

## NEW METHODS IN PHYSICS LEARNING AND TEACHING

### INTEGRATED PHYSICS AND LANGUAGE TEACHING

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#### 1 INTRODUCTION

Motivated by the PISA 2003 findings of the poor performance of migrant students in science classes we initiated the EU-funded project PROMISE (Promotion of Migrants in Science Education) [1] in cooperation with the European Training and Research Centre for Human Rights and Democracy (ETC) Graz. The objective of our research efforts is to scrutinize barriers caused by language skills and socio-cultural reasons that hamper migrant students in learning physics. As a methodological approach to reduce these barriers we designed physics lessons and unit plans that integrate *both* language *and* content teaching. These lessons are being tested in multicultural/multilingual classrooms of grade 5-8 and are evaluated according to the following two research questions: Is the method of integrated physics and language teaching an adequate tool to increase the scientific literacy of migrant students? Do migrant students generally feel addressed by these lessons? As research methods we chose questionnaires, interviews of students and teachers as well as the monitoring of science classes. In this article we present examples of the integrated physics and language lessons together with first outcomes of our explorative study. PROMISE has been coordinated by the European Training and Research Centre for Human Rights and Democracy (ETC), Graz (Austria) and was scientifically and conceptually implemented by the Physics Education Department, Humboldt-Universität zu Berlin (Germany). Project partners were the University of Vienna (Austria), the University of Sarajevo (Bosnia-Herzegovina), Yildiz Technical University of Istanbul (Turkey) and the Employers Association of the German Metal- and Electro Industry (Deutsche Gesamtmetall).

#### 2 METHODOLOGICAL APPROACHES

The structure, objectives and tasks of the project are methodologically developed following the logical framework approach [3]. The “Problem tree” (Figs. 1 and 2) is the starting point of the problem analysis: We consider certain causes for underperformance of migrants in science and identify main problems in a sequence of cause and effect [1]. Thereof we deduce objectives and needs of action to address the deficiencies, which are identified in the “Problem tree”. Their logical

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sequence is shown in the “Objective Tree” (Fig. 3). This approach allows a differentiated evaluation of all levels of activities, objectives and impacts [2].

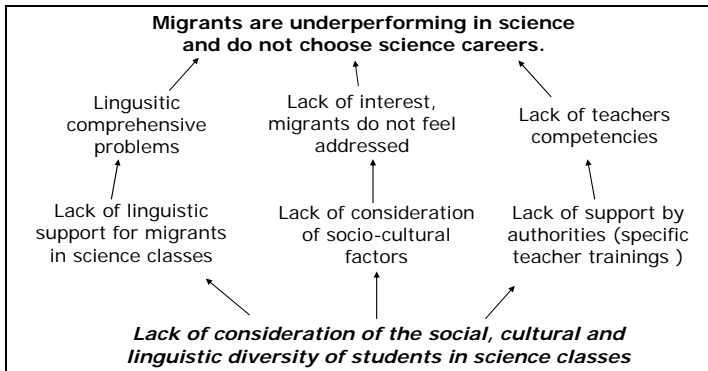


Figure 1 Problem tree.

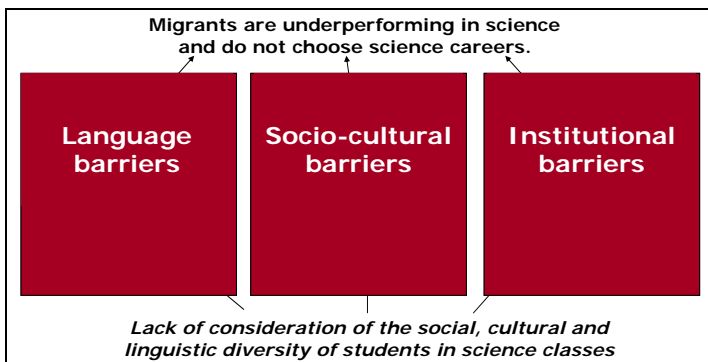


Figure 2 Barrier analysis: The three main barriers that hamper migrants’ access to science education.

