Active geomorphosites and educational application: an itinerary along Trebbia River (Northern Apennines, Italy)

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Introduction

Landscape evolution and Earth surface modelling processes have been studied in depth by geomorphologists for a very long time. More recently, the introduction of the *geomorphosite* concept (Panizza, 2001; Reynard et al., 2009), and in particular of *active geomorphosites* (Reynard, 2004), allowed the application of traditional geomorphological investigations to the connected evolution of natural and cultural heritage (Panizza & Piacente, 2003; Bollati & Pelfini, 2010). Among the features considered during the evaluation of geomorphosites, the educational value can be considered as qualifying the scientific attribute of the geomorphosite (Panizza & Piacente, 2003). Studies on geomorphological processes involving geomorphosites and cultural heritage in a broad sense (Panizza & Piacente, 2003) also allow the dissemination of scientific results into educational frameworks.

The growing attention to this educational aspect is documented by a lot of initiatives dedicated to the introduction of young people and scholars in particular to the natural environment and Earth sciences (e.g. De Waele, 2010 for karst environments and speleology). Moreover, field activity has been recognized as being very important for acquiring knowledge (Boyle et al., 2007) and for a comprehension of the interactions between geomorphological processes, human activities and vegetation presence and dynamic (Davis, 2002; Garavaglia & Pelfini, 2011).

The physical landscape is often considered by young students a boring topic with subjects deeply separated from one another and not connected with the biological world. Often the landscape is considered as immutable in time, and its history and evolution correspond to abstract concepts that appear difficult to understand. A frequent problem regards the comprehension of the "time" concept: in the same spatial dimension, structures deriving from an evolution during both millions of years (e.g. tectonic windows, morphoselected reliefs) and few years (i.e. fluvial, gravity processes) can in fact be present.

At present many strategies are being experimented in order to encourage students to really understand the landscape, including: the analysis of the landscape in movies (Di Palma, 2009), virtual globes and online digital terrain databases (Allen, 2007), field and laboratory workshops in specific environment like coastal areas (Ellis & Rindfleisch, 2006) and desert environments (Stumpf et al., 2008).

These are only some examples demonstrating how field activity is an important instrument for divulging scientific knowledge among students, for developing the ability to observe landscape as a consequence of its interaction with the affective domain (Boyle et al., 2007), and also its implication with disabled students (Hall et al., 2004; Garavaglia & Pelfini, 2011).

Moreover fieldwork along trails facilitates the study of geomorphological processes, the comprehension of how they can represent hazards and risks (Bell, 1998; Pelfini et al., 2009), how they can undergo severe modifications, and how landforms can be classified as "geomorphosites".

In this sense, the number of thematic trail proposals is growing. In many tourist areas, several traditional trails have been recently transformed into thematic paths in order to satisfy a growing interest toward both the landscape and its evolution and the response of the biotic and abiotic systems to the climatic change (Garavaglia et al., 2010), including educational implications. Hiking trails and geomorphological thematic itineraries are becoming an instrument for educational field activities too, often accompanied by naturalistic guides and geotourist maps.

In many cases, fieldwork may be accompanied by laboratory activities that simplify natural processes. Pelfini et al. (2010) proposed, for example, a simple laboratory experience regarding the transformation from clean glaciers to debris covered glaciers and for the comprehension of the consequence for the glacier evolution, which passes through complex physical processes that are difficult to be understood by students from secondary schools.

Based on these considerations, this paper presents the results of a educational project ("A flight into time through the landscape"), tested in a secondary school of first level (age of pupils: 13 years). The main aims were: i) to find a strategy to obtain awareness of the concept of temporal landscape evolution; ii) to test with pupils the efficacy of field and laboratory activities for the comprehension of dimensional (space) and temporal (time) scale of the geological and geomorphological processes.

In more detail, the goal was to find strategies for the comprehension of i) the concepts regarding mountain origin and palaeogeography, ii) fluvial modelling processes and methods for reconstructing the recent fluvial history, iii) relationships between geology/geomorphology and vegetation, and last, but not least, iv) the relationship between human settlements and landform evolution.

Study area

The Trebbia River, located in the North-western Apennines, is one of the right Po tributaries, flowing from SW to NE, through the Liguria and Emilia Romagna Regions (Fig. 1a). The selected area is characterised by important geological features inherent to the formation of the Apennine range, and by the evident interaction of geomorphological processes with the lithologic and structural substrate features, as well as landforms that are very representative of the processes they were generated by. In this sense, the different times of evolution of Earth surface elements are marked. The connection of cultural elements with geomorphology is, in addition, very evident.

