University of Bremen

Science Education and Education for Sustainable Development

Prof. Dr. Ingo Eilks FRSC

University of Bremen - Dept. of Biology and Chemistry - Institute for Science Education (IDN)
Didactics of Chemistry (Group I. Eilks)
www.chemiedidaktik.uni-bremen.de

University of Bremen

Outline

- Sustainable Development
- Education for Sustainable Development (ESD)
- ESD and Science Education - Models and Practices
- Conclusions and Implications

University of Bremen

Sustainable Development

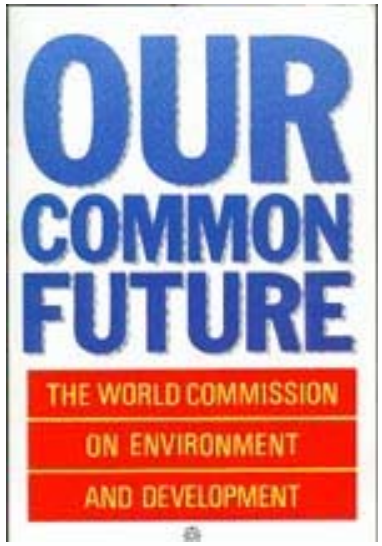
University of Bremen

Sustainable development

- The World Commission on Environment and Development (Brundtland Commission, 1987):

  "[to meet] the needs of the present without compromising the ability of future generations to meet their own needs."

- Current challenges (such as climate change, globalization, or migration) cannot be handled in a fair-minded way without using strategies of sustainable development and not without the STEM fields.



(e.g. Burmeister, Rauch & Eilks, *CERP* 2012)

Goals for 2030

Models of sustainable development

- **Single-pillar-model**
  - Sustainable forestry, 19th century
  - Cultivate the forest in a way that ecological processes, productivity and biodiversity are kept: Cut only as much trees, as can grow in the same time.

- **Three-pillars-model**
  - Defined by the Agenda 21
  - Finding a balance between: ecological, economic and societal sustainability

- **Four- and More-pillars-models**
  - Integrating further dimensions, e.g. cultural and institutional sustainability

University of Bremen

Education for Sustainable Development (ESD)

University of Bremen

The role of education for sustainable development

„Education is critical for promoting sustainable development and improving the capacity of the people to address environment and development issues. While basic education provides the underpinning for any environmental and developmental education, the latter needs to be incorporated as an essential part of learning."

(Agenda 21, 1998)

University of Bremen

The role of education for sustainable development

Agenda 2030 (UN, 2015) states in goal 4.7 of the SDGs:

"*by 2030 ensure all learners acquire knowledge and skills needed to promote sustainable development, including among others through ESD and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to sustainable development*."

University of Bremen

The role of chemistry education for sustainable development

- UN-World-Decade on „Education for Sustainable Development“ (DESD), 2005-2014
- Pupils need special competences for shaping their life, today and in future, within a democratic society
- All domains and levels of education are asked to contribute
- Since developments in science and technology are crucial for most fields of sustainable development, education in STEM subjects should prominently incorporate an ESD philosophy on all levels

University of Bremen

Objectives of ESD

„Education for Sustainable Development (ESD) enables the learner for active participation in analyzing and evaluating processes of non-sustainable development, to orient own life on principles of sustainability, and to start processes of sustainable development with others on the global and local level.“

(German World-Decade Framework: Transfer 21)

University of Bremen

Objectives of ESD

„ESD suggests a holistic and interdisciplinary vision of education that aims on knowledge and skills important for a sustainable development of our planet.“

„ESD aims on enabling students for shaping actively an ecologically compatible, economic powerful and socially fair environment for living under consideration of democratic principles and cultural diversity.“

(German Ministers of Education, 2006)

University of Bremen

ESD and Science Education – Models and Practices

University of Bremen

Model 1: Applying green science in class

- Green science philosophy is applied to practical work and any other action in science classes.
- Traditional practices are replaced by less poisonous, less dangerous and less resource-consuming alternatives.

