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Science Outreach Activities on Biomembrane Research in Formal and Non-Formal Settings

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Abstract

Modern means of generating knowledge, especially in the field of fundamental research, have so far been hardly perceivable in the eye of the general public, as well as in school settings. However, within the context of research funding the demand for science outreach is increasing steadily, aiming at closing the so-called gap between science and society. Based on this development, a collaborative science outreach project was established within the interdisciplinary Collaborative Research Center 803 (CRC 803) at the Georg-August-University Göttingen, in cooperation with the chemistry didactics department. The projects main goal is to promote the CRC's fundamental research on biomembranes using socially relevant research topics, such as drug development and effects, causes of diseases, effects of poisons as well as scientific research methods. With regards to these topics we developed a number of activities and materials for the formal and non-formal education sector, of which we will highlight two within this contribution – our activities at science fairs and the work with adapted primary literature.

Keywords: *Science Outreach, Science Fairs, Adapted Primary Literature*

1. Introduction

Current fundamental scientific research and its achievements only rarely make headline news and therefore oftentimes go unnoticed by the general public. This especially holds true for school settings, since current topics and findings often take decades to make their way into textbooks. This can be traced back to the fact, that knowledge provided in textbooks is primarily regarded as sound and scientifically established [1]. Scientific research, however, as presented in scientific papers, is based on arguments justifying methods, supporting results, and comparing the latter to the findings of others to either substantiate, expand or contradict those. Accordingly, scientific research is always in motion and the validity of its statements can vary (*e.g.* true, probable, uncertain, false) [2, 3]. These differences make it difficult for teachers to include current research into their lessons for several reasons: (1) It is difficult to obtain information through scientific papers, since most papers are very complex and written for a certain community. Furthermore, licenses are expensive. (2) Teachers need to constantly educate themselves to keep up with scientific innovations. However, suitable learning materials or specific teacher trainings are often non-existent. (3) In order to relay information about current research to students, didactically processed materials as well as new and innovative experiments are beneficial. However, the development of such materials takes time as well as a deeper understanding of the matter.

These aspects in mind, a science outreach project was initiated at the Collaborative Research Center 803 (CRC 803) at the University of Göttingen in early 2017 [4]. The projects main goal is to didactically process the complex and increasingly diversified fundamental research on biomembranes conducted within the CRC, by identifying socially relevant topics and developing curricular valid experiments and materials. As we outlined previously [5], the project's three target groups include students, teachers and the interested public. The focus, however, is on the students and, in the interest of sustained progress, the teachers as well. In order to ensure a high congruence between the scientific content and the developed materials and models, a fundamental element of the project is a close collaboration between the didactics department and the involved scientists. This collaboration allowed us to develop a number of novel experiments, models and teaching materials. Apart from the integration of these materials into teaching units we're currently focusing on two further formats. Science fairs offer a large audience of varying age groups. Another format is the development and implementation of adapted primary literature (APL).

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2. Educational Perspectives of Science Fairs

Professional science fairs or science exhibitions offer universities, companies and associations the opportunity to provide information regarding various professions and to showcase their work or their research, particularly in scientific-technological fields. The different exhibitions extend over a period of up to a week, in which time some of them welcome over 350.000 visitors (*e.g.* IdeenExpo Hannover 2015). Depending on their aims, the various science fairs cater to different target groups. While some focus on promoting (high school) students' interest in STEM issues and presenting different career paths, others, such as science nights at universities, are addressed to interested people of all ages.

Students who attend such exhibits can benefit from a number of advantages which they have over general school science. While science lessons are regulated and restricted by different curricula, the exhibits can be as diverse as they are plentiful. With their open-spaced concepts, students have the opportunity to browse the different booths while pursuing their own interests. Additionally, they can find and interact with large and oftentimes expensive devises that can only be covered theoretically in class. Moreover, the different exhibitors provide hands-on activities and experiments and the programs often contain scientific shows and talks as well as science slams and workshops.

The science fair concept developed by this group started off with an EXPOneer [6] exhibition piece as its central element. It is based on a teaching unit titled 'From Surfactants to Biomembranes' [7], and contains a number of informational texts, figures, illustrations and press-the-button experiments, introducing principle concepts pertaining biomembranes to people with varying scientific knowledge and backgrounds (Figure 1).

