

# Flipped-classroom and Perceptual Modalities in the Teaching of Structural Geology, Tectonics and Natural Science

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**Abstract:** The idea of an inductive teaching method based on perceptual modalities in a flipped-classroom concept, to be applied to the teaching of Structural Geology and Tectonics and the Earth Sciences in general, came from the need to appraise new forms of interaction/teaching in today's globalized context. Even if sporadic and carried out in a far from systematic way, the type of teaching examined in this study was tested on secondary school students specializing in science in a heterogeneous sample of children aged 15 to 18 years. The educational experiment was divided into six phases, each characterized by the prevalent use of perceptual modalities. The initial phase, characterized by creative writing, aimed to develop the kinaesthetic modality. The second stood as an "anchor" for the objectives to be achieved through a form of dramatization. The third emphasized individual investigation, in accordance with criteria typical of the flipped-classroom method. The fourth consisted of fieldwork to stimulate visual and tactile modalities. In the fifth, the teacher operated as a "scientific mediator", favouring the auditory capacity. And, finally, the sixth, with its body of knowledge and the finalization of the goal to be achieved, lay within the scope of the issues addressed by Structural Geology and Tectonics.

**Key words:** Perceptual submodalities, flipped-classroom, graben of the Lunigiana and Garfagnana.

## Objective

The Method proposes to create a union between learning timeframes imposed by the fast communication of websites and modern technologies, and those of fieldwork practice, through a connection between perceptual submodalities. The focus centred on the teaching of Structural Geology and Tectonics, but could easily be extended to other branches of the Earth Sciences.

## 1. Introduction

Having deserted various past conceptions, the fruit of a stable society, there is an increasing need on all sides to cope with a society that has become all-encompassing, multi-faceted and constantly shifting, characterized by very rapid and sporadic social changes. In addition, with the rapidity of the

transformation, also processing takes on new dimensions in addition to the interaction between the individual and society that establishes behavioural models [1]. The widespread concept of globalization and interchange that has brought very diverse cultures closer imposes new forms of communication, ones in which both language and perception are the fundamental elements of human interaction, as in the past [2]. In this dynamic framework, the established ways of life of a stable society have been adapted to a society in constant movement. With respect to the standards of the past, today, independent variables of the problem include impersonal agents of socialization, such as schooling and television, which have changed the modalities and rhythms of the education system: there is more to pass on and the material to be transmitted to the youngsters is not the same as that transmitted by previous generations. The heterogeneity of society is a reflection of both the social structure and a new style of behaviour which, in only half a century,

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has become specialized and compartmentalized. In 1933, Alfred Korzybsky [3], in his work “Science and Sanity”, expressed the principles of his theory, which he defined “General Semantics”. This should not be confused with “traditional semantics”, i.e., that branch of linguistics which studies the meaning of individual words, sets of words, sentences and texts. In his work, Korzybsky explains how human beings are limited in their knowledge of reality by both neurological and mental constraints. This principle is summed up by the proposition: “The map is not the territory”. In fact, as human beings, we do not act directly with our behaviour, but do so through a map or a model that we believe to represent the world that surrounds us. And a map or a model, as such, will never be the same as, and identical to what they represent. If all we want is to seize the problem in its initial moment, we must first become familiar with the mechanism of how we build our map of reality. There are “tools” which human beings use to receive information, which are related to five input channels that correspond to the five senses: Sight, Hearing, Touch (bodily sensations), Smell and Taste. Despite the possibility to use all five senses, people very often tend to give greater importance to only one of them. This leads to the obvious conclusion that many people never make the most of their potential [4]. The study of human behaviour patterns has brought out the need to take an increasingly deeper look at the relationships between gesture and mental configuration [5]. It is interesting to note that these systems are those which humans use mainly to acquire and store information. These three modalities are often defined as “Domains and Systems”: (a) Visual, referring to the sense of sight, (b) Auditory, referring to hearing, and (c) Kinaesthetic, which embraces the senses of touch, taste and smell.

