooks. Figure 1 illustrates the contents of the camp by days. At the end of each day there is a joint backup of the results. The arrangement of the topics is comparable to the canonical structure of a scientific article (introduction - material and methods - results - discussion) [7]. The first three days are used to convey the basics of biomembrane research and its methods, so that a basis for the observation of transport processes on the fourth day is given. This general knowledge can then be applied to the pathogens and toxins Legionella, EHEC and Botox on the last day to answer the title question of the camp. Besides pathogens, the analysis of scientific communication is also a topic of the last day.

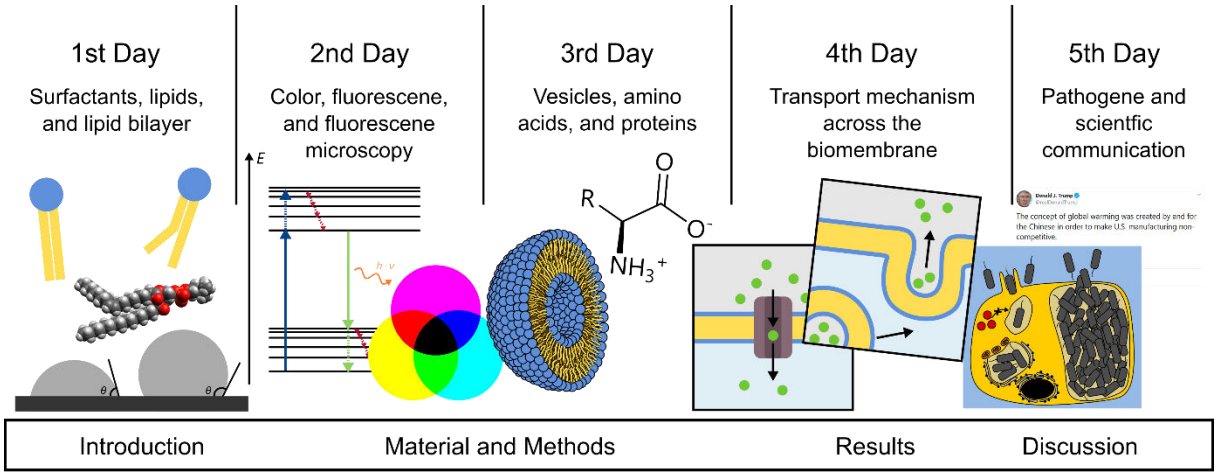

Fig. 1. Illustration of the content of the science camp. The arrangement of the topics is similar to the structure of a scientific article.

3. Analysis of Scientific Communication

For non-scientists, scientific communication is the only way to get in touch with science. Due to different preconditions of the addressees and goals of the communication, different communication channels can be distinguished (see Figure 2). Transfer of knowledge from the scientific community to the general public is not only simplified in terms of content, but also structurally different from communication within the scientific community. Science described by primary scientific literature (e.g. articles in peer-reviewed journals) is characterized by arguments justifying methods, results, hypotheses and explanations, and comparisons of results. In secondary literature (e.g. popular scientific newspaper articles, textbooks) this argumentative structure of research is often neglected [8]. The comparison of a scientific newspaper article and a journal article offers a promising opportunity for students to learn how different science is communicated and thereby how scientific knowledge is gained and discussed in the scientific community. This can lead to an improvement of the students views of nature of science [9, 10].