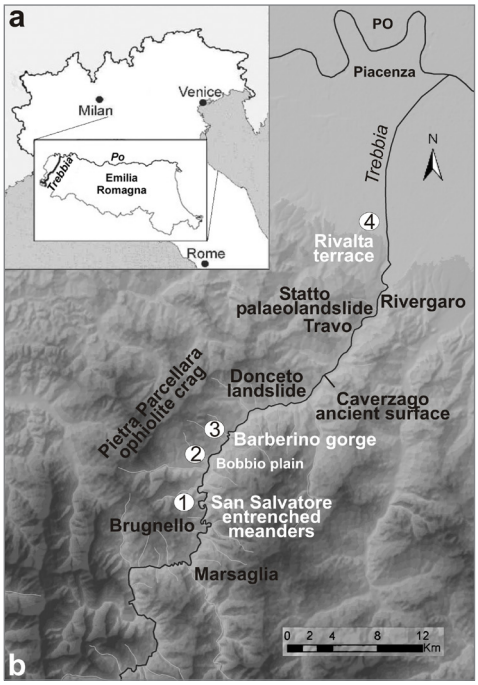
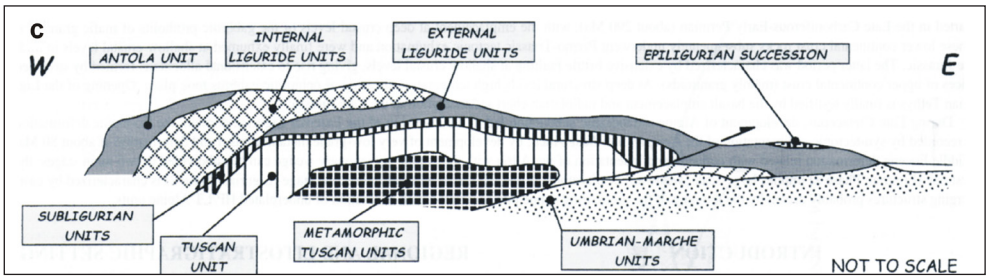
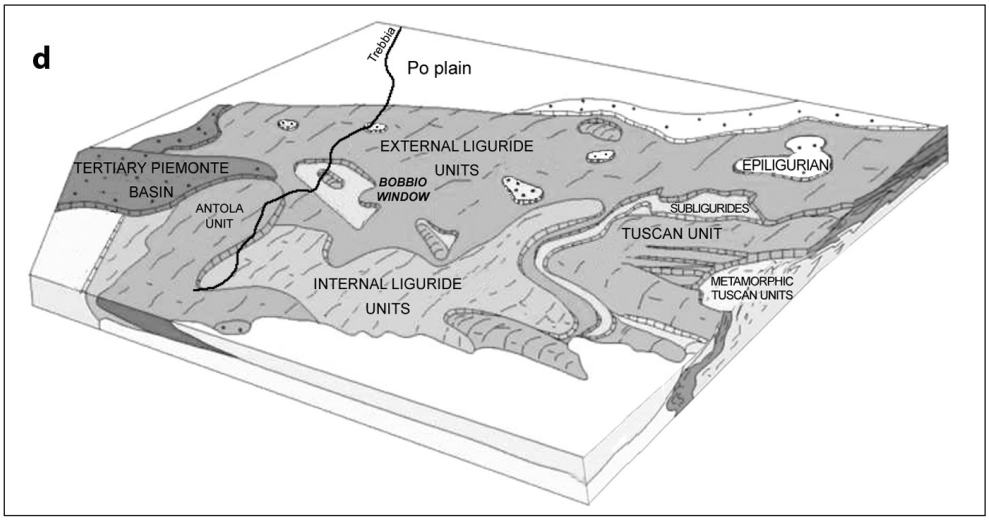


Fig. 1: Location and geological settings of the study area. a) Geographical location of North-western Apennine; b) DEM of Trebbia Valley showing the investigated fluvial reach from Marsaglia to the Po confluence (Piacenza, Emilia Romagna) and the individuated geomorphosites (numbers 1-4); c) Schematic cross section of the Northern Apennine (from Marroni et al., 2002); d) Block diagram of Northern Apennine (modified from Zanzucchi, 1994).