### *1.1 Verbal and Non-Verbal Aspects*

When addressing a class, but also a single student, to be sure to achieve what we want, we must check not only the content of what we want to communicate, but also how it is transmitted [6, 7]. This “how” covers

both verbal and non-verbal aspects [8]. In fact, as human beings, we do not act directly on the world in which we live but we do so by building maps or models and using these as a guide for our behaviour, but we do so through a map or a model that we believe to be a representation of the world that surrounds us. And a map or a model, as such, will never be the same as, and identical to what they represent. Through the senses, human beings perceive the “outside world”, and the information that reaches our mind creates its own representation of what “lies outside” [9]. This mental representation, built with the information coming from the senses, will in turn be composed of information from images, words, sounds, perfumes and everything else that our senses can perceive. Thus, when we think, remember or imagine, we do so through mental representations of which the senses are the main constituent elements. The senses never perceive reality passively but through an incessant search for information. The perception of reality is not a direct phenomenon as might be believed, but is mediated by personal patterns beyond what the senses perceive. The images that we see in the transfer from the eyes to the mind pass through the various areas of the brain that process them to select and give sense to what we see. This process involves not only simple graphic processing, but also the centres connected with the emotions. We all use instruments to enter contact with the outside world, these are traceable to five input channels that correspond to our 5 senses: Sight, Hearing, Touch (bodily sensations), Smell and Taste. Although we can use all five, we often tend to use predominantly only one. Each of us, at every moment, consequently tends to favour the information coming from a specific sense, at various levels. These can also be defined as “perceptual modalities” and the specific sense to which we give greatest importance is defined as the primary or dominant perceptual modality. Visual (V), Auditory (A) and Kinaesthetic (K) representations can be defined as “Modalities”. Within each modality there are distinctions defined “Submodalities”: again,

Visual, Auditory and Kinaesthetic.

## 2. Methods

The teaching of Structural Geology and Tectonics can be summed up in six phases: 1—Classification of the problem, 2—Creating a dramatization through creative writing, 3—Comparison of information between students, 4—Activity following a flipped-classroom timetable, 5—Fieldwork, 6—The teacher representing a scientific mediator and a body of knowledge (Fig. 1).

## 3. Feedback

The experiment involved a sample of Secondary School students (Liceo Scientifico), aged 15 to 18

years, in order to test objectives that were verifiable in the short term on a heterogeneous sample. The experimentation with the Method included the achievement of the following general objectives:

- Improving the ability to tackle scientific themes and, in particular, Structural Geology,
- Becoming familiar with Perceptual Submodalities,
- Acquiring a methodology of scientific inquiry that adheres to reality,
- Enriching the experience of a perceptual type and in the field,
- Learning how to practise and communicate,
- Learning how to evaluate personal performance and to reflect on it,
- Cooperating, understanding and swapping notes.

