

# Using Pictures as Active Models in a Thinking Journey mode of Teaching Physical Concepts

Yaron Schur and Igal Galili

Science Teaching Center, The Hebrew University of Jerusalem

## Abstract

The paper reflects on the argument on the effectiveness of using pictures in teaching. The way is shown to use pictures as a model in teaching the concept of the Earth's rotation. The advantages of such a use are ascribed to the mediation by a teacher provided while using pictures in a special mode of teaching – Thinking Journey (TJ). It is explained why such use may improve the results of teaching the day-night cycle in the middle school and surpass the success of using regular material model of a globe. The activity uses real pictures of the Earth and Mars. Questions regarding estimation of time in a particular location on the planet encourage students to mentally manipulate the pictures thus essentially improving their knowledge of the subject. The applied approach of multiple perspectives helps students to construct scientific understanding of the day-night cycle as an invariant of their experiences.

## Introduction

There is an argument on the effectiveness of using pictures in teaching. Schnotz and Bannert (2003) addressed detrimental effects of such use. In this article we elaborate the advantages of using pictures of astronomical objects as models for teaching about the rotation of the Earth. The advantages of such a use are ascribed to the mediation provided within a special mode of teaching – Thinking Journey (TJ) (Schur et al. 2002; Schur and Galili, 2006). The mode employs pictures of the considered phenomenon made from different perspectives of the observer and in a variety of natural environments. This way the concept to be taught emerges through comparison between various contexts as their invariant core. The active manipulation of pictures by the learner of physics makes them an effective model and stimulates the development of students' ability to imaging different views on the object, a precondition of successful learning.

## Regular teaching of day-night cycle and Earth's rotation with material models

Using an illuminated from a side Earth's globe (or any spherical object), as a model for day-night cycle and Earth's rotation is common. One can represent this teaching approach mentioning the following points:

1. The *teacher* illuminates the globe from aside using a strong source of light. He/she brings the attention of the students to the illuminated areas on the globe, explains and visualizes the day-night exchange phenomenon.
2. The *students* listen to the teacher and observe the demonstration. It is supposed that observing the demonstration and listening to explanations present a sufficient condition for a new knowledge to be constructed.
3. It is common that the phenomenon of day-night circle is presented from one particular perspective: as seen by an imaginary observer located far enough from the Earth. The day-night cycle is seen as a process of exchange of area status: illuminated – for day and non-illuminated – for night.
4. Understanding of the phenomenon of day-night cycle and Earth's rotation is considered to be reached through an *individual* interpretation of the provided explanation.
5. The learning takes place in considering a highly artificial model and in fact is based on the developed ability of imagination and abstract reasoning.
6. The approximate nature of the material model.
  - a. When the day-night cycle is learned students can easily see the “night” part of the globe, although it is not illuminated directly. In reality, however, the night half of the Earth is normally not seen at all by a remote observer who sees only the illuminated part of the Earth (a phase shape).
  - b. By all means, the globe, and especially a simple ball often used to represent the Earth, does not look as the real Earth. Besides the mentioned phase shape, instead of a full sphere, the model never represents the true appearance of the Earth for the neglected

dominance of atmosphere (clouds normally cover half or more of the familiar outline of the continents).

In fact, such an instruction is highly abstract, despite of its apparently concrete nature, it looks totally disconnected from the conception of a rotated planet to many of the young learners. Novice learners of physics are not ready for the assimilation of scientific knowledge from a transfer of abstract information. Indicatively, being asked to draw the Earth from outside, say from the Moon, students normally present our planet as a full sphere with clearly seen continents (no clouds, no phases), whereas in real observations it is often rather difficult even to identify a continent, not speaking about specific countries. The low effectiveness of teaching the topic of Earth and day-night cycle is well known to teachers and researchers (e.g. Baxter 1989).

### ***The alternative approach within TJ***

We advocate here an alternative way of teaching, Thinking Journey, in which the scientific knowledge is mediated to students making an active use of *real* images representing the *real* Earth and containing the necessary representation of the considered concept, also in a variety of perspectives (Schur and Galili 2006). The idea is to take a picture and make it a stage of an imaginary journey of the students to the depicted environment. While performing a conversation on the subject the teacher initiates and encourages considering the depicted phenomenon from the provided perspective and in the specific environment. Teacher's questions guide students to manipulate with the presented picture as if it presents a material model. The understanding of the goal concept is constructed from a series of interactions. We exemplify it in the following.

#### **First interaction**



Figure 1

Teaching Earth's rotation around its axis starts with the class exposure of a photograph of the Earth taken from a spaceship far enough to see the "whole" planet (Fig. 1). Our country, Israel, well known in its outline to our students, can be identified in this picture. The learning interaction begins with the teacher asking: "What was the time in Israel at the time this photograph was made?"