Stop	Topics	Field material	Accessibility
San Salvatore meanders	Geological and tectonic history of the area (geologic time concept); sandstone and shales; outcrops in the Bobbio tectonic window and their relationship with the landforms; palaeogeography of the area and its evolution towards the formation of the entrenched meanders; erosion-deposition dynamic through the observation of a point bar (geomorphological time concept); lithologies of the cobbles forming the point bar in relation to the drainage basin; observation of remnants of ancient human settlements in relation with the fluvial landscape.	X	On foot
Bobbio town and Ponte Gobbo	Modifications of the Ponte Gobbo over centuries in relation to the river-bed changes and the legends associated with the bridge modifications; role of folk tales in reading the landscape modifications.		By bus
Barberino gorge	Relationship between outcrops of hard ophiolites (geology) and the fluvial morphology (geomorphology); the particular vegetation (botany) growing on ophiolites (geology).	X	By bus
Rivalta castle and the lower Trebbia river	Guided excursion to the castle; relation between the river position and place names of the Rivalta village through the observation of braided reach and associated landforms from the castle (geomorphological time concept); dendrogeomorphology application to a flood plain (geomorphology).	X	By bus

Table 1: One-day educational trip proposed to a secondary school. The topics regarding each stop are illustrated; the availability of field material and accessibility for each stop are indicated.

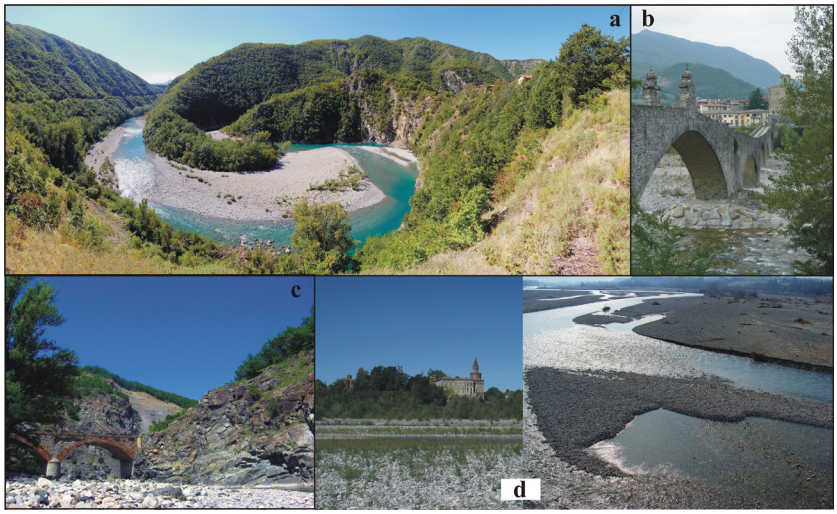


Fig. 2: The four steps of the educational itinerary. a) San Salvatore entrenched meanders (photo: G. Duci); b) Ponte Gobbo at Bobbio village (photo: L. Pellegrini); c) Barberino gorge (photo: A. Bazzi); d) Rivalta Castle and braided reach of Trebbia from Tuna Bridge (photos: L. Pellegrini and I. Bollati). For location, see Fig. 1b.