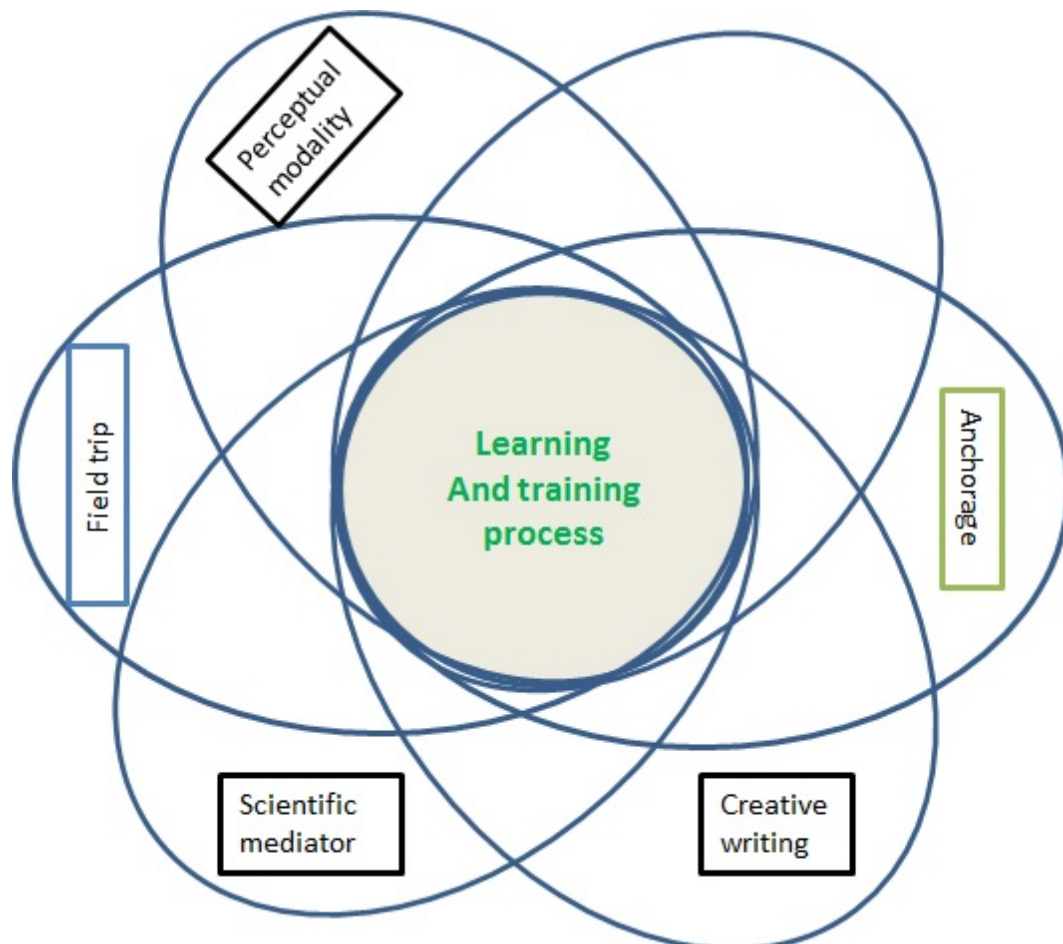


Fig. 1 Diagram of interaction between the phases of the Method and the training and learning objectives.

#### 4. A Case Study

As is well-known, Structural Geology deals with the effects of structures on the morphology of a region. The morphological characteristics are conditioned by faults and folds. Tectonic structural geology explains

structures in relation to crustal dynamics, where deformations are induced by movements that originate in the depths of the Earth. The case study set out to reconstruct the current composition of the Alta Val Magra basin (Fig. 2) in the North-Eastern Apennines (Italy), particularly as regards its extensional structures

