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Geology and the city: how to effectively introduce Geosciences to high school students.

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ABSTRACT

This study assessed the effectiveness of practical field activities in improving interest of high school students in geosciences and their acquired disciplinary and soft skills. The activity was based on the TOURinSTONES app, allowing users to explore geology of Piemonte region (NW Italy), learn about stone materials in historical monuments in Turin, and develop sustainability education. The open-air-lab trained 250 high school students (aged 16) to observe, describe, and classify ornamental stones in the city centre, acting as geoscientists. A questionnaire was used to assess the efficacy of the fieldtrip in enhancing interest and skills of students. Results show that students were moderately interested in the geosciences, but enjoyed the practical aspect and the "learning by doing" approach. Perception of geosciences did not change significantly, but students gained self confidence in their geoscience literacy. Offering more outdoor activities and demonstrating the contribution of geosciences to a sustainable future could increase interest of students in the subject.

KEY WORDS: Earth Science, fieldwork, ornamental stones, TOURinSTONES app, environmental education.

INTRODUCTION

Geoscience education is an essential part of understanding the world around us. It helps us understand the processes that have shaped our planet and the georesources that it provides (Orion, 2019). Good for this, a direct approach and fieldtrips are important components of geoscience education as they allow students to experience the subject matter firsthand and make connections between theory and practice. Through outdoor education, students are exposed to the real world, thus increasing their ability to focus and enhance cognitive abilities supporting self-directed learning (Weels, 2000).

From a methodological point of view, the discovery of outdoor contexts is characterized by a variety of elements capable of simultaneously activating the three spheres (cognitive, perceptual-motor and emotional-relational) and of promoting meaningful learning (Littledyke, 2008; Hong et al., 2012).

The cognitive sphere is directly connected with sensory perception facilitated by direct contact with the environment, which is discovery and re-discovery with new eyes.

In this way, direct data are collected, the details are analysed, the look at the environment is widened, relationships between different factors are recognized, traces are sought to reconstruct processes and transformations that have taken place over time. All this leads to active movement in the environment, discovering new things, exploring with a new curiosity sites that are part of everyday life and which, for this very reason, allow the visitors to get excited by activating new points of view (Magagna et al., 2018).

Alongside the cognitive sphere, the outdoor environments therefore stimulate the perceptual-motor and emotional-relational spheres. The latter, in addition to what already said above, takes on particular importance when space is given to paths of sharing learning. In fact, sharing experiences helps to build meanings and going beyond one’s own point of view and the relationship with others becomes part itself of an educational path which, instead of closing itself off, opens new paths to follow (Darling-Hammond et al., 2020).

As already mentioned, also the urban fieldtrips are a crucial component of geoscience education as they allow students to sensorially experience geological features, in their natural and urban environment (Kemp, 1992; Wetzel, 2002). Students can observe and explore objects such as rocks, fossils, and human artifacts, which can help them better understand their physical characteristics and reflect on geological processes that have shaped them (Ingold, 2007). Fieldtrips also provide opportunities for students to collect geological data and samples, and potentially study them later on in the classroom, further increasing their knowledge. This experiential learning at informal fieldtrip increases student interest, knowledge, and motivation (Behrendt & Franklin, 2014).

In the case of the TOURinSTONES activity presented to high school students in 2022, the direct discovery of the rocks as important resources for our life is also a great opportunity for discovering the geology of the Piemonte region, the use of stone materials in the historical monuments, and for developing a sustainability education, reflecting on the hidden impact of extracting and bringing those geomaterials to the city centre. The students can spontaneously learn about visible aspects and physical property of rocks and their importance to society. This direct and practical approach can lead to an increased interest in geosciences and inspire the next generation of citizen and scientists.

The Turin fieldtrip activity presented here, takes cue from TOURinSTONES, an application created by the Earth Sciences Department of the University of Turin for smartphones and tablets, available in Italian and English; it describes the main historical ornamental stones used in Turin monuments over the centuries. In this way the app creates an "open-air museum" in the city, offering the user to follow itineraries developing in the city centre and including sites and points of historical and geological interest (Gambino et al., 2019). The app, free and downloadable on iOS and Android devices, is organized into 26 sites and 4 thematic itineraries, in order to provide an overview of the main rocks used in buildings, churches and streets. The app proposes some self-guided geo-touristic walks in the historic centre of Turin that tell some important moments in the history of the city, described by its main monuments, but also by the geological history that, over tens and hundreds of millions of years, has seen the formation of the Alps.