In fact, the teacher invites the students to make several mental actions: a. Students have to identify Israel in the picture; b. They have to appreciate the meaning of the line separating the illuminated and non-illuminated areas of the Earth (the terminator); c. To evaluate the time instant students start hypothetical thinking regarding the changing the situation in time, "Does the situation change?", "In what direction does the Earth turn?" d. To estimate more precisely the hour in Israel, the students should apply proportional reasoning: how far is Israel from the terminator?

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Figure 2

After the estimation of the time is made, students are asked to imagine themselves there, in Israel, at that moment and describe the day-night changes as they would take place from that moment. Students are asked to make a report of their hypothetical experience. The normally provided descriptions include light changes usually taking place during the day-night cycle: dawn, noon, twilight time, sunset, night. While describing their experience students perform an imaginary journey, drawing on the life experience they accumulated. Slowly, the revolution of the Earth, the succession of its entering and leaving the darkness becomes a natural element of the story and thus the relevant students' knowledge is established.

### **Second interaction**

At the next step the teacher repeats the process, asking the same question about the time in Israel while showing pictures of the Earth on which Israel might be seen in different perspectives or not seen at all (Fig. 2).

The picture in Fig. 2 was made from a satellite and has America continents in its center, Israel does not appear. In such a situation, in order to estimate the time in Israel the students have to imagine its location on the globe relatively to the shown geographical place and subsequently reveal that the absence of Israel in the picture of the illuminated Earth implies Israel being at night. Proportional thinking might help in determining the specific hour. The time difference between America and Israel (about 7-10 hours), known or provided to the students, is realized in this context in its operational meaning. The discovery of the time hour variation and the relationship of the day hours between different locations on the Earth (the knowledge of time at some place determines the hour at another) also contribute to the learning of day-night cycle being conceptually related to this concept.

### **Third interaction**



Figure 3

In this interaction the whole context is changed. Day-night cycle is relevant to any planet and therefore the concept might and should be learned in this broader aspect. The next interaction employs the picture made by a spaceship approaching Mars (Fig. 3).

The picture shows the globe of Mars partially illuminated. Observing the picture, one naturally sees its salient feature on the illuminated surface of the planet: a huge volcano (Olympus Mons). The teacher asks: "What time is now at this point (the volcano)?" While presenting the question teacher mentions the nature of the object (answering natural curiosity) and two important facts about Mars, its rotation period (about 24 hours) and the direction of its spinning in the perspective of the considered picture.

Going through a similar dialogue with the students regarding Mars strengthens the knowledge of day-night cycle by its application to a different context. The dialogue may expand and touch on another particular feature of this unique picture: light spot in the dark part of Mars. Not far from the terminator line the top of the high mounting area (Southern Pole) is seen being illuminated by the Sun while its vicinity apparently remains in the darkness of night (approaching the morning). Understanding of this feature further strengthens students' concept of day while learning about day-night cycle.

### **Cognitive skills involved**

Our approach is sensitive to the need of the learner to master some cognitive skills essential for the success in learning physics. Within the considered mode of learning, TJ, teacher is aware of and helps to promote the following major cognitive functions of the students:

1. *Relationship between the viewer's location and the kind of appearance of the observed phenomenon.* The learner knows precisely where he/she is located and tries to imagine the special view determined by this location.
2. *Mental manipulations with the picture.* Seeking the answer to the particular question the learner needs to mentally manipulate the picture considering the changes expected in the future and reconstructed from the past. This activity implies manipulation with the picture as with a material model.
3. *Construction of a mental model of day-night cycle.* Going through a series of tutorials the students perform analysis of several situations and by identifying the similar and the different in them they make an inference regarding the concepts of day-night cycle and rotating Earth.

## Summary

Our approach to teaching about day-night cycle within TJ interactions uses pictures as interactive models implying a significant change to *the role of the teacher* who guides a dialogue in the context designed to fit the goal concept and chosen pictures. The dialogue is not only a stimulating and interesting activity, but provides the teacher with an opportunity of mediation the scientific contents and cognitive tools of science to the learners.

Students find themselves being involved participators, engaged in the process of knowledge construction. This role causes their many questions of various types, not only about "what", but also about "how does it happen?" and "which way we know that it is so?".

The TJ based approach deliberately employs multiple views on the considered subject of the Earth's rotation which causes concept construction as an invariant from several contexts.

Using real pictures of Earth or Mars as models reduces the level of abstraction associated with using material artificial models in the class. Day-night cycle becomes an observed reality of any planet. Such a use of pictures for thinking journey is effective and introduces a new enjoyable way of teaching and learning physics.

## References

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