- Students can learn, compare and reflect upon the altered strategies.
- However, development of general educational skills for ESD is not necessarily in focus.

(e.g. Burmeister, Rauch & Eilks, *CERP* 2012)

University of Bremen

Example: Student Active Learning in Science (SALiS)

Low-cost and microscale experiments for classrooms in developed and less developed environments, implementation of IBSE and practical work without labs

SALiS
Student Active Learning in Science

(Kapanadze & Eilks, *EJMSTE* 2014)

University of Bremen

Model 2: Making green science content an explicit content for chemistry education

- Applications of sustainable science are made an explicit content in the science curriculum, e.g. learning about Green Chemistry.
- The approach highlights the science behind sustainable processes and products as part of the curriculum, e.g. chemistry of biofuels, physics of photovoltaic applications, bio-engineering.

- The approach makes science meaningful to students and offers conceptual knowledge for understanding societal discourse.
- However, understanding of the interplay of economic, ecological and societal sustainability and gaining generals educational skills for societal participation is not necessarily in focus.

(e.g. Burmeister, Rauch & Eilks, *CERP* 2012)

University of Bremen

Example: A green chemistry curriculum

Teaching organic chemistry along the twelve principles of green chemistry in the first year of upper secondary education

- Green chemistry pinciples
- Renewable resources
- Microwave induced reactions
- Enzymatic catalysis
- Bio-polymer synthesis

(Linkwitz & Eilks, *ACS* 2019)

University of Bremen

Model 3: Sustainability in SSI-based science education

- Socio-scientific issues become the driver for science education, e.g. climate change, biofuels, risks and chances of products or processes.
- The lessons are either context-based learning or focus controversial SSIs to make both learning of science and societal discourse about them balanced parts of science education.

- SSI approaches (and if reflected CBSL) contributes understanding on the interplay of economic, ecological and societal sustainability and helps developing generals educational skills.
- However, there is no direct contribution to developing innovative structures.

(e.g. Burmeister, Rauch & Eilks, *CERP*, 2012)

University of Bremen

Learning the debate behind biodiesel synthesis

Teaching fat chemistry and chemical equilibria behind the trans-esterification process of rape seed oil to biodiesel, but also about the controversy of using biofuels, e.g. palm oil imports to the EU.

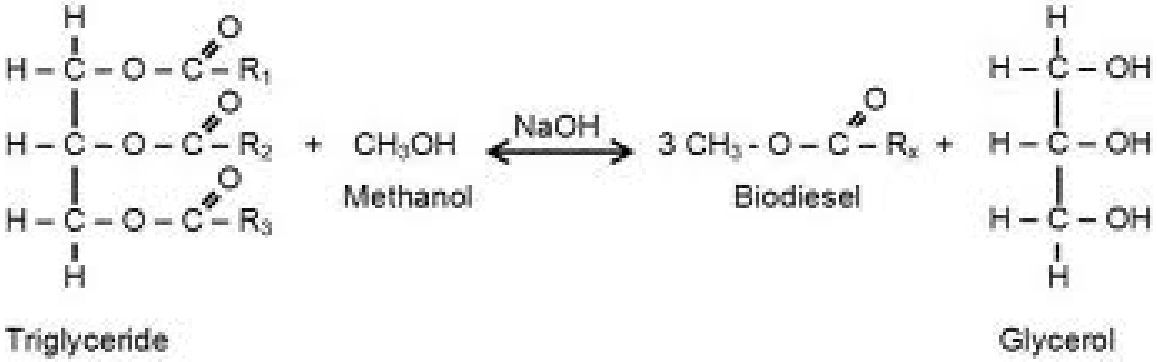


Figure 1. The NaOH-Catalyzed Reaction of a Triglyceride to Biodiesel and Glycerol

(Eilks, *Chemkon* 2001; SEI 2001)

University of Bremen

Model 4: ESD in school development

- School life is reorganized according to ESD goals.
- Reforms focus innovative structures, interdisciplinary knowledge, and participatory learning.
- ESD becomes an essential component of a school‘s life, e.g. project work or networking schools with businesses.