In fact, TOURinSTONES presents the detailed petrographic study of 42 main ornamental lithotypes used in the city of Turin and creates a precise, detailed and uniform catalogue in its contents. The development of itineraries and simplified texts for non-experts can create a bridge between the geology of the Alps and the story and architecture of the city. The language, graphic and structural organization of the app have been designed in a simple and clear way so that the complexity of geological contents can be understood by a wide audience: this tool allows to value and disseminate the urban geological heritage of Turin city centre. Finally, the use of the app conveys the message that rocks are part of the history of the city itself, they build its tangible heritage, and that the choice of the stones used has a specific meaning and value.

In addition, the following have been made available to users in the app: maps with the location of the surveyed buildings, cards containing information on the geographical location, historical-architectural descriptions of palaces, churches and monuments, some important historical notes and an extensive description of the stones used (scientific classification, commercial name, extraction sites, geological framework of Piemonte region and Italy, location of the stone materials in Turin, macroscopic description of the rocks and minerals and, finally, a glossary that provides further insights.

The TOURinSTONES app has been developed to collect and disseminate data and materials on the architecture and petrography of the city of Turin for students and so-called "geotourists". The former are already introduced to geology, science, and art history from the early years in school; the latter are instead people who, for different reasons, are passionate about these subjects. In particular, it allows high school students to be educated in the study of petrography and geology in their own city perusing the cultural and scientific aspects of the main monuments with an interdisciplinary approach.

TOURinSTONES is an application useful to this innovative way of educating and arousing the curiosity of young students and a wider audience than just the academic audience. The technical-scientific study of materials, its popularization and dissemination, the mixing with the cultural aspect and the territory represent a new way to research, educate, and train, to achieve the objectives of the Universities, especially the public engagement.

This study present an new didactic use of this tool, which stems from the originally designed self-education tool (Gambino et al. 2019); the use of the app accompanies the performance of the activity developed for and offered to 16 years old high school students. The new activity, which takes advantage of the app, allows student to get involved with the discovery of stone artefacts around the city and to act like a geologist, describing rocks and learning to interpret them to understand the processes and environment in which they have formed: in synthesis, their geological history and their importance and meaning to society.

This paper discusses the outcomes of the designed field activity, analyzing the answers provided by the students involved in the project, testing the efficacy of the urban fieldtrip in enhancing the students interest in the geosciences and their improved disciplinary and soft skills.

MATERIALS AND METHODS

In this edition of the TOURinSTONES field activity, 250 high school students aged 16, enrolled in the Liceo Scientifico (scientific high school, LSS Volta and IIS Majorana, both based in Turin) were involved in the research. In their curriculum, 4 classes have 6 hours of science teaching per week (including Chemistry, Biology, Geology), the remaining 6 classes have 3 hours.

The activity included an introductory lecture (1 or 2 hours) to 5 out of 10 classes. The lecture was aimed at providing students with the skill of describing and recognizing minerals and fossils constituting all rocks, briefly discussing the processes responsible for their formation, the rock forming cycle, and the different environments in which rocks can form. The lecture also included a general discussion on the importance of geoscience for society. The remaining classes, had brief instruction on how to perform the activity on site.

All classes were invited to join the tour around the Turin city centre, where the practical activities were leaded by 2 to 3 instructors (professors, master and/or doctoral students from the Earth Sciences Department and GeoDidaLab of Turin University). The assigned activity was designed in order to mimic a day-in-the field of a geologist, hunting for rocky outcrops and describing and categorizing the different type of rocks. The students were firstly asked to describe the building components (minerals, fossils, structure and texture etc.) of rocks and recognize 5 different ornamental stones (either sedimentary, metamorphic or magmatic rocks) used in the monuments around CLN square and San Carlo square (see Fig.1 for sites location, number 1 and 2 respectively). The students were provided with a very simplified form to record their observations and their interpretation (color, texture, mineral and fossil components, formation environment, age and name of the rock). The students were also provided with a hand lens to better observe tiny details, such as small mineral grains or fossils. A simplified chart with mesoscale characteristic of the main minerals visible in the monuments (quartz, calcite, K-feldspar, plagioclase, amphibole, pyroxene, biotite, white mica, chlorite) and a flow diagram leading to organize the observations and to categorize the described rocks was used in the field under the guidance of the experts. The students were encouraged to work independently in small groups (3 to 5 individuals) and then each group was joined by an expert, discussing their findings on the ornamental stones observed along the tour. After an hour and half work, a brief recap was offered by the experts and the groups moved on in Roma street (Sites 3 and 4 in Fig.1), to discover more ornamental stones, limiting their observation to sedimentary-fossil-bearing rocks, focalizing on extinct fossils and familiarizing with how assign age to rocks; they were also asked to fill a new form with their observations and interpretations, recording specific characteristics of the sedimentary stones visible in Roma street (color, grain size, fossil content, depositional environment, age, name). Again, all groups were helped by the experts in fulfilling their tasks.

