Chapter 46
Learning about Sustainability in a Non-Formal Laboratory Context for Secondary Level Students:
A Module on Climate Change, the Ozone Hole, and Summer Smog

Nicole Garner
Institute for Science Education, University of Bremen, Germany

Maria de Lourdes Lischke
Institute for Science Education, University of Bremen, Germany

Antje Siol
Institute for Environmental Research and Sustainable Technologies, University of Bremen, Germany

Ingo Eilks
Institute for Science Education, University of Bremen, Germany

ABSTRACT

This chapter discusses a project of curriculum development for the non-formal educational sector. The project aims at student learning about sustainability issues in a chemistry-related context. For this purpose, non-formal laboratory-based learning environments are developed. The learning environments center round half- or one-day visits of secondary school students in a university laboratory and are networked with the formal school syllabus in chemistry and science education respectively. All modules integrate the non-formal laboratory event about issues of sustainability with teaching materials for preparation and assessment tasks in school to fulfill part of the school curriculum in chemistry or science teaching. This chapter discusses the project of developing respective modules, the structure thereof, and initial findings from their application. The discussion is illustrated by a module on environmental problems connected to the chemistry of the atmosphere, namely climate change, the hole in the ozone layer, and the phenomenon of summer smog.

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INTRODUCTION

The global economy of the last few decades can be characterized, at least in the Western countries, by continuous growth, and in most cases a great improvement in the quality of life. A lot of innovations from science and technology have simplified life. Today, it is hard to imagine life without modern health care, materials, or energy supply. Chemistry and chemical industry contributes greatly to this development (Bradley, 2005). However, this development had and still has its price. Mankind has to cope with growing scarcity of resources, availability of clean water, climate change, and many other problems (Mortensen, 2000). In order to deal with these issues, emissions have to be reduced and both energy and available raw materials must be used as efficiently as possible (Vinten, 1994). Again, chemistry is central to the response to these challenges. One way in which chemistry may answer these challenges is constructed around the idea of a *Green* or *Sustainable Chemistry* as a guiding framework for contemporary chemistry research, development, and industrial production (Centi & Perathoner, 2009; Höfer & Bigorra, 2007).

With the growing importance of sustainability issues in science and technology research and industrial production, it is suggested that respective topics play a more prominent role in education in general (Wheeler & Bijur, 2000), and chemistry education in particular (Burmeister, Rauch & Eilks, 2012). Student learning, about issues of sustainability and the environment, is needed to develop a balanced view towards contemporary chemistry and shaping respective attitudes (Ware, 2000). Knowledge and skills are needed to enable students to assess new chemistry-based products and technologies in their life and society and to act appropriately (Hjeresen, Schutt & Boese, 2000; Dawe, Jucker & Martin, 2005; Arbuthnott, 2009; Karpudewan, Ismail & Mohamed, 2011). Unfortunately, research has shown that students have a lack of understanding sustainable issues such as global warming, ozone and greenhouse effect (Howard, Brown, Chung, Jobson & Van-Reken, 2013). This may be caused due the fact that learning about sustainability issues is barely represented in many science curricula in general, and in secondary chemistry education in particular (Burmeister et al., 2012). The reasons for this range from teaching and learning materials not being sufficiently available, via a lack of adequate experiments and laboratory equipment in schools, towards deficits in teacher education (Burmeister, Schmidt-Jacob & Eilks, 2013).

The project discussed in this paper intends to rectify this situation by implementing innovations into chemistry teaching via non-formal settings, combined with curriculum development for secondary chemistry education, and contributions to teacher continuous professional development. The project is called "Sustainability and chemistry in non-formal student laboratories." It aims at developing and implementing innovative non-formal laboratory teaching and learning environments for secondary school students which allow for contention with sustainability issues connected to the science and chemistry curricula in schools respectively. This paper discusses the basic issues of the project, the structure of the teaching and learning environments, and illustrates the description utilizing an exemplary case focusing environmental problems connected to the chemistry of the atmosphere, namely climate change, the hole in the ozone layer, and the phenomenon of summer smog.

ORGANIZATION BACKGROUND

"Sustainability and chemistry in non-formal student laboratories" is a cooperative project between the Universities of Bremen and of the Saarland, both in Germany. The project is driven both by researchers in chemistry and environmental sciences together with domain-specific researchers and curriculum experts from the field of chemistry education. The cooperation was established to