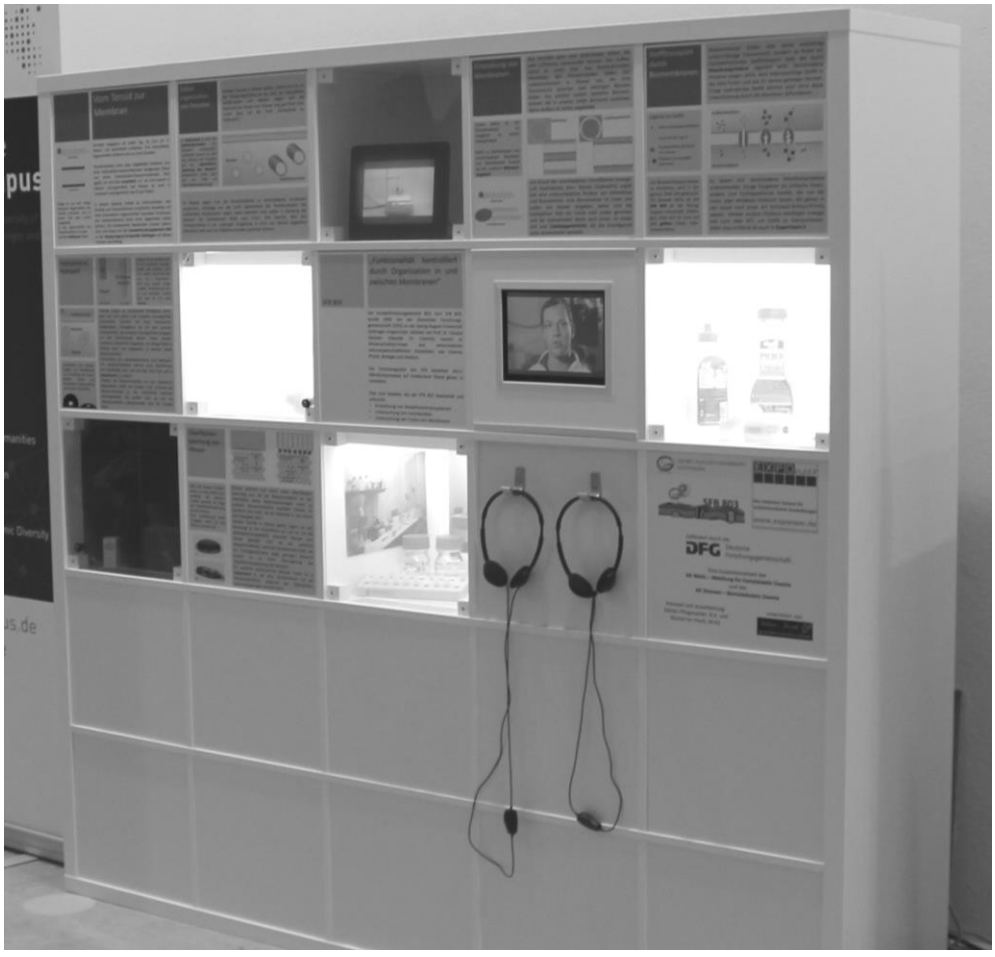

Fig. 1. EXPOneer exhibition piece with informational texts, figures, illustrations and press-the-button experiments.

While this exhibition piece provides the basics needed to understand the interdisciplinary research conducted within the CRC, a number of newly developed experiments and models help to explain and visualize certain more complex aspects of the CRC's research. All experiments are suitable for

students grades 10 and up. Their essence, however, can also be understood by considerably younger students. In order to ensure that all arousing questions by either students or parents and teachers are answered, a team of teacher trainees, CRC scientists and personnel from the chemistry didactics department is always on site.

3. Evaluation of the Science Fair Concept

Research Questions:

In accordance with the three target groups, the research questions differed depending on the respective recipients. Our main interest regarding students was to learn more about their motivation to stop at our booth, their knowledge regarding biomembrane research, their interest in learning more about scientists' day-to-day routines and whether or not they were learning something while at our booth. We furthermore wanted to know from STEM teachers, whether they already integrated the topic of biomembranes into their teaching, if they were interested to learn more about current biomembrane research and if they would consider attending in-service training regarding the matter. From the general public we further wanted to know, whether or not they regarded science research as important for society as well as for their personal future.

Methods:

To answer these questions, we decided to use a method mix containing questionnaires, interviews and observations. This allowed us to ask both open- and closed-ended questions in a short time frame, adjusting to the fast pace of fluctuating visitors.