Fig. 1

In order to evaluate the effectiveness of our practical activities in improving the interest of students in the geosciences and test their satisfaction and engagement in the field activities, an anonymous online questionnaire was designed, to be filled before (indicated as PRE in Fig. 2a) and after the activities (indicated as POST in Fig. 2a). All questionnaires were presented to the students by their teachers, who agreed to take part in the survey. General anagraphic data (Male/Female) were also collected. The questionnaires were aimed at testing if the field activity could raise the interest of students on the geosciences (Fig. 2a), whether they gained disciplinary and soft skills during the practical activities (Fig. 2a, Fig. 3a, and Fig. 3b). The students were also asked when was the activity included in the school curriculum (introductory, in the topic on the rock cycle, after the lessons dedicated to rocks, or if it was not linked to the curriculum at all; Fig. 2b). With regard to disciplinary skills, the questionnaire tested the confidence of students in recognizing a (sedimentary) rock in picture (Fig. 3a). With regard to soft skills, the interest roused during the fieldtrip was tested (Fig. 3b) and wether the students would feel confident to lead a similar activity among their peers and why (open question; Fig. 4a and Fig. 4b). Among students from the LSS Volta only the degree of usefulness of the introductory lecture was also tested (Fig. 4c). Finally, the students were also asked to give their opinion on how the fieldtrip activity could be improved. To standardize the answers and the processing of the data, most of the questions were offered the students with a Likert type scale of 5 answers (from disagree, to totally agree) to the relevant sentences (as an example: The fieldtrip in the centre of Turin has been interesting).

Fig. 2

RESULTS

The students from the two schools were in total 250, 139 from LSS Volta, 111 from IIS Majorana. Of those, 199 (101 male, 98 female) responded to the PRE questionnaire, 140 (76 male, 64 female) to the POST. Filling the questionnaire was not mandatory, and this justifies the discrepancy between the students involved and the answers obtained.

In the PRE questionnaire the students were asked their generic interest about the geosciences (Fig. 2a); 20% declared no or very low interest, 38% high to very high interest, and 42% had no clear interest (as for the LSS Volta, 21%, 35%, and 44% respectively, whereas for the IIS Majorana 19%, 43%, and 38%, respectively). In the POST questionnaire, 23% declared no or very low interest, 33% high to very high interest, and 44% had no clear interest (as for the LSS Volta, 23%, 33%, and 44% respectively, whereas for the IIS Majorana 23%, 34%, and 43% respectively) (Fig. 2a).

Most of the answers come from the POST questionnaire. The students answers about how was the activity included in the school curriculum (introductory: 36%, in the discourse on the rock cycle: 21%, after the lessons dedicated to rocks: 19%, or if it was not linked to the curriculum at all: 24%) clearly show that the activity was mainly intended by the teachers as an introduction to the topic of the rock cycle and rock categorization (Fig. 2b). In detail, at LSS Volta, the activity was performed as an introduction to the topic for 25% of the students, during the discourse on the topic for 16%, at the end of the subject for 25%, and was part of a separate learning activity for the remaining 34%. As for the IIS Majorana, the fieldtrip was mainly intended to introduce the topic of the rock cycle and minerals (53%), or during the discourse on the topic (30%), only few (8%) after the completion of the lectures on the topic or as an independent learning activity (9%). In some cases, the independent learning activity was interdisciplinary, also involving the Art teachers (2 classes from LSS Volta). In fact the teachers asked the students to observe and describe rocks used in the main monuments of the city centre, and investigate the relationship between ornamental stones, architecture and society (provenance and manufacture of the stones).

