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Student's conceptions on circadian and seasonal cycles

Sylvia Weizinger and Ingrid Hemmer

Summary

Every day the change between day and night can be observed. Furthermore, the seasons change during the year at least in the Central European lines of latitude. There is a constant rotation between the warm summers and the cold winters, in which these extreme seasons are superseded by the moderate seasons spring and autumn. In the meantime one can also notice that in December there are people in swimming-suits on the Australian beaches and that in the summer-months of the Northern Hemisphere one can go skiing in the Snowy Mountains. But how are these differences to explain? In Germany pupils start dealing with the topic late in secondary school. Nevertheless, the pupils normally have their own pre-educational concepts which can possibly disturb the learning process at school.

According to the theory of conceptual change, a group of 10 to 12 year old Central European students was examined on their pre-curricular conceptions of the circadian and seasonal cycles, a topic which they can observe every day. Furthermore, they were questioned on their ideas of polar night and midnight sun, which they possibly have not yet experienced themselves.

The purpose of the study was to show if the pupils have some common misconceptions concerning the above mentioned topics. In addition, it was examined whether wrong ideas can be easily replaced by the scientific facts or if the pupils still prefer using their own conceptions after a geography lesson. Therefore, the students were questioned before and after the lesson, with the result that the pre-educational concepts can be changed into scientific knowledge, though it was easier to make them adopt scientific explanations with topics they had not heard of before.

Theoretical background

Already in their early childhood human beings start constructing their knowledge actively by systemizing information, observations and explanations given by their parents, for instance, about one specific topic and assembling them to their own common conception. However, this does not mean that the learner's self-constructed knowledge corresponds to the scientific facts. That means that especially teachers of geoscientific subjects should be aware of the fact that the students' previous knowledge could be an impediment to the learning process. Although the learners' explanations might differ from the scientific theories, the student might have had positive experiences with his concept. The conceptual change theory shows that learners, who did not have to face any problems with their pre-educational conceptions and therefore consider them as log-

ical, often are not willing to adapt the scientific facts. Scientific facts often are only used at school but in everyday life pupils prefer their own concepts (SCHULER 2004, p. 42). Even some centuries ago well-known pedagogues like Comenius, Rousseau or Pestalozzi mentioned this gulf between the common knowledge and the "school knowledge" and demanded "true-to-life" classes (SCHNOTZ 1996, p.16). Apart from the intelligence, the pupil's cognitive development, the interest and the motivation, such pre-educational concepts in addition influence the learning process. This theory David P. AUSUBEL had in mind in 1968 when he opened his Educational Psychology with the following motto: "If I had to reduce all of educational psychology to just one principle I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (AUSUBEL 1968, p. IV)
Owing to this theoretical basis the aim of the depicted study was to exemplify which conceptions exist, how pre-instructional knowledge can disturb the learning process in geography lessons and to illustrate how potential common conceptions can be substituted by the scientific facts.
Therefore, an everyday life's topic was chosen: The genesis of the seasons and the circadian cycle. This was opposed with the terms 'midnight sun' and 'polar night' which German students normally do not face in their everyday's life.
Although researches about pupil's pre-educational concepts are very common in the subjects like biology, chemistry or physics, one can rarely find such studies for geoscientific subjects like geography. Only some authors have dealt with the topic. BAXTER (1995), for instance, has already dealt with the genesis of the seasons and the circadian cycle. NUSSBAUM (1979) and PHILIPS (1991) have examined student's conceptions on the shape of the planet Earth. Studies on midnight sun or polar night have not been published yet.

Research questions

This theoretical basis produced the following research questions which were investigated in the depicted study:

- Do the pupils already have a thorough knowledge of the basic movements of our solar system?
- Do the pupils have associations before the instruction on why there is a change between day and night?
- Which ideas do the pupils have about the genesis of the seasons?
- In what way can the pupils explain, what the terms "polar night" and "midnight sun" stand for?
- Is it easy for teachers to change possible misconceptions?
- Are there gender-specific differences regarding the modification of the pre-instructional knowledge?