Findings:

Most of the students who decided to stop at our booth stated that they were especially drawn by the hands-on experiments. Furthermore, a lot of the students were generally interested in chemistry and biology and one of the students claimed, that especially chemistry was underrepresented at the fair. When asked about their knowledge regarding biomembrane research, the answers varied from "something to do with the human body" or "how cells work" to more concrete ideas such as "advancements in medicine" or "development of new drugs for certain diseases". However, a few of the students also related the research to synthetic and artificial membranes. These wrong associations as well as the other rather undifferentiated answers reveal a lack of knowledge about biomembrane research and hence a potential to further our efforts in promoting the topic.

The students were also generally interest in learning more about researcher's day-to-day routines, stating that schools often didn't provide such information during class and that science fairs or internships were the main options they used to learn more about certain professions. Hence the question arises, whether schools should provide more opportunities for students to gain insights into different careers. Additionally, most of the content related questions were answered correctly by more than 60 % of the students, with an especially high rate of correct answers (78 % - 100 %) in the age range of 10^{th} to 12^{th} graders, for which the materials were designed.

Out of the N = 44 science teachers who completed our survey, 25 were already teaching biomembranes. Most of them (21) had biology as one of their subjects, while most of the teachers who had not yet taught the topic came from other science disciplines. However, 36 teachers were interested in learning more about current research, including most non-biologists, and 30 teachers were also interested in attending respective in-service training. Especially the great interest of non-biologists is encouraging, since the topic is typically situated in the biology curriculum. A more chemical approach to the topic, however, allows teachers to highlight the interdisciplinary nature of the CRC's research as well as science in general.

Another 49 visitors with both scientific and non-scientific backgrounds answered the questions designed for the general public. While 48 participants considered scientific research as very important (40) or important (8) for society, only 42 considered it as relevant to their personal future. More than half of the participants with non-scientific backgrounds (N = 25) changed their answer compared to the first question, while only 3 out of 24 scientist did the same (Figure 2), which can be argued as an indicator for the above mentioned gap between science and society.

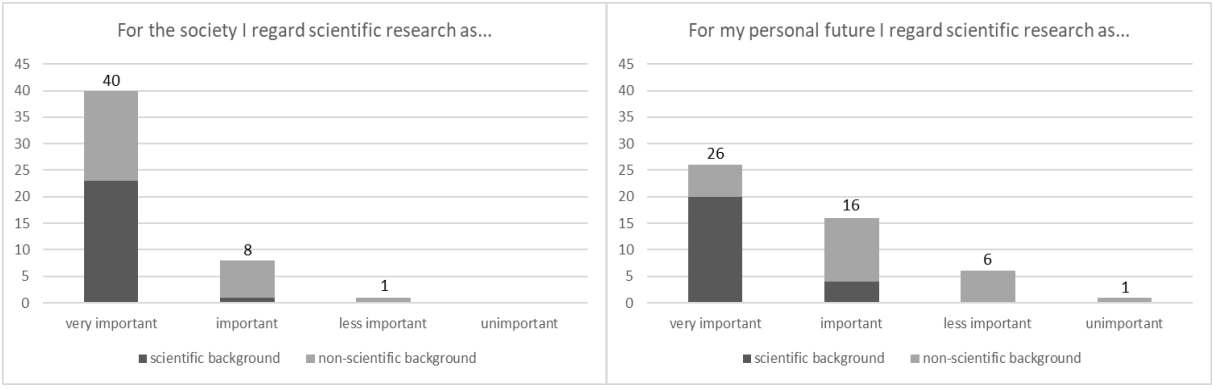

Fig. 2. Importance of scientific research as mentioned by the general public.

In general, we were furthermore able to observe that, when engaged into conversation with our personnel, students tended to stay for a longer period (10-20 minutes), then without the help of guiding explanations (1-5 minutes). Additionally, teachers showed a heightened interest in obtaining teaching materials and experiments.

4. Adapted Primary Literature

Another more recent project is the development of APL [3]. Acting as a missing link between textbooks and primary literature (e.g. scientific publications in peer-reviewed journals), this text form's goals are not limited to imparting knowledge but offer the opportunity to provide insights into current scientific research while illustrating processes of modern knowledge generation. While the chosen primary literature needs to be didactically reduced and adjusted to students' prior knowledge, the characteristic structural features (*e.g.* abstract, introduction, methods, results and discussion), as well as the argumentative level of the original are maintained. In contrast to school textbooks, this text form confronts students with the uncertain nature of research findings, opening their eyes to how science conducted in research labs differs from science lessons in school.

So far we adapted one CRC publication and are currently working on a second. The APL is accompanied by an exercise sheet, guiding students through the article, helping to identify and recognize the novel structural elements. In the near future we will trial and evaluate both the APL and the exercise sheet in an upper level chemistry class.

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