In order to test the disciplinary outcome of the activity, the students were asked to categorize a rock sample shown in a picture (Fig. 3a). They had to select among 4 options (Sedimentary, Metamorphic, Magmatic, I don't know) and motivate their choice. In general, most of the students were able to identify the sedimentary rock shown, and correctly motivate their answers, since their most common reply contained the word *fossil*. Among those selecting the answer *metamorphic* (14% from LSS Volta, 7% from IIS Majorana), their motivation was "I see a layering", possibly mistaking fossils as large minerals.

Fig. 3

As for the general perception, the majority of the students were interested in the field activity (Fig. 3b; 60% high and very high interest, 25% neutral, 15% low or no interest). The students from LSS Volta were the more interested (65%; 16% neutral; 18% none or little interested), whereas among those from the IIS Majorana the share of students with a neutral attitude increased (37%), even if the share of those with low or no interest show a partitioning similar to the LSS Volta. Half the students from the IIS Majorana demonstrate a high and very high interest (50%) in the fieldtrip activity (Fig. 3b). To better understand whether the students were highly involved in the fieldtrip, we also asked them if they felt confident in reproducing the field activity among their peers. In general, most students felt very confident (75% answered yes), and those from IIS Majorana more than those from

LSS Volta (87% and 65% respectively; Fig. 4a). Students were also asked to comment on their answer, and the most common reply (Fig. 4b) contained the words *interesting*, *knowledge*, *rocks*, *city* (*centre*), *experience, peers*, *discover*, *observe*, *share*, *watch*, *beautiful*, *learning*, *monuments*, *provenance*, *everyday, Earth*, *environment*….

Fig. 4

One additional question was asked to the students of the LSS Volta only, who had an introductory lesson by expert geoscientist to the field activity (1 or 2 hours, depending on the choice of their teachers). The questionnaire checked if the students felt that the lecture was useful to them (Fig. 4c): 55% answered useful or very useful, 32% neutral, 13% think the lesson was of little or no usefulness.

Finally, all students were asked to provide suggestions on how to improve the quality and organization of the fieldtrip (open). This resulted in many positive comments (good/interesting/useful as it is), but also some requested and suggested improvements such as a longer and more detailed introductory lecture and practical lab before going in the field, improved didactic material (students were provided with the slides used in the lecture, the flow chart used in the field, the plate presenting the essential macroscopic characteristic of 10 common rock forming minerals), extended number of lithotypes during the fieldtrip, engaging the groups in a competition while describing and recognizing the different lithotypes, visiting different sites, adding a fieldtrip to observe rocks in the natural environment, providing more information about the use of the stone materials in the buildings, providing more tutors (in some fieldtrip the number of groups largely exceeded those of the tutors), make the fieldtrip during a good weather day, organize the fieldtrip during school time (some fieldtrips were held, in agreement with the teachers, outside the regular school time).

DISCUSSION

Considering that answering to our PRE and POST questionnaires was not mandatory, the number of replies was significant; 79.6% of the students taking part in the research responded to the PRE questionnaire, administered just before the activity (the introductory lecture for the students of LSS Volta, the fieldtrip to the city centre for those of IIS Majorana), while those responding to the POST questionnaire sum up to 56%. Possibly the reduced participation in the second step of the survey, administered by their teachers in the days following the activities, was linked to the fact that the activity was over and their interest was reduced. Little shift in the general interest of the students in the geosciences is found (Fig. 2a), since before the fieldtrip 38% of the sample was interested in the geoscience, while after the activity this number is slightly reduced (33%). It follows that most of the students had a good self-representation of their attitude and were aware of their liking or disliking the subject in general. As for the two schools, LSS Volta students seem to be more self-aware of their attitude and only a small percentage changed their mind (2%), while among students from the IIS Majorana those disliking or indifferent to the geosciences increased by a 9%. Moreover, the students show a good interest in the geosciences (33%), not related to the number of hours dedicated to the subject in the Italian high school curricula (Bonaccorsi et al., 2020), nor in the frequency of appearance of the subject in generalist media such as TV, radio and social media.

