ENHANCING COMPREHENSION IN SCIENCE EDUCATION
GOSCIENCE ONLINE TEXT BOOK (OTB): How to work with the GOSCIENCE database

Authors: Romans Vitkovskis, Uldis Heidingers

An online textbook (OTB) is based on the formula: theme – model, experiment – example to raise the awareness among the learners. This approach is based on the development of reverse thinking (1) and the fact that the existence of it is a direct sign of understanding (2). OTB makes the job of the teacher significantly easier, because the audience may not always be able to create the right model for the theme and it may take too long to explain the cont of the new study subject. The OTB experiment provides additional options for observations and the learner has versions of how to perceive them and, in most cases, to understand the earlier researchers, why they have compiled and formalized them. Examples/illustrations of theory themes are only versions as they are used in the particular theory/subject.

The published (3) methodology is universal for working with models, but does not include the relief provided by OTB with the appropriate/compatible/interpretive correct model for each theme, which the teacher can freely use. The methodology provides a proven version of the model evaluation criteria in the practice, that can be used with the OTB. In practice, there have been several examples, when the level of knowledge of the teacher prevents accurate assessment of the correctness of the model according to the theme (conclusion prepared by a high level scientist, engineer or other expert in the subject is required). OTB with proven and accepted models has the status of a textbook, and evaluating models similar to the OTB proven models is already the task that can be completed by the teacher. The teacher should promote a sense in the learner (hereinafter referred to as "the student", but let's consider that it is referred to lifelong learning, etc.) that the formal presentation of any topic can be interpreted/compatible – according to the theory canons – as a model experienced in one's own life or easy to perceive in other areas.
Methodology (3) does not include work with experiment and example in the context of the model approach, it is the task of this methodology.
The essence of the reverse thinking is intuitive placement of oneself instead of a scientist or an inventor by creating such model that can be used to reinvent the mentioned theme. Reverse thinking cannot be acquired quickly and cannot be successfully mastered by everyone in a short time, but its elements can be practiced by the students, giving them a sense of comfort that they have understood – intuitively felt the naturalness of the theme themselves. The feeling of comfort arouses interest in the subject, instead of being repelled by the discomfort, which is caused by misunderstanding, which in turn triggers thinking with the task of avoiding the object as such, when possible.

New study themes – explaining the theme/-es

To explain the new themes using the OTB, it is advisable to start with the task of viewing the table, where the models can represent different themes and subjects of the OTB, but one of them is relevant to the theme of the OTB

Model 1	Theme explanation
Model 2	
...	
Model 6	

and the requirement for the students to give their views on which model might fit the theme. Each student has to give his or her own explanation as to why he or she has made the particular choice, but the entire audience can be involved in discussing the reasoning for the choice. After the right pair – (model – theme) is stated, an extended explanation of the subject can be continued, as well as the students can be introduced to the range of observations they have made, which has been the reason for explaining the existing theme.

Verification of understanding using the OTB

The teacher takes the model from the OTB according to the theme and suggests that the students create an equivalent or similar model to the particular model, but from another area – social life, sports, culinary, etc. The particular task will demonstrate the level of creativity of each student. If an original model representing another field is created or a model for another subject is found, the student has the understanding and great potential for creativity, but if there is "plagiarism" – something very close to the OTB model, only having other characters, objects, for example, the resistance of electricity– many people walk over a narrow bridge or even a narrower one and plagiarism – the fish go spawning in a narrow river and a narrower one, the student is aware of the situation and is able to find analogues, which indicates to the understanding of the situation.
The understanding of the theme must also be verified by inviting the students to explain, how they relate the topic to the chosen model – they have to defend their own model. A discussion can be organised about each model regarding its correctness according to the theme. Inaccuracies must be analysed and students must have an understanding of where and why they have made mistakes, devoting special attention not to judge them for the inability of the student, but to perceive it as an integral part of the creative process. Students should be introduced to the observations that can be made about the theme (series of experimental results, other observations) and the question should be asked – whether such a model can explain the occurrence of the observations and whether it can be used to reinvent the theme.

For developing creativity in students a useful task is to improve the correct model created for the OTB or a theme created by others – by developing visualization of the model (drawing, video, interpreting it into material), as well as by improving/modifying the model description so that it is better rated according to the criteria for rating the models.

The criteria of model assessment The assessed position	Criteria
The theoretical justification of the model – *work sheet (1)*	• A scientifically correctly explained natural science/mathematical concept, process or phenomenon in the theoretical justification, and the source of this information is correctly indicated – **2 points.** • There are separate non-essential inaccuracies or the used source of information is not sufficiently indicated in the theoretical justification – **1 point.** • There are essential faults and the used source of information is not indicated in the theoretical justification – **0 points.**
The description of the chosen association for the model – *work sheet (1)*	• The object, process or phenomenon observed in the daily life or in nature correctly depicts natural scientific/mathematical concept, process or phenomenon at its core, the author of the model has described it logically and comprehensibly – **2 points.** • The object, process or phenomenon observed in the daily life or in nature correctly depicts natural scientific/mathematical concept, process or phenomenon at its core, but the written description of the model by the author has some non-essential faults – **1 point.** • The object, process or phenomenon observed in the daily life or in nature does not depict correctly natural scientific/mathematical concept, process or phenomenon at its core – **0 points**.
The visual perceptibility of the model – *work sheet (1)*	• The model is visually attractive, simple, easily perceptible, is not supersaturated with unnecessary information and excessive details – **2 points.** • Some non-essential faults disturb the perception of the depicted information in the model at its core idea immediately – **1 point.** • The included information in the model is not understandable and perceptible – **0 points**.
The originality of the chosen association – *work sheet (1)*	• The object, process or phenomenon observed in the daily life or in nature is selected creatively in the model, and it depicts the scientific/mathematical concept, process or phenomenon in a non-traditional way – **1 point**. • The object, process or phenomenon observed in the daily life or in nature is often used in different information sources to explain the scientific/mathematical concept, process or phenomenon – **0 points.**