Design of the study

The study was divided in three parts. The first part was investigating the

pupil's pre-instructional knowledge by an anonymous questionnaire (t1), covering the three main topics of the research. After a few days the tested pupils had to participate in a lesson (= treatment), which covered every topic that was necessary for completing the questionnaire in the correct way. In order to guarantee the vividness of the abstract movements in the solar system the tellurium, a moveable model of the earth, the sun and the moon (see figure 1), was chosen as the main medium to explain the movements of the earth, the genesis of the circadian cycle, the seasons, the midnight sun and the polar night. Finally, the pupil's had to fill in the questionnaire used in t1 again a few days after the lesson (t2).
The research, in which 27 pupils (18 boys and 9 girls) of a German secondary school participated, took place in July 2005.

Methods

Questionnaire
The questionnaire was divided into two parts. The first part was designed to test the basic knowledge about the movements of the planet Earth. For this purpose multiple-choice questions were used, which can be valuated objectively. The second part of the questionnaire consists of questions with the opportunity of free response. The advantage of this method is that one can examine the student's ability of remembering, organizing and integrating complex relations about a topic. That means one can discover which common ideas the pupil has developed. For this the pupils had the choice between verbal and non-verbal (e.g. paintings) responses.

The tellurium

As the main medium for the lesson the tellurium (see figure 1) was cho-

Figure 1: The tellurium (Source: www.tellurium.de)

sen. This model helps the teacher to demonstrate the movements of the Earth and the moon on their orbit around the sun and moreover, the rotation of the planet Earth around its own axis.
The tellurium offers several advantages for a lesson:

- If the pupils have never seen the model before they might be more interested in the lesson.
- The vividness of the model makes it easier to explain the complex movements.
- The pupils can participate actively in the lesson, which supports the learning process.

However, there are some points which should not be forgotten:

- The model is quite expensive.
- In big groups one must assure that every pupil has a good sight on the model.
- It is not possible that every pupil participates actively.

Results

The results of the research were unambiguous. While nearly all of the pupils already showed correct understanding of the general movements of the earth and the sun, which means that the earth turns about the sun in one year, the explanations for the genesis of the circadian cycle and the genesis of the seasons showed common conceptions.
Although the circadian cycle was correctly explained with the earth's

