2.38 Energy around the House. A Lesson Plan for early Secondary Science Education, with a Focus on Contemporary Energy Use

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Background, scope and method

In the year 2010, the state of Bremen, within Germany, undertook a school reform to implement a thorough system of comprehensive schools. Within the reform, the three science subjects, namely biology, chemistry and physics, were integrated into one subject, 'science', for the early years of lower secondary education (grades 5-8, age range 11-14).

PROFILES-Bremen is supporting schools through this reform process. By forming teams of science teachers from different subject areas and schools, PROFILES-Bremen seeks to help teachers in meeting the challenge of the curriculum shift by integrating the science subjects.

This paper reports on the work of a group of teachers focusing on a syllabus unit for grades 5/6. Utilising the model of Participatory Action Research in science education (Eilks & Ralle, 2002) the group structured an 8-12 weeks lesson plan on basic content of energy, utilising the everyday life context of energy in the house.

Objectives of the lesson plan

The lesson plan "Energy around the House" for comprehensive schools in the state of Bremen (Germany) deals with the syllabus over-arching issue "energy from the sun". In the PROFILES-Bremen project group, this issue is connected with the everyday life context "around the House." The focus of the lesson plan is on alternative energy supplies and energy saving by insulation.

The lesson plan is divided into segments which allow for modular use and given the high levels of heterogeneity in Germany's urban comprehensive schools (as in the case in Bremen), is important.

The modular structure provides an option for teaching the whole unit, selecting different aspects, or combining both for inner differentiation. In each phase, optional activities are included if time allows, or for differentiating for the faster learners and higher achievers. The lesson plan also focuses on a societal orientation of science education (Hofstein, Eilks & Bybee, 2011), referred to as socio-scientific in PROFILES, by reflecting upon the political situation in Germany, which has placed emphasis on intensifying house insulation and promoting more thoroughly the use of renewable energy sources. The latter aspect is dealt with through focusing on solar and wind energy. In this case, the use of energy conversion by windmills, photovoltaic devices, and solar collectors are to be discussed.

The lesson plan is designed to allow for student-active and cooperative pedagogies, e.g. the learning at stations mode or the jigsaw classroom structure. It applies problem-based and inquiry-oriented learning, in combination with cooperative tasks throughout the course. The single activities include a wide range of tasks, such as creating charts, experimenting in groups with open cooperation, or developing and optimizing a model of a solar collector.

Overall the students are taught to think about energy from the sun as an important basis for life on earth.

They also should learn that nowadays the sun's energy can become an important source as an energy supply for household and technical applications in the future, such as supporting energy for heating, mobility, or electrical devices.

Central elements of the pedagogy

Prior to the lesson, the students are asked to measure and record the daily outside tempera-

ture in their local environment for two weeks. The analysis of the data functions as the introduction to the topic. If insufficient time is available for individual measurement, default values can also be evaluated. The motivation for the discussion is the need for the use of heat in the house and the demand for cheap and environmentally friendly technologies.

The first major segment of the lesson plan is the creative inquiry to re-invent an effective solar collector. Before this is possible, the students need to develop relevant basic knowledge. To allow for self-directed creation of the model, this phase is embedded into a jigsaw classroom (Eilks & Leerhoff, 2001). For this purpose five equally sized groups are formed.

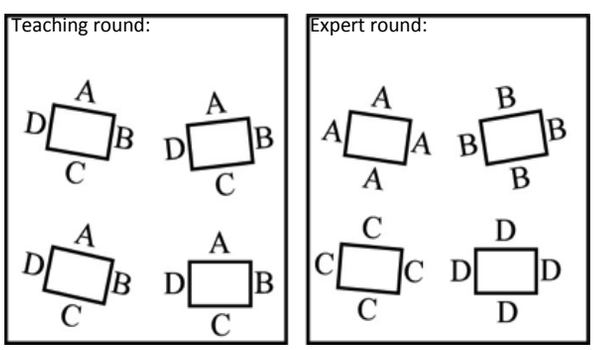

Figure 1. Method of the jigsaw classroom

Each student receives a subtopic. Students with the same topic form a joint group in the expert round. The students learn about different aspects important for understanding a solar collector. The expert groups use experiments such as the greenhouse effect of flow velocity of a liquid to collect thermal energy in a warm compartment as a basis for their inquiry.