In general, the fieldtrip was mainly intended as an introduction to the students about the rock cycle (Fig. 2b), rock description and rock classification (36%). The fieldtrip preceded the curricular lecture by their teachers for most of the students from the IIS Majorana (53%), signifying that the fieldtrip itself was the main source of information for learning how to describe rock components (minerals, fossils..), classify rocks in to metamorphic, sedimentary or magmatic, correctly identify the processes leading to their formation, and assign an age (sedimentary rocks only). On the contrary, most students from the LSS Volta already had an introduction about rocks by their teachers (41%) or the activity was not program-integrated (34%), but intended as a complementary interdisciplinary activity devoted to the deepening of the relationship between the monumental architecture of the city and its building stones, as requested by the teachers. These data are of great interest if compared to the outcome of the disciplinary question, asking students to recognise a sedimentary rock full of fossil shells from a picture (82% correct answers; Fig. 3a). In fact, students from the IIS Majorana, who had not much prior knowledge of the rock cycle and rock classification before the fieldtrip, had a much better result (87% correct answers) then those from the LSS Volta (79%). Of course, the general outcome is that the activity mostly made the students able at discriminate a rock sample from a picture, but an even better result was expected, since the sample was hardly mistaken for a magmatic or metamorphic rock (Fig. 3a). Among those who stated the rock was metamorphic, some students declared that they saw layering or a planar texture. In this case they mistook the stratification highlighted by the fossil shells as a layering, and the shells as large minerals. This could be due to the fact that many ornamental stones in Turin are gneiss, and most of them show a gneissic banded texture. In fact, in the CLN square, all students observed and described the typical Serizzo gneiss (back of San Carlo Church, fig 1 top right). As a general comment, one might reflect on the possibility that the answers of the students from LSS Volta were also affected by incorrect preconceptions (=preconceived notions), since most of them had two different introductory lectures, firstly from their teachers, and secondly from the expert introductory lecture, that may have had a different approach and thus caused some confusion to the students. Instead, students from the IIS Majorana had only the instruction given by the expert during the fieldtrip to observe, describe and categorize rocks, and no preconceived notions confused them in the identification of the sample shown in the picture.

The students in general showed a good interest in the field activity (60%), with students from the IIS Majorana least interested (50%) and those from LSS Volta most interested (65%). This datum, if compared to the declared interest in the geosciences, both before and after the practical activity, is very striking, since it suggests that, despite only about 1/3 of the students has an interest in the geosciences, at least half of them was interested in the practical activity with ornamental rocks. This in turn suggests that a "learning by doing" and "hands on" approach to the Earth science subjects is better appreciated by the students and thus could be implemented in the curricula to improve the geoscience literacy among young persons (Mogk & Goodwin, 2012; Guertin, 2014; Ferrero & Magagna, 2015; Van Loon, 2019). In Italy this practice has been widely restricted in recent years, and most of the teaching is nowdays offered as frontal lectures accompanied by little laboratory time, if any. The interest of the students in the simple research-like activity offered by the TOURinSTONES fieldtrip demonstrates that including such practicals in the curriculum could highly benefit the students in developing their interest, participation and learning oucomes.

This kind of field activity also developed the students engagement, tested asking if they felt able to lead their peers in the same fieldtrip across the city, discovering ornamental stones of the main monuments. Most of the students (75%) felt confident and willing to lead their peers in the same TOURinSTONES activity, with those from IIS Majorana more likely than those from LSS Volta (87% and 65% respectively; Fig. 4a). Compared to the declared interest in the Geosciences (33%) and the interest the students demonstrated in the fieldtrip (60%), this datum is very surprising and suggests that much more students not only liked the experience in the field observing and describing rocks, but they also learnt and gathered all information needed to lead their friends in the same experience. In fact this is demonstrated by the word cloud (Fig. 4b) produced with the most abundant word used by the students to justify their positive choice to lead their peers in discovering the characteristics of the ornamental stones in Turin. Despite the most common words are *interesting*, *knowledge*, *rocks,* as expected, the words *experience, peers, discover*, *observe*, *share*, *watch*, *beautiful*, and *learning*, strongly support the knowledge that the TOURinSTONES experience provided the students with the geoscience literacy and the soft skills (like observing, analysing, interpreting, engage with peers, lead a group) essential to propose their peers to explore and discover a mostly overlooked characteristic of the monumental city centre This outcome could possibly be linked also to the fact that students were engaged in the activity not as individuals, but working in small groups of 3-4 persons. This could have improved their ability to cooperate, listen, discuss and support their own ideas, and ultimately improved their self-confidence in leading their peers in the same experience. Moreover, the use of the word *beautiful* supports the idea that emotional engagement of the students occurred during the fieldtrip, which is in line with main educational research outcomes, that emotional engagement dramatically favour learning in the geosciences (McConnell & Van Der Hoeven Kraft, 2011; Van Der Hoeven Kraft et al., 2011). Finally, the word *everyday* suggest that the students reached the awareness that georesources and geology in general are present in our daily life.