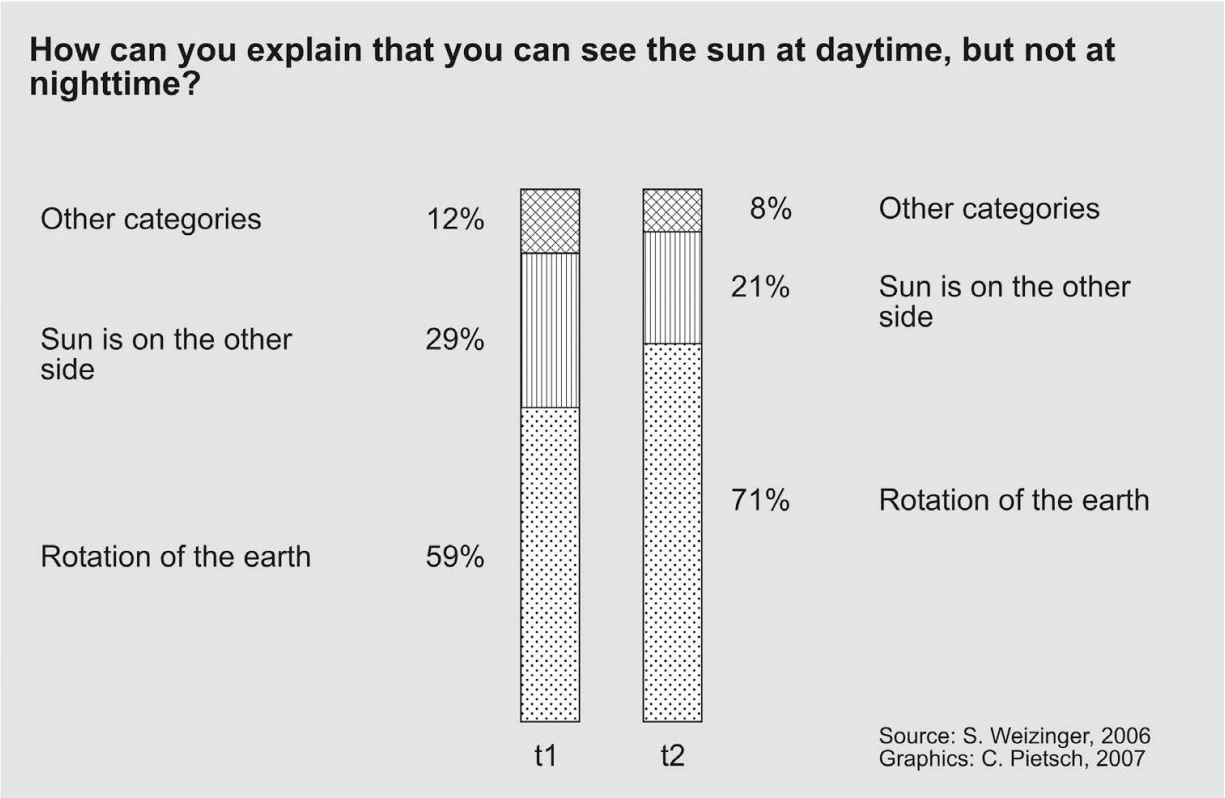

Figure 2: Results: Conceptions on the circadian cycle (Source: WEIZINGER 2006)

