International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION
5th Edition

Goerudio Models or How to Motivate Students to Love Science

Anca Colibaba, Irina Gheorghiu, Stefan Colibaba, Rodica Gardikiotis
[1]Universitatea Gr.T.Popa, Iasi, Romania/ EuroED Foundation Iasi (Romania)
[2]Albert Ludwigs University Freiburg (Germany)
[3]Universitatea Al. I. Cuza Iasi (Romania)
[4]Universitatea Gr.T.Popa (Romania)
[1]acolib@euroed.ro,[2]irina_gheorghiu16@yahoo.com,[3]stefan.colibaba@euroed.ro,[4]bartisro@yahoo.gr

Abstract
The article is a study of the main outputs created within the Goerudio project (543223-LLP-1-2013-1-LV-KA4- KA4MP), which has been implemented by the EuroEd Foundation Iasi, Romania. The article focuses on the Goerudio educational models, which have been developed through the joint efforts of the learning community of science teachers and students set up during the project lifetime. The Goerudio educational models are metaphors, associations or analogies students are guided to make between complex scientific concepts and common everyday issues. They connect students' familiar and concrete experience with the unknown and abstract information provided by scientific subjects. The models are supported by drawings, pictures or films, which make them even more memorable and accessible. The study examines the steps and activities leading to the creation of the models, as as well their role in enhancing students' motivation to learn science. Suggestions as to how to create and use the Goerudio models are also given through the presentation of the best Goerudio models devised. The article concludes with teachers' feedback: the Goerudio educational models are tools which not only enable learners to get a better understanding of the scientific subjects but also stimulate their interest in science.
Key words: Goerudio educational models, science, students' motivation, learning community

1. The Goerudio project
The Goerudio science project, implemented in seven European countries, has been a European funded project in the framework of the Lifelong Learning Programme – Transversal Programme – Key Activity 4 Multilateral Project. The project aimed at enhancing students' motivation to learn science by creating a strong learning community across Europe made up of teachers and students [1]. The project community analysed the existing challenges and the solutions suggested so far and made new amendments addressing the situation. The most significant project outputs have been the Goerudio models.

2. The Goerudio project
A Goerudio model relies on an analogy or a comparison between two items (e.g. blood coagulation to team building/ electric current to the way water flows/ a chemical equation to a recipe/ inertia to everyday routine [1]). Analogies are often used informally in conversation. At an academic level as they require analysis, evaluation and transfer of information, such analogies can be used in the teaching and learning processes. They become valuable educational models. The type of transfer of information used in models is based on students' comprehension. Incorrect models are also useful as students analyse the relationships their models suggest, and then correct them accordingly. Students get engaged in their learning process by monitoring and revising their thinking until they establish the complex relationships between disparate things [2].
Abstract or challenging concepts taught in science classes become accessible and easy to understand if they are related to something familiar from everyday experiences. Effective models motivate students to be active learners and help them visualize abstract concepts. When they are used appropriately, models stimulate students' meaningful learning [3].

3. Teaching with the Goerudio model: the Romanian experiment
The Goerudio project experiment was carried out during science classes (biology, chemistry, physics and mathematics) in five schools in Iasi, Romania; models were used with two different types of classes: lower and upper secondary school students. The upper secondary students created models

in the consolidation stage of their learning process, at the end of a learning unit, while with the lower secondary school students models were used to introduce new scientific concepts.

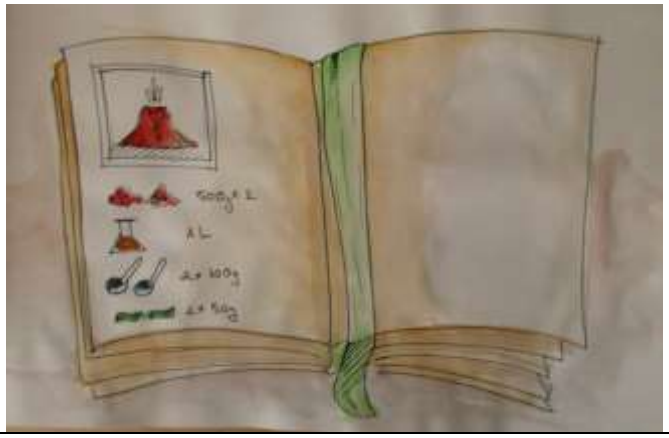
With the upper secondary students the process went through the following stages: preparation, creation of the model and evaluation of the model. The students worked in small groups; the teacher first initiated them in the model making process by giving examples, analysing and evaluating them with their students. The specific features of a good model were also highlighted: accuracy of the information, simplicity and its visual attractiveness [4]. To engage students and stir their interest, the model had to be novel, out-of-the-ordinary, visual (e.g., accompanied by a drawing, animation), and directly related to students' everyday experiences. The students were also asked to create their own model for a concept. When creating models the students interacted directly with the material and concepts and applied knowledge they had gained to new situations, which demonstrated that they understood the new concept. The teacher acted as a facilitator rather than giving instructions.