After finishing these topics, the 'teaching round' groups are formed by having, in each group, one expert from all the groups of the expert round. Within the 'teaching round', the students are asked to report the experiments which they did and to teach the others about the learned content. The joint task they have to accomplish is the development of a solar collector by combining the knowledge from the different expert topics. From a list of materials the students select the most appropriate materials and explain to the other group members why they rate certain materials to be more suitable than others. The groups' work is supported by a competition inspired by the idea of the egg-races. The different groups compete with each other to find out which solar collector is the most effective. The goal is to achieve the highest temperature increase for a given amount of water.

The second major segment of the lesson plan focuses on heat conduction and thermal insulation. It is not the energy production, which is now the focus, but the reduction of heat loss in and around the house. The students compare two detached houses with each other with the

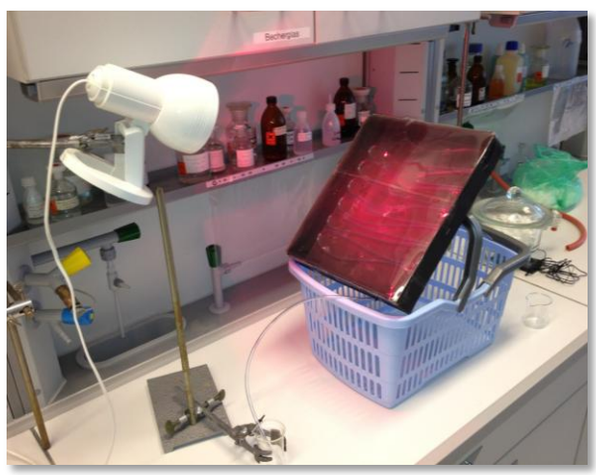

Figure 2. Example of sun collector model

help of a thermal image. One of the houses is provided with thermal insulation and the other is not. Based on the image, the students are expected to recognize the weak points of a house, where the heat escapes to the outside.

The experimental and inquiry learning in this phase is based on the learning at stations pedagogy (Eilks, 2002). The weak points of the house are the individual stations for the 'learning at stations'. The insulation needs to be tested for the roof, the windows and on the outer wall. There is another station working on the thermal insulation in the animal world.

In the overall lesson plan, more options for inner differentiation are embedded, e.g. inquiring the effect of the sun on the phenomenon of sea and land wind, or on the influence of the solar altitude for the effect of solar radiation and thus

the efficiency of photovoltaic devices on roofs of houses.

At the end of the unit, all the learned contents are combined. Tasks to repeat and consolidate were developed. A complex task, on the situation from the animal world, functions as a link between the previously learned contents. The question is how a polar bear protects itself from the cold. The task combines both the content from the construction of a solar collector and

Figure 3. Model of a photovoltaic energy converter

the thermal insulation in a house, so the contents of the jigsaw classroom and the learning at stations are connected. Thus, students can repeat and reinforce what they learned.

Implementation

Following the model of Participatory Action Research in science education (Eilks & Ralle, 2002) the first draft of the lesson plan was developed over a time period of about 9 months. Continuous influence from the literature and the ongoing negotiating and refining of the lesson plan and teaching materials took place in meetings of the teachers' group.

From spring 2011, systematic testing started in different schools in Bremen. Within PROFILES Bremen, testing is not only operated in the learning groups of the teachers involved in the energy topic. Also members from other subgroups of PROFILES-Bremen intend to use the materials and will provide information for further development and thorough implementation. Implementation actually takes place in five learning groups and it is planned to broaden this in the coming school year.

In addition to developing and implementing the lesson plan, working on this topic allowed for networking the teachers with the university and to establish a partnership which allows for further cooperation.

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