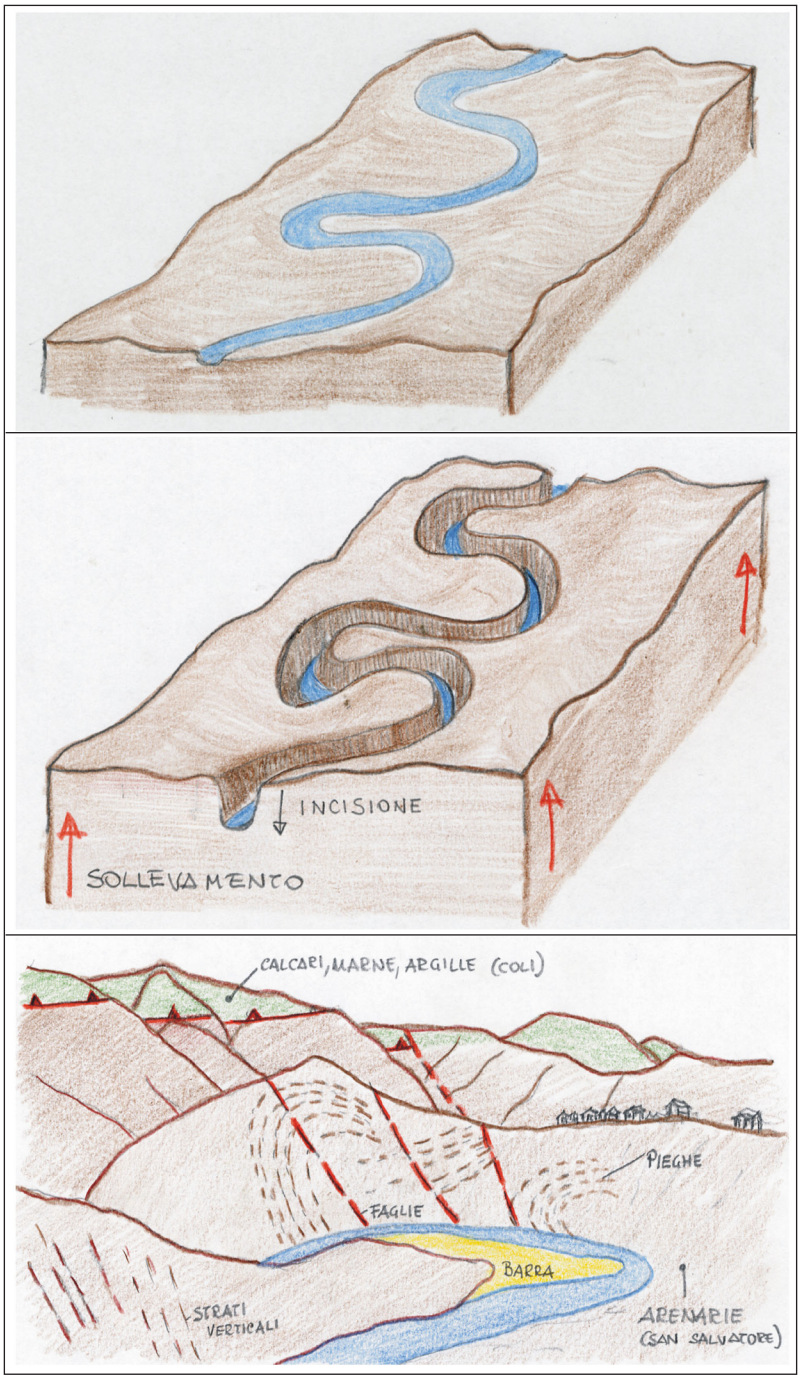


Fig. 3: Example of supporting material prepared for students to be used during the fieldtrip. This one regards the formation of entrenched meanders at San Salvatore (by L. Pellegrini).

The structure of the project

The educational project was planned including classes and laboratories and a one-day fieldtrip in order to investigate the contribution of these activities to the comprehension of landscape evolution. Tests were structured before and after the experience to verify its efficiency. The project was focused around the Trebbia Valley and its evolution through time.

The educational project was developed in collaboration with a secondary school. Two classes were involved in the project: one class (Class 1) experienced lessons on a specific programme, laboratories, fieldtrip and fieldwork, while the second one (Class 2) was involved in traditional lessons and in the field activities (Fig. 4).