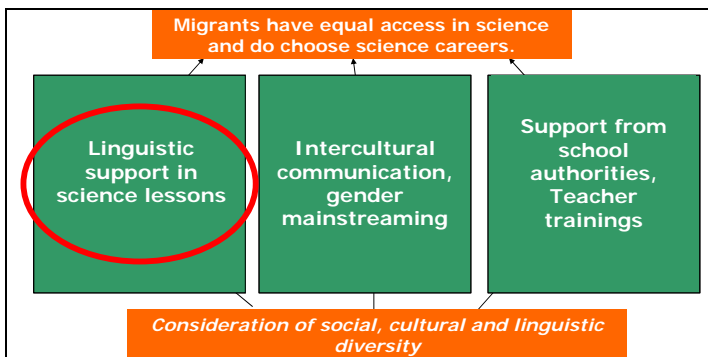


Figure 3 Objective tree: Approaches to overcome the barriers.

### 3 IDENTIFICATION OF LANGUAGE PROBLEMS IN PHYSICS LESSONS

In order to set specific promotion activities the various language problems have to be identified. One major field is the treasury of words and the lack of vocabulary hampering migrants to understand and/or express, what they would like to say. The structure of language, its syntax and the sentence structure are further possible reasons for language problems. In the following some examples of major language problems are given.

#### 3.1 Unknown terms

We asked 49 students of grade 8 with background of migration (*i.e.*, students and/or parents are not born in Germany) the following concepts: *Polysterol*, *cork*, *taw*, *pebble*, *perch*, *metal button*, *wax*, *wooden skewer*, *wooden board with holes*, *fixin pin*, *wet sponge*; the answers are depicted in Figure 4. Interestingly, around 22% did not know the term *polysterol*, 14% did not know the term *cork*.

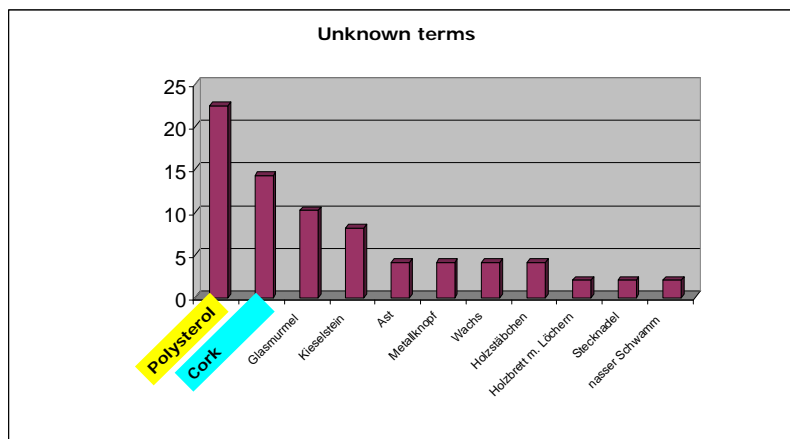


Figure 4

#### 3.2 Open answers

Eight students were asked the following questions and were requested to write down their answer:

*Schwimmt ein großer Baumstamm? Begründe deine Entscheidung.*  
*(Does a big trunk float in water? Give reasons for your answer.)*

In the following examples we tried to translate the mistakes into English in a way that the mistake is transported in a similar sense.

A girl answered:

„Der Baumstamm schwimmt, ... weil das baum aus Holz entschteht.“  
 (“The trunk floats, ... because it becomes out of wood.”)

*Schwimmt eine Metallplatte?*  
*(Does a metal plate float or sink?)*

The same girl answered:

„Eine Metallplatte geht unter, ... weil der platte aus Metall entschteht und der metal *ist immer schwer egal ob es leicht oder schwer ist* wen es ein Metall ist dan geht es unter!“

(„... the plate sinks because it becomes out of metal and metal is always heavy equally if it is light or heavy when it is metal it sinks!“)

From the physical point of view the girl understands that it depends on the material if a body floats or sinks in water. It is the metal that makes the body sink instead of the weight or the size of the metal plate; it is the wood that makes the trunk float instead of the big or small size of the trunk.

However, from the linguistic point of view the girl did not answer correctly. The mistakes have been made in German (note, that the girl’s mother tongue is Turkish and she lives in Germany, thus being migrant in Germany). The girl did not pass the physics course, although she likes physics and reports the impression that she understands physics very well, which corresponds well with our impression. Hence, the question arises why she was badly graded in physics. Asked, if she would have better marks in physics if she could answer in her first language, she answered in the affirmative.