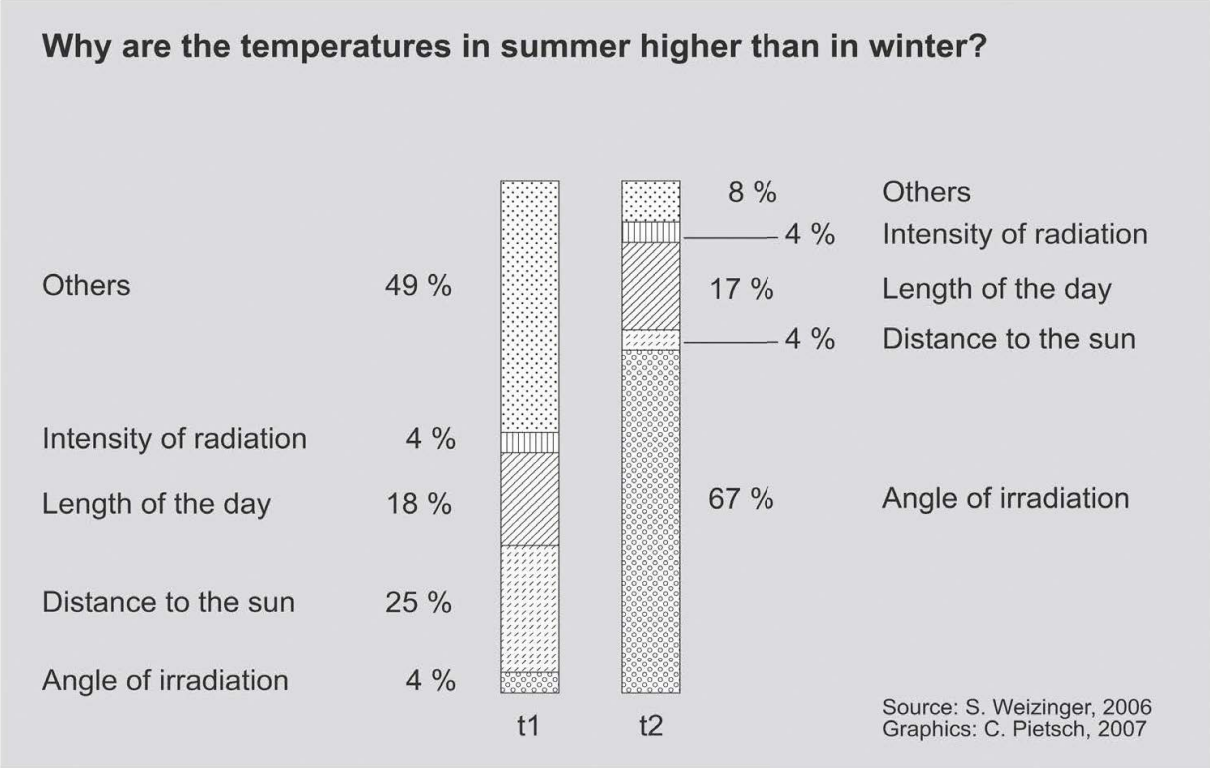

Figure 3: Results: Conceptions on the genesis of winter and summer (Source: WEIZINGER 2006)

rotation by 59% of the learners, 29% of the students commented on the question "How can you explain that you can see the sun at daytime but not at night time?" with statements like "The sun shines on the other side of the earth.", which shows a general knowledge but a lack of explaining scientifically. After the treatment the percentages changed in favour of the correct explanation, though 21% of the pupils still used the explanation that the sun shines on the other side of the earth (compare figure 2).

More convincing were the pupils' statements on how they would explain the differences in the temperatures in winter and summer, regarding Central European conditions. In this case the prevailing statement was that these differences exist because of a varying distance between the earth and the sun, which is a very common explanation. Furthermore, the length of the days was mentioned by 17% of the students, whereas only 4% could explain the topic with the scientific explanation of the sun ray's angle of irradiation. After the treatment in the lesson the percentages changed in favour of the scientific explanations but still common conceptions such as the length of the day remained (compare figure 3).

Furthermore, the pupils were examined on how they can explain the genesis of spring and autumn. Especially in this case common explanations prevailed. Again only 4% of the pupils were able to ex-

press the right scientific explanation. The distance of the earth to the sun and the length of the day were the most frequently used explanations. In addition, 25% of the pupils explained the similar temperatures in spring and in autumn with the fact that these seasons are the seasons of transition between summer and winter with their extreme temperatures to which they have to acclimatise. Once again the explanations changed in support of the scientific explanation after the lesson. However, 42% of the pupils still were convinced by their own explanations.

To provide a basis of comparison with these results a topic which Central European students do not see themselves confronted with in everyday life was chosen. They were to explain the polar night and the midnight sun. Here, only 4% of the learners knew the right solution in the first examination. The rest either did not give an answer or acted out their fantasies. In return, the results after the lessons were very positive: 75% of the students were able to explain the polar night in the correct way, 88% knew what the mid night sun was (compare figure 5).

In the research no gender specific differences in the learning process could be discovered. The boys and girls achieved similar results. That means that both genders can learn scientific explanations easier when they have not constructed their own pre-instructional knowledge about a topic.