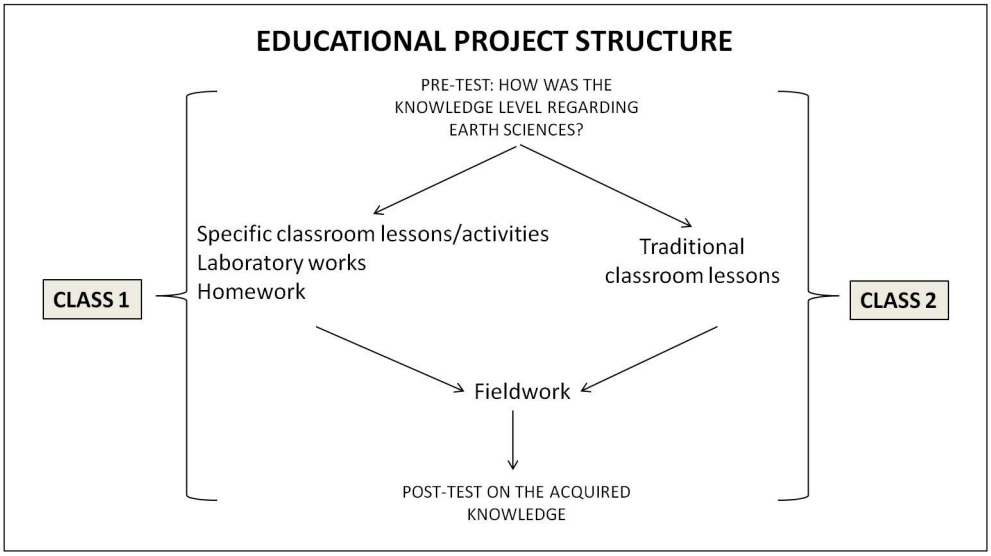


Fig. 4: Sketch of the educational project structure. Before the fieldtrip Class 1 participated in specific lessons integrated with laboratory activities while Class 2 only in traditional lessons about geological and geomorphological general themes.

The topics selected for the specific lessons in Class 1 were compatible with the regular school programme and were built around the Trebbia Valley's geological and geomorphological context. The lessons regarded: plate tectonics and rock classification, fluvial morphologies, and dendrochronological applications in a fluvial context. They were correlated with laboratory activities developed at the Dendrogeomorphology and Petrography laboratories (University of Milano, Earth Science Department "A. Desio").

A testing phase was planned before and after the experience in order to check the importance of both theory and practice (laboratory and fieldwork) in acquiring environmental knowledge. In particular, a pre-project evaluation test was formulated in order to check the previously acquired notions and whether they were erroneous or not. During the experience, homework regarding the discussed topics (fluvial pat-

terns, rocks cycle, dendrochronology dating method) was proposed and at the end a post-test concluded the experience (Fig. 4).

Results and discussion

The elaborated data derives from a sample of 41 students. The results of the students that did not follow the complete path of Class 1 or Class 2 were excluded from the data elaboration. The pre-tests (Fig. 5) aimed at individuating mis-knowledge about Earth science in general and they were formulated using very general questions regarding geology, geomorphology and dendrochronology topics. The results show a similar level of knowledge between Class 1 and 2 (Fig. 5a, b). Dendrochronology (98%) and geology (66%) questions obtained a higher number of right answers in respect to geomorphology (60%) (Fig. 5c). The question regarding dendrochronology was, in reality, concerning botanic concepts already approached by pupils. The open-ended questions (Fig. 5d) were kept separated because in these ones the students obtained the worst results: the maximum percentage of right answers was about 32 % (geology, class 1), very much less than the other questions. This is probably due to the fact that they had to write without the help of multiple choices.

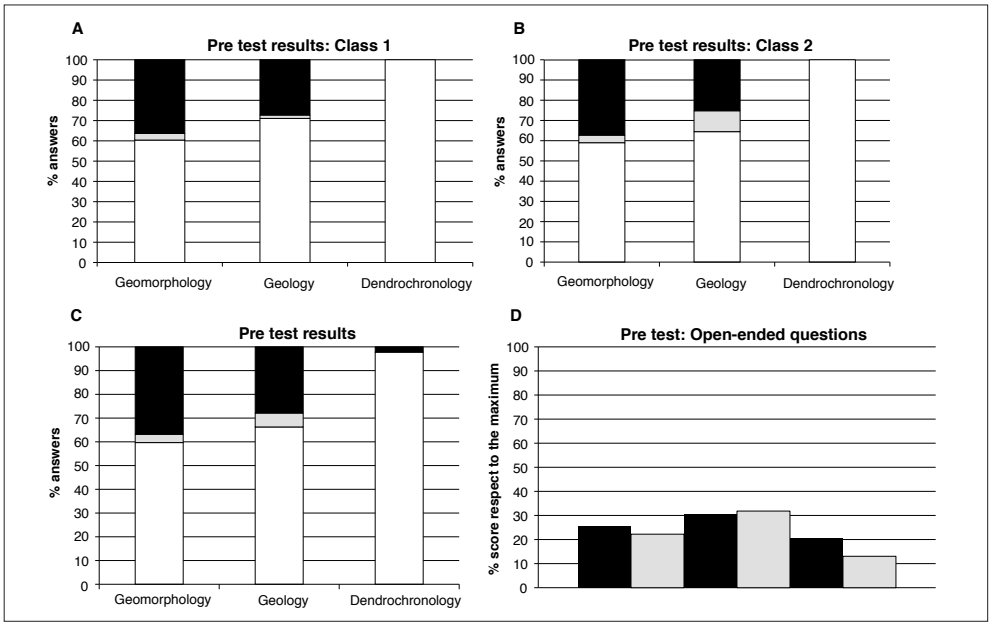


Fig. 5: Pre-test results on basic knowledge regarding Earth science. The results are subdivided by the topics (geomorphology, geology and dendrochronology). They are presented as percentages of various types of answers. a) percentage for Class 1; b) percentage for Class 2; c) percentage for both classes; d) open-ended questions results for both the classes. For figures a, b and c the answers are considered wrong (black), right (white) and no answer (grey).