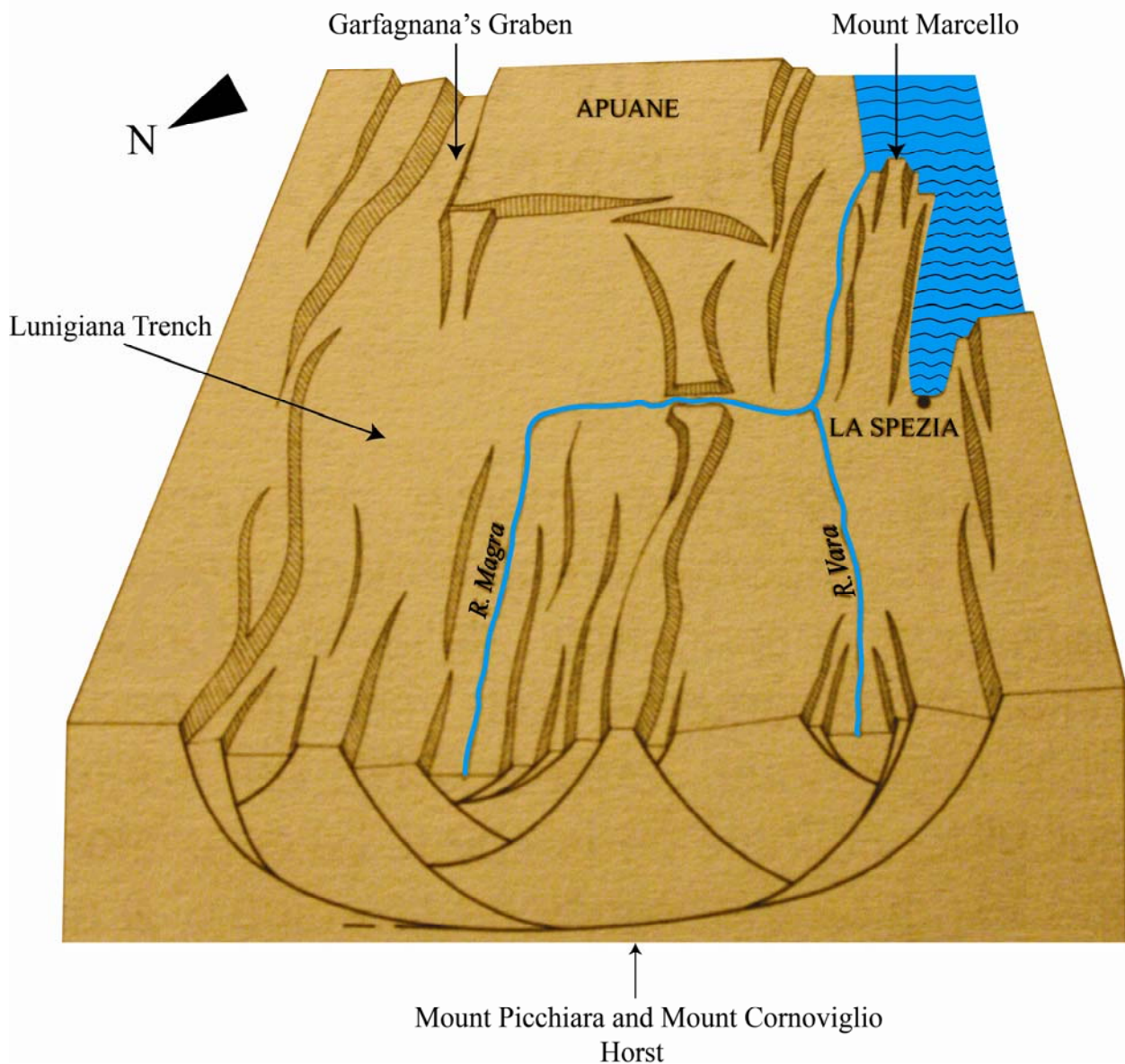


Fig. 2 Index map of the area under study.

[10]. In this area of the Northern Apennines, the active tectonics are characterized by distinctive tectonics that the thrust face has left behind while advancing northeastward. This type of tectonic produces typical horst and graben structures, with high and low topographic areas due to the distension of the continental crust. In Northern Tuscany, we have evidence of a horst represented by the Apuan Alps, between two grabens represented by the Lunigiana and

Garfagnana areas (Fig. 3).

Thus, the seismicity that affects the Garfagnana is mainly localized in the areas at the limit of the graben, where we also find boundary faults that separate it from the adjacent horst [11-15]. The genesis and evolution of the area is linked to the geological events that have affected this sector of the Northern Apennines, an overlapping fault chain whose complex evolutionary history is linked mainly to two key tectonic phases



**Fig. 3** Three-dimensional diagram of the structure of the Lunigiana-Garfagnana. Taken and adapted from Bernini, Papani, 2002.

[16, 17]: a compressive phase which, from the Upper Cretaceous to the Upper Miocene, with the closure of the Liguria-Piedmont Paleo-Ocean, determined the establishment of the units that constitute the chain (Ligurian Domain, Sub-Ligurian Domain and the Tuscan Domain), and an extensional phase which, between the upper Miocene and Lower Pliocene, resulted in the formation of tectonic troughs (graben). The area under study is delimited by normal fault systems, generally in the direction of the Apennines, which confers a characteristic stepped profile to the sides of the depression [18, 19]. The faults are due to a relaxing process that has never been continuous and constant over time, but has featured two breakaway moments characterized by an accentuation of lifting, witnessed by discrepancies in regional character within the fluvio-lacustrine successions [20].