- This appraoch allows for development of competences in the broadest means.
- It has potential for contributing sustainable development and innovative structures.

(e.g. Burmeister, Rauch & Eilks, *CERP* 2012)

University of Bremen

Example: Sustainability and Chemistry in the Non-formal Student Laboratory

- Modules for science education under inclusion of a half- or full-day laboratory visit in the university
- Embedded into formal school education
- Following an SSI approach
- Opens school to society, contributes teacher CPD
- Specific programs for sudents from lower socio-economic status areas and with migration backgrounds
- Topics: Climate change, biofuels, solid state catalysts, safe and environmental friendly synthesis of vanillin, …

Nachhaltigkeit + Chemie im Schülerlabor

Nachhaltigkeit lernen
Weltdekade der Vereinten Nationen 2005-2014
Bildung für nachhaltige Entwicklung
UNESCO
Offizielles Projekt der Weltdekade 2014

(e.g. Garner, Hayes & Eilks, *Sisyphos* 2014)

University of Bremen

Potentials of the different models in connection to chemistry education

Potential for …	Model 1	Model 2	Model 3	Model 4
… learning about sustainable development.	(+)	++	++	+
… learning for sustainable development.	-	-	++	++
… directly contributing to sustainable development.	(+)	-	-	+

University of Bremen

The students‘ view

University of Bremen

The students‘ voice

“Yes, the topic should definitely be included more often in chemistry lessons. Because the topic of sustainability is particularly important for our generation as well as for all those who come after us. Students should be taught that chemistry is not just about making things explode. Chemistry can contribute to a sustainable and environmentally friendly world. Green chemistry offers many opportunities to our generation, which we should definitely learn about in class.”

University of Bremen

The students‘ voice

“Sustainability is an important topic in general, especially at the moment. That alone would greatly expand and positively improve chemistry teaching. Green chemistry is certainly an interesting topic, although for many it might not be as interesting as something as broad as sustainability. But, if you combine these two topics well, you can certainly learn a lot from them and it will be a positive enrichment for everyone. So yes, I think these things should be integrated more (although we already do a lot with them).”

University of Bremen

The students‘ voice

“For many students, chemistry is a subject where it is difficult to find a comprehensible context. However, sustainability is a tangible topic and could certainly increase motivation for chemistry lessons, as there is often also personal interest in it.”

University of Bremen

Conclusions and Implications

University of Bremen

Conclusions and Implications

- ESD is a political goal and educationally well justified concept.
- ESD allows for operating educational theories like Activity Theory or Allgemeinbildung in the science classroom.
- ESD can contribute to all three dimensions of relevance of science education: individual, societal and vocational relevance.
- ESD can act as a promoter for educational reform beyond curriculum revision and domain specific pedagogical innovation.

(e.g. Burmeister, Rauch & Eilks, *CERP*, 2012; Hofstein & Eilks, Bremen Symp. 2014)

University of Bremen

Conclusions and Implications

- Implementation is still rare and focuses in most cases content and context-driven approaches rather than SSI-education or institutional development.
- Teachers‘ knowledge about ESD philosophy and pedagogy is limited, however their attitudes are positive.
- Also on tertiary level science teaching the focus of handling SD-related issues seems to be limited to the scientific background, at least in certain domains and programs.
- Investment in curriculum development and teacher education is needed.

(e.g. Burmeister, Rauch & Eilks, *CERP*, 2012; Hofstein & Eilks, Bremen Symp. 2014)

University of Bremen

Thank you for your attention!

University of Bremen

gefördert durch

DBU

Deutsche Bundesstiftung Umwelt

www.dbu.de

I gratefully acknowledge the funding for many of the described projects by The German Federal Trust for the Environment (DBU),

also the funding from the European Union within their programs TEMPUS, ERASMUS+ and FP7,

… and the contributions of my PhD students Mareike Burmeister, Nicole Garner, Fiona Affeldt, Timo Feierabend, Marc Stuckey, Nadja Belova, Christian Zowada, Michael Linkwitz, Safwatun Nida and Robby Zidny.