Hereafter, laboratory activities, exercises and manual activities guided by a teacher, and homework for each topic were prepared on: i) geomorphological pattern of

rivers; ii) the cycle of the rocks; iii) dendrochronology application: dating a tree core.

The results of the homework are reported in Figure 6. The lessons on fluvial geomorphology, for example, improve the knowledge on the topic as demonstrated by the results showing that geomorphology obtains the highest percentage of right answers (83%). Geological topics resulted to be a hard topic especially concerning the cycle of the rocks object of the exercise (only 17.5% of right answers). This probably requires a greater abstraction ability.

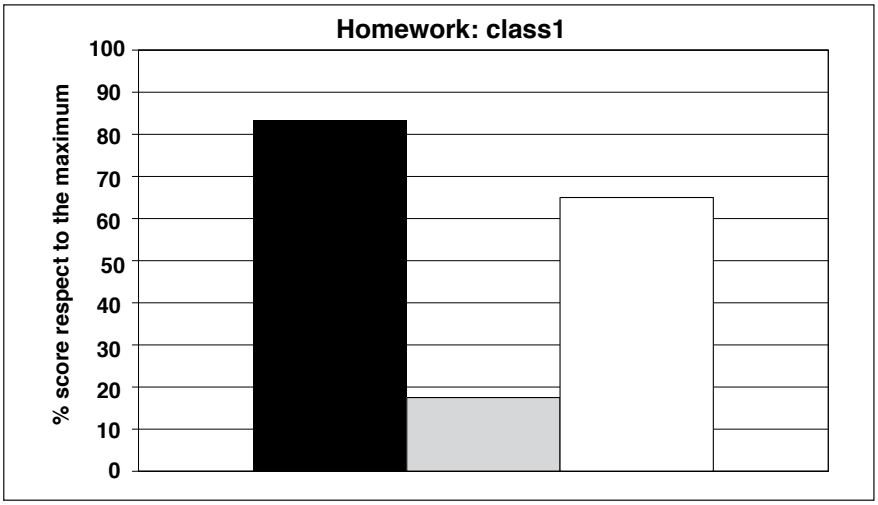


Fig. 6: Homework results. Geomorphology (fluvial course typologies; black), geology (rock cycle; grey) and dendrochronology (tree core measurements; white) results are illustrated. The most successful exercise is the recognition of geomorphological fluvial patterns. The greatest difficulties were found in the creation of an hypothetic rock cycle.

A post-test was proposed to both classes at the end of the field activities, and the questions regarded both basic knowledge of Earth science and observation and experimentation on the field. It was constituted by different types of exercise:

- filling in empty spaces with provided terms regarding fluvial modelling processes (erosion, transport and deposition) and landforms;
- identification of a rock sample;
- association of rock types with a genetic process;
- multiple choice question on the ophiolite concept;True / false questions on geology and dendrochronology;
- open-ended questions on dendrochronology, geomorphology and relation with human settlements.

Generally, the results show the importance of joining a guided tour with synthesis lessons to fix the knowledge and observation gained in the field.

As highlighted also in the pre-test results, the problem in managing geological concepts is evident. The most apparent difficulty during the post-tests regarded the

identification of samples of rocks. One of the most common errors concerned the distinction between the magmatic and siliciclastic rocks because of the similarity between the structure of magmatic rocks and texture of sedimentary ones that are composed respectively by minerals/grains. Both have been considered by young students as aggregates and it is not easy to distinguish between fractional crystallization and sedimentation/lithification genetic processes.