## **5. Phases of the Method**

After reviewing the topic and the theme to be dealt with, the work began with a creative writing exercise, done individually, to develop the kinaesthetic modality. Here, by way of example, are three cases.

### **ONE**

The first describes the adventure of a fragment of rock which becomes detached from an igneous ridge, moves along a slope, reaches a watercourse and, after various vicissitudes, settles on a seabed. There it remains asleep for a long time, to be woken up by a giant of nature. The second describes the vehemence of the giant of nature which, after a long sleep, abruptly moves in the bed of the terrestrial crust, lifting, breaking and crumbling everything around it. Thanks to this disturbance the fragment of rock awakes and observes the upheaval surrounding it. The third speaks of natural entities which, with coordinated synergic work, try to fit the pieces of the puzzle generated by the giant's mayhem back together. Despite the commitment of the natural entities, the result is a basin that tends to sink, since some elements of the puzzle have been lost. The result is a slow continuous sinking

that exposes the inclined surfaces of blocks that were once in contact.

### **TWO**

The second step consists in creating an "anchor". Like anyone who has happened to hear a certain melody that automatically and spontaneously recalls a past situation, which for some reason, is associated with that music, perhaps precisely because it was being listened to in that situation. Thus, the anchorage consists in associating the Structural Geology theme to the emotion transmitted in the creative writing. The anchor is inspired by a drama that sees the students exchanging notes, through a dialogue that connects the various aspects of the issues dealt with in the creative writing.

### **THREE**

The third step follows the "flipped-classroom" indications, with an individual and autonomous investigation [21, 24]. As is well-known, this means reversing the traditional teaching and learning scheme, turning the classroom into a work and discussion space where students learn how to use them in conjunction with their peers and the teacher. In the "flipped-classroom" context, the teacher gives the youngsters useful material to independently explore the topic under study. These may include: books, presentations, website links, video tutorials, and the like. In this phase, the teacher is modelled on the role of a moderator of the debate and, in this context, more than concepts which are important are the questions being asked, in such a way as to inspire the curiosity fitting to science, and the motivation behind scientific investigation. And it is precise motivation that is the keystone and the guarantee of success of this teaching approach.

### **FOUR**

The fourth step consists in reproducing a fundamental element in the study of Natural Sciences and Earth Sciences and, therefore, also of Structural Geology and Tectonics: fieldwork, to stimulate the visual and tactile perceptual submodalities and associate the perceptive experience to the physical nature of the excursion itself



and the displacements in the field.

#### FIVE

The fifth step consists in the traditional role of the teacher as a “scientific mediator”.

#### SIX

Lastly, the sixth step concerns the body of knowledge and the finalization of the set objective, within the scope of the topics to be addressed as part of Structural Geology and Tectonics.

#### TIMEFRAME

The first and second steps can be carried out in a single lesson, while for the remaining ones, they depend on the course timetable and the type of goal.

## 6. Results

The timetable for the application of the method is purely indicative. Certainly, if the time devoted to the topic is increased, then the probability of success also increases. The characterizing element of this approach to science, half tackled with traditional rhythms and half following the speed of virtual information, is curiosity. The application of all of the perceptual modalities, followed in the various phases of the Method, allows interception of students' individual modalities, knowing a priori that it is possible to communicate with all of them. The result is the ability to teach the geometric-structural relationships of Structural Geology and Tectonics according to unanimously confirmed laws, to lay down a solid experimental scientific method, but also to teach the use of intuition, and the modalities of dialogue and communication to draw out all of the students' potential, even through a different perception of reality [25]. Starting from the ability to work in a group, is a key element for success in any scientific field. An initial goal of this method is to arrive at verifications and acquire a quantity of data that are sufficient for a reliable statistical correlation.

## 7. Conclusions

The partial data, intended as a didactic answer to the

Perceptual Modality Method, indicate that scientific rigour can be accompanied by both intuition and the new forms of communication for an understanding of Science that adheres to the fast pace of modernity. In fact, the primary objective of science is to explore the world, and not merely to describe better what we already know, starting from a reflection on teaching methods.

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