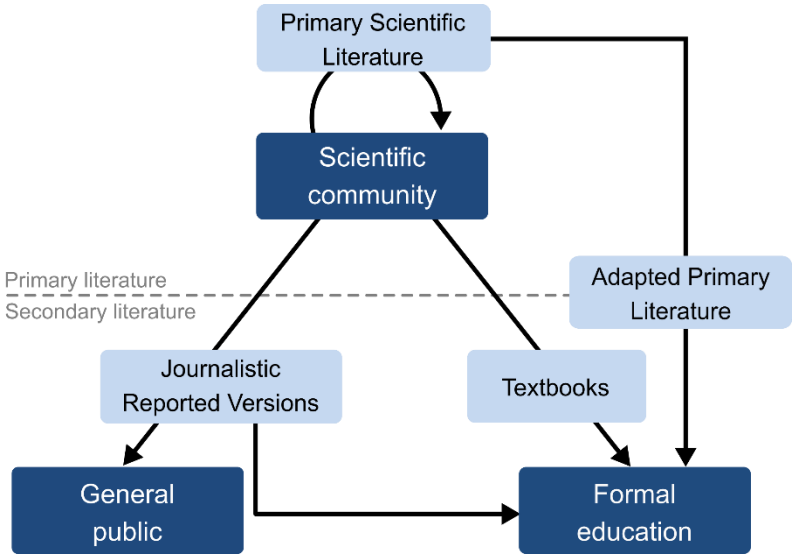

Fig. 2. Overview of the genres of scientific texts according to Goldman und Bisanz [8]. The three different communities use different types of texts to communicate about science. Adapted primary literature, a new text genre developed by Yarden et al. [10], acts as a missing link between textbooks and primary literature. Figure cited from von Hoff et al. [9].

Facing the fact that original primary scientific literature is for novice difficult to read, the format of adapted primary literature (APL) represents a didactically reduced variant of primary scientific literature without losing important features such as the argumentative style, the canonical structure or the uncertainty of scientific knowledge. The reduction is necessary because the students have a different prior knowledge than the scientific community. Unlike textbooks, APL confronts students with the representation of knowledge in the scientific community [10]. For the camp, an APL based on current research by CRC 803 on SNARE-mediated exocytosis at the presynapse [11] was prepared and categorically compared with a freely available newspaper article on medical research on Botox. The considered categories were the target groups, structure, language, illustrations and reference sources of the texts.

4. First Experiences and Evaluation

The science camp took place for the first time in October 2019 with nine students aged 16 to 19. In order to investigate the success of the camp, a questionnaire was developed to test the participants' understanding of the nature of science. The questionnaire was based on the three dimensions of the nature of science according to Osborne et al. [12] ("Nature of Scientific Knowledge", "Methods of Science" and "Institutions and Social Practices in Science", see Figure 3), for which various statements were developed, which the participants could agree or disagree with on a four-level scale. In addition, the students' opinions about the camp were asked for in further informal talks.

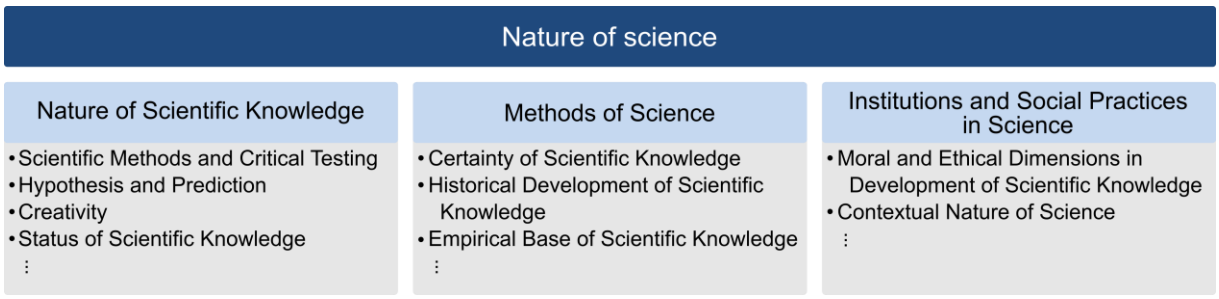

Fig. 3. Three Dimensions of nature of science with exemplary themes based on the Delphi-study form Osborne et al. [12].

The discussions with the participants drew an overall positive picture of the Science Camp. The possibility of working autonomously was positively emphasized, but also the analysis of science

communication was evaluated as exciting and informative. However, some experiments of the first four days were described as worthy of revision, especially because the experimental instructions were still difficult to understand. The results of the survey give reason to hope for an improvement in the understanding of the nature of science in the first two dimensions. This includes the students views of the status and the empirical base of scientific knowledge as well as the need of creativity for research. In the third dimension "Institutions to Social Practices in Science", however, no change could be observed. Since the number of participants is still very small, no absolute statements can yet be made about the effect of the camp. However, the first results are motivating for the further pursuit of the project, so that an improved edition of the camp can already be offered in April. Further dates are planned, so that after several performances a significant statement about the effect of the camp can be made.

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