The most interesting improvement was obtained in geomorphology and especially in the integrated vision of geomorphology and geological settings and the relationship with human settlements (Fig. 7) (52 % to 74% of right answers). Especially good results were recorded in the comprehension of typologies of river courses and their relation with the outcropping lithologies that were exposed in fieldtrip stops 1, 2 and 3. The results are especially meaningful for Class 1, which attended the whole educational programme. Class 1 demonstrated better results in questions that were faced during the fieldwork thanks to the concepts acquired during the previous laboratory activities (Fig. 8), as in the case of *ophiolite*s, where an overview on plate tectonics and the environmental origin of this kind of stones is desirable. In fact, Class 1 obtained a better result (85% of right answers) in respect to Class 2 (33%). In this way, the already explained concepts can be fixed during the fieldwork. Less contrasting but at the same time meaningful are the questions regarding lithological control on landforms (Class 1: 72%; Class 2: 60%) and dendrochronology (Class 1: 65%; Class 2: 48%).

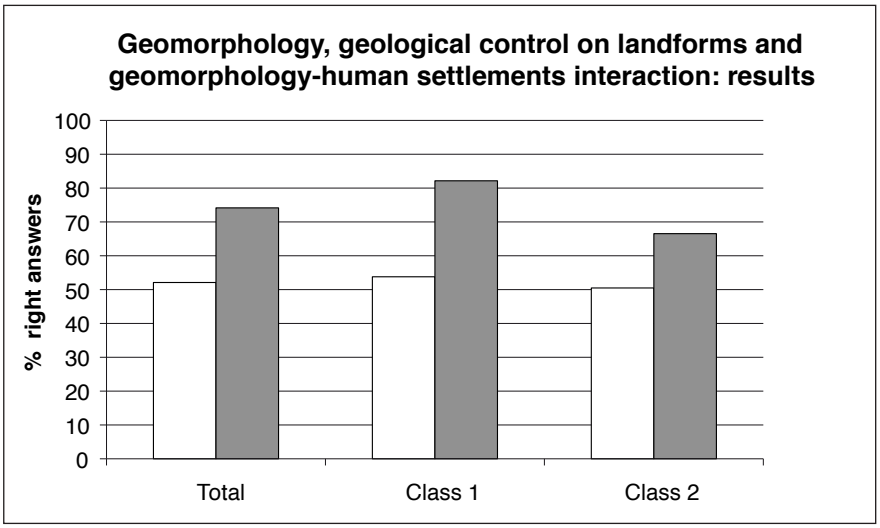


Fig. 7: The improvement in Earth science perception by the pre-test (white) to post-test (grey) results for Class 1 and Class 2. The results concern the questions regarding geomorphology (fluvial modelling processes, erosion, transport and deposition; San Salvatore and Barberino Gorge), geological settings (lithological control on fluvial landforms) and interactions and relations with human settlements (the case of Ponte Gobbo).