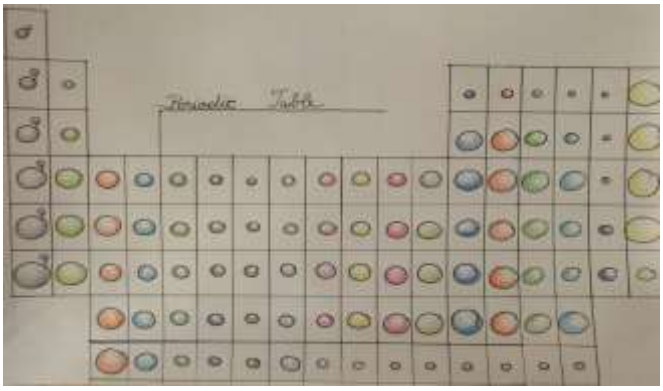
In the last stage the students presented their own model to their colleagues. Their peers evaluated both the content knowledge and their colleagues' ability to explain why their model was appropriate. Such models provided teachers with a great deal of information about their students' understanding of the target conceptsWith the younger students the experiment had different stages: the presentation of the model, its analysis and exploration followed by teachers' scientific explanations. The goal of the first phase was to give students an opportunity to become motivated about the information they were about to learn. Models are perfectly suited to the goal of this phase. They created a stimulating atmosphere and above all, stirred students' interest in the issues. The teachers participating in the project noticed that students were more likely to pay attention to the familiar language used in models than to unfamiliar, more "scientific" terminology [4]. The students were given the opportunity to interact with the material, to examine both similarities and differences between the two elements of the model. In the last stage the teachers helped students understand scientific explanations and introduced terminology to provide students with a common language about the content. Goerudio models can make new concepts easier to understand, visualize, remember, and more plausible in students' minds. Models can also introduce students to unfamiliar scientific language by giving them a concrete reference for the new vocabulary.

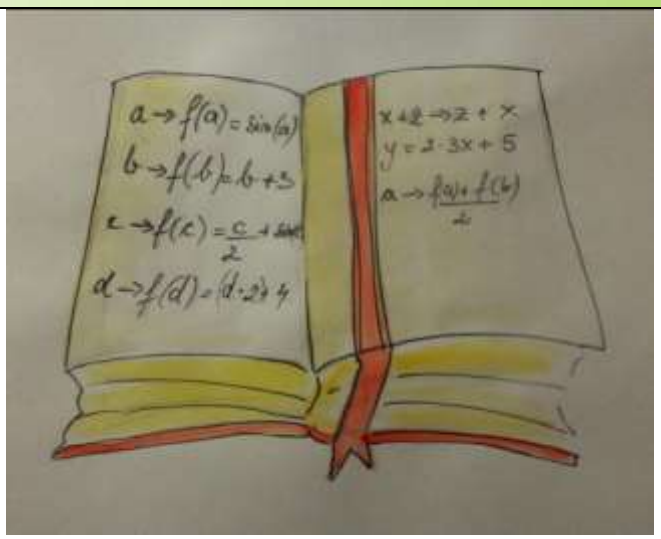
3. Results and discussions

The Romanian group created 24 Goerudio models as follows: 15 models for Physics, 3 for chemistry, 3 for maths and 3 for biology, although the required number was 12. Students' favourite subject was physics and electricity inspired most of the models. Each model was made up of the scientific definition of the concept, the analogy between the scientific concept and an apparently similar familiar issue and an accompanying drawing or animation [1]. The translation of the text of the model into a foreign language is also advisable as it reinforces the analogy.

