PROMOTING RENEWABLE ENERGY ISSUES IN SECONDARY MATHEMATICS CLASSROOMS

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ABSTRACT

For the young generation it is indispensable to be concerned itself with the environmental consequences of the extensive usage of fossil fuels and to become familiar with renewable energies. Thus the topic of renewable energies must be integrated in a respectively education of our children, and this can even be done advantageously for classroom teaching.

It seems to be particularly suitable to treat future energy issues in mathematics education; however, there is a great lack of respective teaching material. Thus we have developed a didactic concept in respect to content and structure of mathematical problems allowing their direct and broad usage in classrooms, and a series of problems following this concept have been constructed. They were presented in several conferences and further teacher educations. This contribution gives an overview of our project.

INTRODUCTION

One of the most effective methods to achieve a sustainable change of our momentary existing power supply system to a system mainly based on renewable energy conversion is the education of our children. Especially the young generation would be more conflicted with the environmental consequences of the extensive usage of fossil fuels. For our children it is indispensable to become familiar with renewable energies, because the decentralised character of this future kind of energy supply requires surely more personal effort of everyone.

In comparison to the parental education, the public schools give the possibility of a successful and especially easier controllable contribution to this theme. This can even be done advantageously for classroom teaching, as realistic and attractive contents have a particular motivating effect on students. In addition to that, a contribution to interdisciplinary teaching would be given, which is a significant educational method demanded by school curricula [1]. Regarding the fact, that not all students participate at technical orientated lessons in a comparable proportion, it seems to be especially suited to treat this topic in mathematics education for this purpose.

In addition this would be quite profitable for mathematics education itself, as “the application of mathematics in contexts which have relevance and interest is an important means of developing students’ understanding and appreciation of the subject and of those contexts” [2, para F1.4]. However, although mathematics curricula demand application-oriented mathematics education, this not only in Germany [3, p.110], there is a great lack of mathematical problems suitable for school lessons [4, p.251]. Especially there is a need of mathematical problems concerning environmental issues that are strongly connected with future energy issues. An added problem is, that the development of such mathematical problems affords the co-operation of experts in future energy matters with their specialist knowledge and mathematics educators with their pedagogical content knowledge.

In such a co-operation the authors developed a didactical concept in respect to content and structure of mathematical problems allowing their direct and broad usage in classrooms and created on the basis of this concept a series of problems for the secondary grades.

DIDACTICAL CONCEPT

The cornerstones of the underlying didactical concept are:

- The problems are chosen that way, that the needed mathematical contents in order to solve them are part of mathematics school curricula.
- Advantageously every problem should concentrate on a special mathematical topic, such that it can be integrated in an existing teaching unit; as project-oriented problems referring to several mathematical topics are seldom picked up by teachers.
- The problems should not afford special knowledge of teachers concerning future energy issues and especially physical matters. For this reason all nonmathematical information and explanations concerning the problem's foundations are included in separated text frames.
- By going on this way, information with respect to future energy issues is provided for both, teachers and students, helping them to concern themselves with the topic.

PROBLEMS

Following this concept, the authors have constructed and worked out a series of mathematical problems for secondary classrooms concerning the topics of rational usage of energy, photovoltaic, biomass, traffic and transport, wind energy; further problems for example to hydro power and thermal solar energy are in preparation.

For illustration, here is given an example of a problem:

The Problem of the CO_2 – Emission

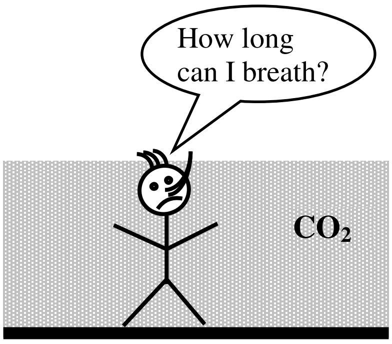
➤ This is an inter-disciplinary problem linked to the subjects of mathematics as well as chemistry, physics, biology, geography, and social sciences. Nevertheless, it may be treated already in lower secondary classrooms. With respect to mathematics the *conversion of quantities* is practised, knowledge of *rule of three* and *percentage calculation* is required. The *amount of the annually in Germany produced* CO_2, especially also for the purpose of transport and traffic, is illustrated vividly, so that students become aware of it.

Info:

In Germany, each inhabitant produces annual averaged nearly 13 t CO_2 (Carbondioxid). Responsible for this emission into the atmosphere are combustion processes (for example from power plants or vehicle combustion motors).