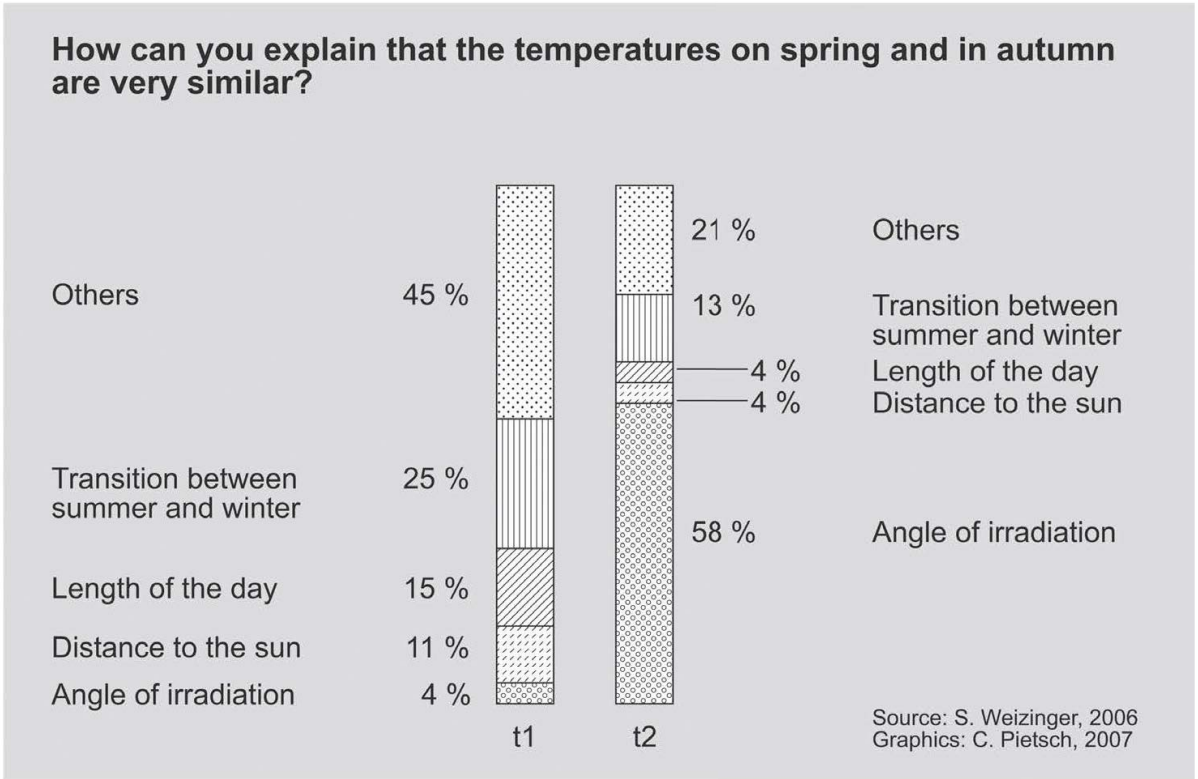

Figure 4: Results: Conceptions on the genesis of spring and autumn (Source: WEIZINGER 2006)