Also linked to the interest in the geoscience and the self-confidence in teaching their peers, is the perception of the LSS Volta students of the usefulness of the introductory lecture given by the expert (55%). This result, coupled with the lower confidence of these students in the identification of the sedimentary rock and in leading their peers, suggests that it is very important to design the activity with the teachers and to provide coherent instructions (i.e. introductory lecture) to the students. In fact, the lower rate of correct answer and self-confidence gained by the LSS Volta students could be linked to the double introductory lecture that many of them (31%) had, from their teachers and from the expert. The simple instructions provided by the expert prior to the fieldtrip would probably be sufficient to take part in the activity, and could greatly serve to improve geoscience knowledge deepening in the following classroom activities lead by the teachers (Van Der Hoeven Kraft, 2017).

Finally, the students provided us with few suggestion on how to improve the activity. Despite most of the comments were very positive, stating that the fieldtrip was agreable (good), interesting, and useful as it was organized, most suggestion deal with the desire of having a better knowledge before going in the field (longer or more detailed introductory lecture), and with the desire to increase the number of rocks observed along the itinerary, demonstrating that, all in all, the activity had raisen their interest on the ornamental stones and possibly on other geoscience topics. This improved interest is also suggested by the request of visiting natural environments and observe and describe rocks in place. This contrast with some critics about the weather ("good weather day for the fieldtrip"), pointing our attention to the fact that young generations have a conflicting approach to the natural environment: some of them are keen of exploring it, while others fear non optimal weather conditions, demonstrating their detachment from the environment of which they are a part. This is also due to the poor aptitude for outdoor teaching of many secondary school teachers who, for reasons of time, organisation, safety, or collaboration with other colleagues, prefer indoor teaching with little engagement in practical activities. This must be a warning to educators, since several lines of research suggest that outdoor education is much more effective, engaging student's emotions (Weels, 2000), and should spur to increase such activities in the didactic curricula. Finally, since this practical activity was organized by their school but outside school hours (according to some teachers: "in order not to take time away from the programme"), the students asked to preserve their free time, thus revealing that they perceive the time dedicated to field activity as subtracted from one's "free time". This could be a partial cause of the lower interest of some classes.

CONCLUSION

In this work the efficacy of the fieldtrip activity TOURinSTONES, stemmed from the homonymous app designed by the Earth Sciences Department of the University of Turin, was tested. The activity was offered to the high school in Piemonte region to demonstrate that ornamental stones in the city centre provide an outdoor laboratory well suited to introduce the geosciences to high school students and raise their interest on the subject. The students show a moderate general interest in the geosciences, prior to and following the experience in the field. But the same students are very interested in the practical activity, and seem to enjoy the “learning by doing” approach and working in groups of peers. Their general perception of the geoscience didn't change after the experience, but they were clearly very interested in working as a scientist, discovering the different stone materials of the monumental buildings of the city of Turin. This resulted in a good disciplinary learning, as suggested by the correct identification of an unknown rock sample, but more interesting in a strong personal engagement, resulting in the self-confidence of leading their peers in the same activity. No apparent benefit is given by the introductory lecture provided by the expert, and the activity results to be well supported by the didactic material provided. In contrast, it could be interpreted that, when students are introduced to the rock cycles, rock identification, and rock forming processes by their teachers and by the expert, this could lead to some confusion and preconception, suggesting that the accurate integration of curricular didacticals and of the expert lecture is essential to achieve a better disciplinary outcome. Nevertheless this does not hinder the positive perception of the fieldtrip by the students, who enjoyed working “hands on” and gained sufficient knowledge and self-confidence as to lead their peer in the same experience.

Since most of the high school classes hardly gain experience in the field, even though this is the real geological laboratory *par excellence*, the activity developed from the TOURinSTONES app offers the opportunity to fill this educational and experiential gap, and provides students with the possibility of working “like a scientist”, even if for a short time. To strengthen the students engagement derived from this experience and increase their interest in the geosciences, more outdoor activities able to engage and trigger emotions should be offered to high school students, involving also different geological subject, and showing how the geosciences are important in imaging and realizing a sustainable future (Gerbaudo et al., 2022).