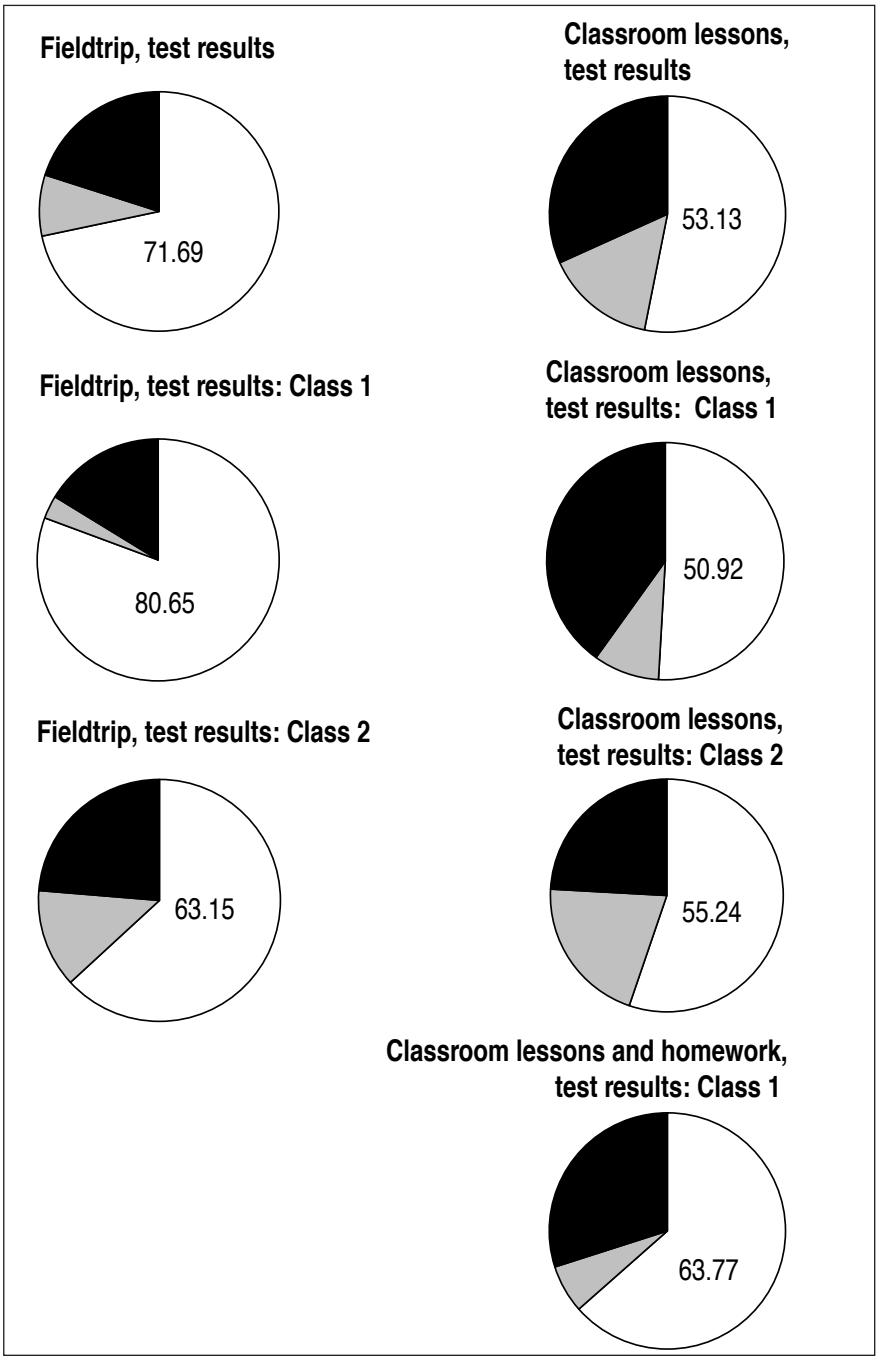


Fig. 8: Results of fieldtrip (left column) and lesson (right column) questions. The results are divided in questions that are pertinent to both fieldtrip and lessons. In addition they have been considered at first cumulatively for both the classes, and then they have been separated for Class 1 and Class 2, which followed different educational paths. The answers are considered wrong (black), right (white) and no answer (grey).

An "impressions" section was set to collect the comments about the experience. The most common note was the appreciation of the possibility of having a look at an ongoing process, a concept that is inherent to active geomorphosites. In the specific case, the students demonstrated a great enthusiasm for the activities related to finding all the different pebbles on a fluvial bar in order to highlight the concept of provenance basin. These positive considerations must be related mainly to the possibility of "seeing with their own eyes" the product of geomorphological processes.

Conclusions

Scientific research continuously adds new information to the geomorphological knowledge of different landscape areas, contributing to supplying the basis for understanding phenomena and processes. In the field, geological, geomorphological and naturalistic elements are obvious only to expert eyes. Nevertheless, through simplifications and guided field observations it is possible to give a good scientific formation to different levels of audiences and arise in students an interest about landscape evolution.

The main aims of this project were to test the efficacy of an articulate programme comprehending classroom lessons, laboratory activities and fieldwork as tools for introducing young students to the concepts of time and spatial scales in the landscape evolution. Sites characterised by the presence of active geomorphosites and historical human settlements represent a suitable situation for educational purposes.

The Val Trebbia offers the possibility of working on active geomorphosites through a multidisciplinary approach. As emerged from the results of the tests, the coordination between classroom lessons, laboratories, class activities and fieldwork topics is a powerful tool for fixing ideas regarding Earth Sciences. In order to acquire a complete knowledge of a territory, and more in detail a global awareness of landscape elements and their reciprocal evolution, it appears that a whole educational path, with both classroom lessons and fieldwork, is indispensable. The fieldwork looks important in order to fix all the ideas already acquired in classes. The fascinating aspect of seeing with their own eyes the active processes and the material that the processes model was really appreciated by students, enhancing the role of fieldwork in arousing the interest in Earth science comprehension. As observed by Stumpf et al. (2008) concerning desert geomorphology, the learning results derived by real fieldwork reveal the deepest personal acquisition of knowledge among fieldtrip participants.

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