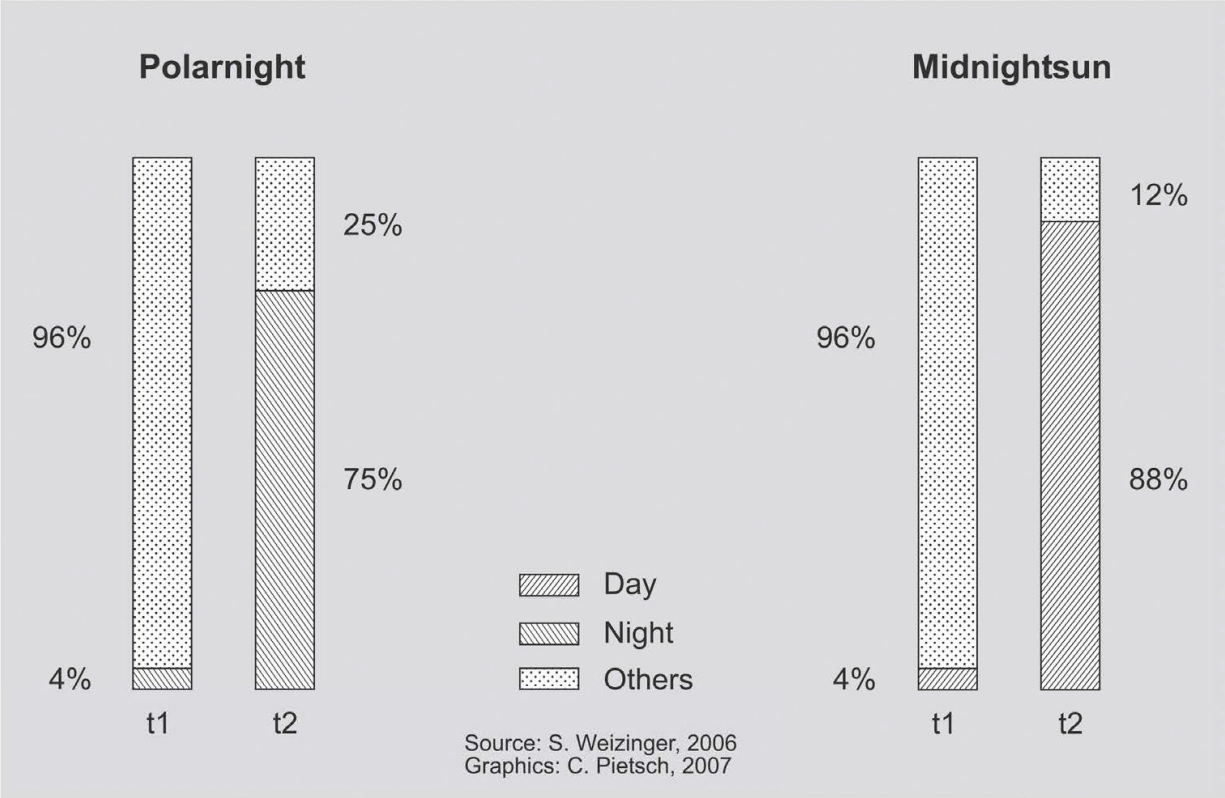

Figure 5: Results: polar night and midnight sun (Source: WEIZINGER 2006)

Conclusion and significance for geoscientific education

- The study proved that the pupils already had some basic knowledge of the movements of the planet earth.
- Already before the treatment many pupils were able to connect the genesis of the circadian cycle with the earth's rotation. Some of the tested students had a vague idea of the genesis of day and night, however, the approach was on the right way. Only a small percentage of the tested children were committed to pre-instructional common conceptions
- None of the pupils explained the genesis of the seasons with the earth's revolution and with the angle of irradiation which is connected with it. Besides the common conceptions prevailed.
- The terms "polar night" and "midnight sun" were unheard-of by the students.

Resulting from these different findings the research detected three different types of modifying the pupils' pre-instructional knowledge:

a) Topics which are familiar to the pupils from everyday life and have already been mentioned in a lesson before
In the study the pupils already had a very good knowledge of the basic movements in the solar system. This knowledge was tightened by the treatment.

b) Topics which are familiar to the pupils from everyday life but have not been mentioned in a lesson yet
Concerning the genesis of the seasons the pupils already had developed concrete ideas. These ideas mainly correlated to common observations which can be made in everyday's life (length of the days, spring and summer as seasons of transition), or explanations which are often used in common speech (distance from the earth to the sun). Indeed, modifications in the knowledge could be discovered after the lesson, however, it was noticeable that the pupils preferred their pre-educational conceptions to the scientific explanation. In order to provide an effective modification it is indispensable presenting the topic in detail, to make sure that the pupils understand the relation between the earth's revolution and the angle of irradiation.

c) Topics which are totally unfamiliar to the pupils.
The study verified that the tested pupils were not familiar with the terms "polar night" and "midnight sun". In the first examination only 4% of the students were able to answer the related questions correctly, whereas in the second examination (after the lesson) 75% of the pupils answered the question on "polar night" in the correct way and 88% succeeded in replying the question on "midnight sun". This result testifies that it is easier for pupils to accept the scientific explanations of topics they are not familiar with yet. (also see Häussler et al. 1998, Duit 1996)

From these results one can draw the conclusion that it is easier for teachers of geoscientific or geographic subjects to instruct learners who have little previous knowledge of a topic. If the students already had positive experiences with their self-made conceptions they are less willing to adapt the scientific facts. Certainly, there is still the possibility to change the pre-educational conceptions but it is a very long-drawn out process which requires great patience.
Furthermore, one can record that it is useful to choose a vivid medium when teaching abstract contexts. Thus, it is more likely that the students accept the scientific explanations as more logical than their own concepts. An example of it is the tellurium which has proved itself as a useful medium for instruction, as it helps to explain the abstract movements of the earth, the sun and the moon vividly.
Nevertheless, many of the tested pupils still had difficulties in understanding the sun ray's angle of irradiation on what teachers should put special effort when using the tellurium.
In general there is to say that the children's previous knowledge is a very influential factor on the pupils' learning process which should not be forgotten.

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