Assume now, this CO_2 would build up a gaseous layer, which stays directly above the ground.

a) Which height would this CO_2-layer reach in Germany after one year?



Hints:

- Helpful for your calculation is knowledge from chemical lessons. There you learn, that amounts of material could be measured with the help of the unit 'mole'. *1 mole CO_2 weights 44 g and takes a volume of 22,4 l*, under normal standard conditions (pressure 1013 hPa and temperature 0°C). With these values you can calculate approximately.
- You will find the surface area and amount of habitants of Germany in a lexicon.

Help: Find the answers of the following partial questions in the given order.

i) How many tons CO_2 are produced in Germany in total every year?
ii) Which volume in l takes this amount of CO_2 ? (Regard the Hint!)
iii) How many m^3 CO_2 are therefore annually produced in Germany? Express this in km^3!
iv) Assume, the annually in Germany produced CO_2 would cover directly the ground as a lowest gas layer, which height would it have?

Info:

- In Germany the amount of waste is nearly 1 t for each habitant (private households as well as industry) every year, the averaged produced amount of CO_2 per habitant is therefore 13 times of this.
- The CO_2, which is produced during combustion processes and emitted into the atmosphere, distributes itself in the air. One part will be absorbed by the plants with the help of the photosynthesis, a much more greater part goes into solution in the oceans water. But the potential of CO_2 absorption is limited.
- 20% of the total CO_2-Emissions in Germany came in the years of the 90th solely from the combustion engines of the traffic activities.

b) Which height would the CO_2-layer over Germany take, if this layer results only from the annual emissions from individual vehicles? How many km^3 CO_2 are this?

EXPERTS', TEACHERS' AND STUDENTS' REACTIONS AND EXPERIENCES

The general didactical concept and examples of mathematical problems according to this were first published at the '12. Internationales Sonnenforum 2000' in Freiburg [5]. Meanwhile several further presentations followed, in the frames of international technical conferences concerning renewable energies as well as in conferences on didactics on mathematics and teacher education events [6, 7, 8, 9, 10, 11, 12].

The experts' and teachers' reactions were throughout very positive. While experts in future energy matters are familiar with the environmental consequences of the extensive usage of fossil fuels, we could experience that teachers often underestimate the problematic. Thus, teachers were very pleased to get some information and deeper insights in the topic of future energy. Not few of them were dismayed when hearing some facts they didn't get aware up to then. It resulted in a wide consensus about the importance of treating future energy issues in secondary school classrooms. Thus the authors earned a great support and received many valuable hints and materials with regard to the development of further problems.

The didactical concept presented was absolutely convincing. With regard to its implementation in the presented problems, of course, teachers had sometimes some doubts when thinking on their special courses and students. The problems can't be offered to all students in full length, the students' abilities have to be considered. Therefore the problems must be seen as an offer for teaching material. However, the information frames included in the problems came in for praise from the teachers; this is very important as it is not realistic to expect teachers to get by themselves a right overview on a topic that is to a large extent new for them. Meanwhile the problems were distributed in several parts of Germany to a lot of teachers that want to experience them in classroom. In addition, the problems with extended solutions are published in the internet on a page for mathematics teachers: http://www.math-edu.de and can be free downloaded.

With respect to classroom experiences only a few first observations can be given. Students react in a very different way on problems of applied mathematics, especially on the topic of renewable energy. Some students are concerned themselves with the problem contexts, the energy issues, very extensively. They debate and ask questions, and sometimes they moan at the politicians. Then it might even be difficult for a teacher to focus students' attention again on mathematics. But some students just don't care about the problem contexts; for them ten or twenty years is a lot of time, the future in one or two decades is far from their interest. Here it becomes obvious, that a discussion in classroom is necessary.

OUTLOOK AND FINAL REMARKS

In this paper we presented a project to open the field of renewable energies for students, as well as for their teachers. The collection of problems for mathematics classrooms worked out in this project should finally be edited as a special text book for mathematics school education. For this purpose, the acceptance and supporting promotion of experts as well as politicians and educators is very important.

In order to integrate future energy issues in curricula of public schools, several initiatives have been started in Germany, supported and co-operated by the 'Deutsche Gesellschaft für Sonnenergie e.V. (DGS)', the German section of the ISES (International Solar Energy Society). The wide spectrum of respective activities going on has been presented amongst others also on the 3rd Solar Didactica within the Solar-Energy World Exposition. This event took place under the patronage of the German minister for education and research E. Bulmahn, expressing thus the great interest and importance devoted by politicians.

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