Testing the flexibility of the understanding and thinking

In order for the students to perceive the versatility of using the model and to gradually begin to use the model approach in everyday life, as well as in the acquisition of new subjects and themes, they need to repeatedly implement the control game.

Model 1	Subject 1
Model 2	Subject 2
.....	.....
Model n	Subject k

It is necessary to note in the table, which theme refers to which OTB model, and there may be situations when no pair matches or only a few match. This game – the test can be varied by asking to find one OTB model from several, which interprets the theme (is compatible) or vice versa to find the compatible theme for the given OTB model among several themes.

About the models of mathematics.

In mathematics, the presence of observations/experiments in virtually every area of life and their naturalness has enabled previous science to summarize them in the basic concepts of mathematics – parallelism, circle, the independence of the sum from the order of the items, etc. , which makes these observations/experiments practically comparable to models. In the further development of mathematics the models are used to define, for example, a function, a derivative, an equation, a recipe/algorithm, and other more complex things using fixed basic concepts. A large base of observations/experiments, which is based on what is observable in many areas of everyday life, allows the students to discover the naturalness of these basic math concepts themselves. The models in their literal sense are already used to create further mathematical constructions. This is something the teacher must remember, when using experiments/observations (in the role of models) to develop basic math concepts and when models are needed to build further mathematical constructions.

An experiment in nature science.

The oldest are the visual observations: what is taking place, under what circumstances and how. Their descriptions had to make clear distinctions between the object with which something is happening and the circumstances (external circumstances) causing it. The description (the outcome) of the observation allowed the events to be predicted in the same or sufficiently similar circumstances.

The experimenting began, when the experimenter (the person, who plans and conducts the experiment) chose the object himself or herself and knew and was able to control the external conditions, under which it was located. Initially the experimenter was the observer himself or herself (usually the visual observer) and the describer of the observation in everyday language. Such methods were developed that provided measuring of the object behaviour and volume of changes in the circumstances for observing the possible subjectivity of something that was visually perceived and provided more precise description of the observation, by expressing the results of the measurements in numeric values of specific scientific language.

The behaviour of an object under pre-selected and controlled conditions is studied in order:

- to find out what is previously unknown;
- to test the hypothesis (some prediction);
- to test the veracity of the calculation (theoretical) results.

To be stated:

- what feature of the object changes as certain external conditions change;
- what is the correlation between the volume of these changes (graphical or analytical for continuous change; visual leap state, phase change).

The reliability of the result:

- the possibility to acquire the same result repeatedly;
- the possibility to find an adequate theoretical model known in advance.

The exact sciences investigate objects, the behaviour of which entirely and solely depends on the external conditions, which allows these conditions to be repeated. It is also possible to study objects, the "self-behaviour" of which is weaker than the external conditions. They are non-living or those of weak will living in conditions of very strong external conditions. No experiments are made with the living, but only their behaviour is identified.

The specifics of the non-living is the ability to accurately determine their state prior to the experiment and to track their changes caused by external conditions determined and controlled by the experimenter. The determination of the starting state is complicated by its dependence on the not always definable "history" of the object, i.e. the "memory" of the object, which is very characteristic to, for example, solid bodies ("the hard memory") but not at all, for example, to elementary particles.

Some questions to be viewed in more detail (optional)

Experimental sciences are exact (physics and chemistry) and non-exact (psychology, biology). This is determined by the research objects of these sciences, because exactness (in the modern scientific sense) is characteristic to the non-living, but non-exactness – to the living.

The theoretical sciences are exact (physics, astronomy) and non-exact (philosophy). Theoretically acquired cognitions can only be tested in exact sciences. In non-exact sciences they can only be verified or simply believed.

In physics, the subject of an experiment can be any physical object (substance in a particular state, body). The external conditions can be have any physical effects.

The behaviour (changes) of an object is determined by the change in its physical parameters.

Changes in the external conditions are determined by their physical nature.

[1] Romans Vitkovskis, Uldis Heidingers "Use of Models in Reverse Thinking", US-China Education Review, 2018

[2] Romans Vitkovskis, Uldis Heidingers "How to teach differently?"

[3] Gaidule, A., & Heidingers, U. (2015). The use of associative images (models) for the development of comprehension in sciences education. *American Journal of Educational Research, 3*(10), 1305-1310. doi:10.12691/education-3-10-15