Table 1 Samples of Goerudio models

Model 1: Chemical reaction *Definition or explanation*: A chemical reaction is a process that leads to the transformation of one set of chemical substances into another. *Description of the model:* The chemical reaction is like a recipe: you add the ingredients and the result is a newly crafted substance.	
Model 2: The immune system *Definition or explanation:* The immune system consists of biological structures	

and processes within an organism that protects against disease. To function properly, an immune system must detect a wide variety of agents, known as pathogens, from viruses to parasitic worms, and distinguish them from the organism's own healthy tissue. *Description of the model*: The immune system represented by enzymes is like a police force fighting against hooligans (bacteria, parasites, viruses) that try to vandalize a nice building (the human body).	
Model 3: Magnetic force *Definition or explanation*: Magnetic force is the attraction or repulsion that arises between electrically charged particles because of their motion. Magnetic objects exhibit a magnetic influence. A magnetic object can attract or push away another magnetic object. *Description of the model*: A cat and its hungry kittens Magnets have two poles, called the north (N) and south (S) poles-cats are also made up of two parts, heads and tails. Two magnets will be attracted by their opposite poles, and each will repel the like pole of the other magnet. When the kittens don't see their mother they aren't aware of her presence. The moment they see her they will be attracted to their mother and come for feeding. It is very difficult to separate them from their mother's breasts–like two magnets that are attached to each other.	
Model 4: The periodic table *Definition or explanation*: The periodic table is a tabular arrangement of the chemical elements, ordered by their atomic number (number of protons in the nucleus), electron configurations, and recurring chemical properties.The periodic table provides a useful framework for analyzing chemical behavior. *Description of the model*: The groups of elements in the periodic table of chemical elements are like families sharing common characteristics yet different in size or other features.	
Model 5: Functions *Definition or explanation*: A function is a relation between set of inputs and a set of permissible outputs with the property that	

each input is related to exactly one output. *Description of the model*: A function can be associated to a dictionary because a function f takes an input x, and returns a single output f(x). In a very similar way, the variable 'x' can be seen as a word which, once found in a dictionary (once you apply a function f to variable 'x'), you can read its unique definition, its meaning. In a mathematical sense, there is a unique output for f(x). One can say that for each word there is a particular meaning as there is a particular value for f(x), depending on x.	

Romanian teachers found that Goerudio models can be useful especially when abstract scientific concepts are first introduced to students. Students are asked to find similarities between the scientific concept and the familiar information with a view to integrating new information in their previous knowledge base. They use familiar information to explain unfamiliar information; and thus students build knowledge [5]. The new knowledge is explored from different angles as students get actively engaged in finding explanations and applying the newly learned material to new situations related to their own experience.

Romanian teachers have appreciated the Goerudio models for stirring students' interest in geometry, chemistry, physics or biology. They highlighted the importance of using examples from the reality students are familiar with whenever students are taught scientific issues.

Teachers appreciated Goerudio models as:

- innovative, intriguing, interesting, captivating: "A Goerudio model is an interesting exercise for the mind. It challenges students' mind;" "I think that Goerudio models offer plenty opportunities for students to exercise their creativity;"
- addressing all learning styles: e.g.: making use of drawings or pictures (visual students), involving students body and mind;
- a lot of fun by making good use of humour and games: "This concept is rather difficult, but the model really gives a very good first idea of what coagulation is. Maybe the student will have to study deeper the concepts later, but the first approach is mind-catching."
- memorable: " it helps students retain the scientific issue and continue looking for such examples and comparisons in real life," "an original way of retaining information;"
- giving students clear explanations "making connections between the theoretical concepts and what happens around us;" "Science classes are full of abstract concepts, which are difficult to understand. Goerudio models help students understand them by relating them their everyday experiences."
- simple and easy to understand. "Students may understand better the main logic of this subject using this comparison, which is so simple and clear."
- applicable in real life: "They develop students' knowledge about how to live a healthy life."

Romanian teachers have expressed their intention to use Goerudio models in class. "I am planning to use it because I find it interesting and useful." "Students find it hard to make connections between concepts, definitions and reality. That is why I think this model is useful; it also captures their attention. The explanation is not very complicated. I am planning to use this model with my students too because I find it useful."

The Goerudio educational models have been further used in a CLIL programme, where students developed not only their knowledge and understanding of the world but also their language competences [5].

5. Conclusions

The first Goerudio experiences related to the project educational models are positive. Goerudio models offer an alternative to traditional teacher-based learning by promoting a more inquiry-based, student-centered learning. They promote active learning which makes knowledge lasting. Students get a better understanding of the scientific concept by anchoring it to their everyday life and making the learning process memorable and very personal. Goerudio models enable students to see the relevance of the topic in relation to their lives, introducing an element of fun in the learning process and providing adequate hands-on activities to stimulate and motivate them to learn. [2].

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