**4 CONTENT AND LANGUAGE INTEGRATIVE PHYSICS LESSONS (CLIL)**

Integrating content and language learning means that methods of language learning are integrated into physics lessons [4]. The difference to pure language learning is that the focus is laid on the content rather than on the grammatical correctness. Linguistic modifications and simplifications are allowed in order to support migrant students to understand the content. Additional exercises to vocabulary and sentence structures, which are typical for the specific topic, are therefore implemented.

In cooperation with physics teachers and experts in second language education we developed science lessons for grade 6-8 on the topic “Floating - Sinking” by implementing language-learning elements [5].

*Examples for worksheets*

Table 1

<i>PHYSICS</i>	<i>LANGUAGE</i>
<p><b>Record your values in the value table!</b></p> <p>Divide the mass by the volume. The result is the <b>DENSITY</b> of the body.</p> <p>Give, which material the body is made of and whether it swims or not!</p>	<p>the value/ the values the value table to record values/ I <u>record</u> the values. the density</p> <p>The body is <u>made of</u> wood.</p>

Our worksheets consist of two parts: One part for physics, one part for language. The physical part is more or less the instruction being found in lessons without integration of language. The language part gives explicit linguistic support by providing new vocabulary, adequate (... made of ...) prepositions and relevant sentence structures (passive forms like: *The body is made of wood.*). Moreover, the new terms are explained by the teacher. He or she also gives examples for the specific contextual use [6]. When working with the worksheet the students use the new vocabulary in the context of the experiment.

## 5 QUESTIONS OF RESEARCH

There already exist linguistic research results that content- and language-integrative learning has a positive effect on the learning of language. The open question from the point of view of physics education is:

*Does content and language integrative learning have a positive effect on the learning of physics?*

To find an answer to this question we are currently testing science lessons in several schools in Germany. The design of the study is a pre-post-design. The tested co-variables are: Females/males; first/second language; interest in physics.

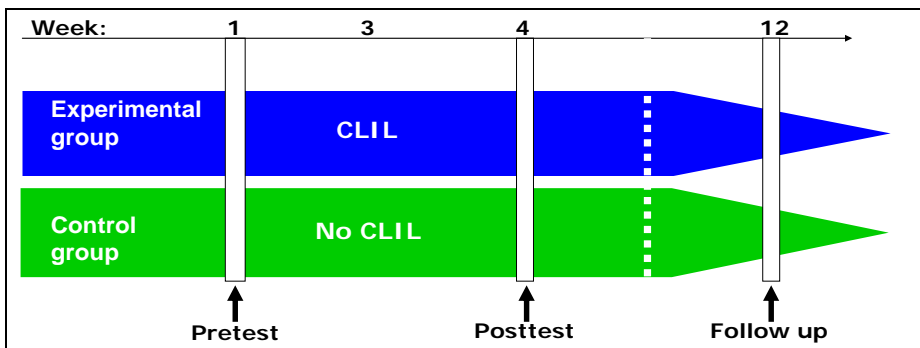


Figure 5 Design of the intervention study on the effect of CLIL on the learning of physics.

## 6 FIRST OUTCOMES

Although the data collection is still going on, first outcomes from the pre-test can be presented in the following: In lessons without CLIL 66% of 1<sup>st</sup> generation, 35% of 2<sup>nd</sup> generation and 20% of 3<sup>rd</sup> generation students say that they do not participate in oral conversations in science lessons, because they are afraid to answer incorrectly. Interestingly, a similar percentage of the students maintain that their performance would not be better, if they could answer in another language (e.g., their first language).

These findings give evidence that -according to the students self conception- the competence of the students in their first language is not sufficient to gain a better performance at school. The students appear to be very much aware of the specific lingual competencies, which they need to succeed at school. The school-

relevant cognitive academic language [7] is of different kind than the language the students use at home or with their friends. The CLIL lessons promote the acquisition of cognitive academic language proficiency skills (CALP) [7] being supposed to be relevant for educational success [8].

## 7 CONCLUSIONS

The PISA results show that especially migrants do not have the same access to science education as non-migrants. As possible reason we regard the lack of the consideration of cultural and linguistic diversity. The integration of content and language learning gives the chance to make science lesson easier to understand for migrants while promoting the cognitive academic literacy proficiency skills (CALP), which are assumed to be relevant for educational success. In order to get empirical data on the effects of content and linguistic integrative science lessons, the lessons developed within this study are currently being tested in several schools in Germany.

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