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Figure captions

Figure 1. TOURinSTONES itinerary in the city centre, and two example of monuments investigated: back (top) of the San Carlo church in CLN square (1 on the map) and front of Santa Cristina church in San Carlo square (2 on the map). Other site of interest cited in the text: Roma street (3 and 4 on the map).

Figure 2. a) Cumulative interest on geosciences reported by the students, for LSS Volta, and for IIS Majorana. b) cumulative integration of the activity in the school curriculum, for LSS Volta, and for IIS Majorana.

Figure 3. a) Student confidence in recognizing a sedimentary rock sample from a picture. Cumulative results are shown (all), together with those for LSS Volta, and for IIS Majorana. b) appreciation of the fieldtrip: cumulative (all), for LSS Volta, and for IIS Majorana.

Figure 4. a) Cumulative (all) likeliness to lead peers in the same activity, for LSS Volta, and for IIS Majorana. b) word cloud of the main reason indicated. c) cumulative perception of the usefulness of the introductory lecture by expert (LSS Volta only).

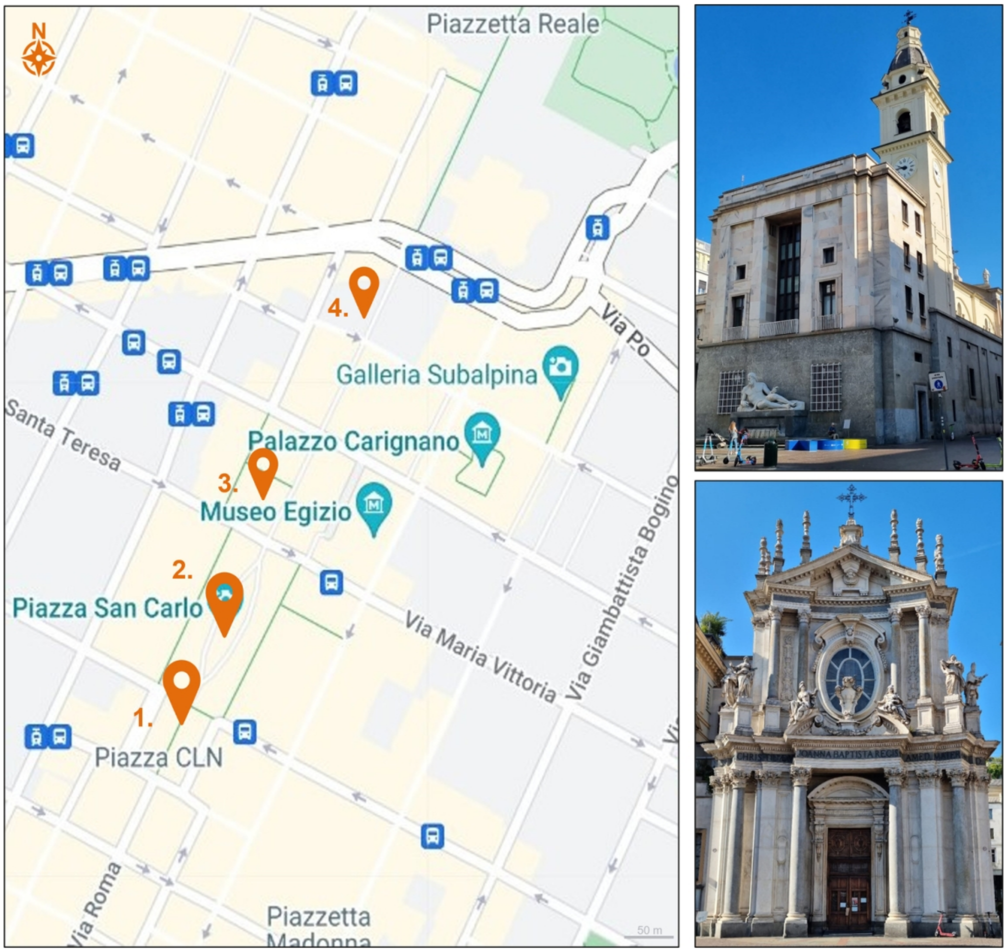

Figure 1. TOURinSTONES itinerary in the city centre, and two example of monuments investigated: back (top) of the San Carlo church in CLN square (1 on the map) and front of Santa Cristina church in San Carlo square (2 on the map). Other site of interest cited in the text: Roma street (3 and 4 on the map).

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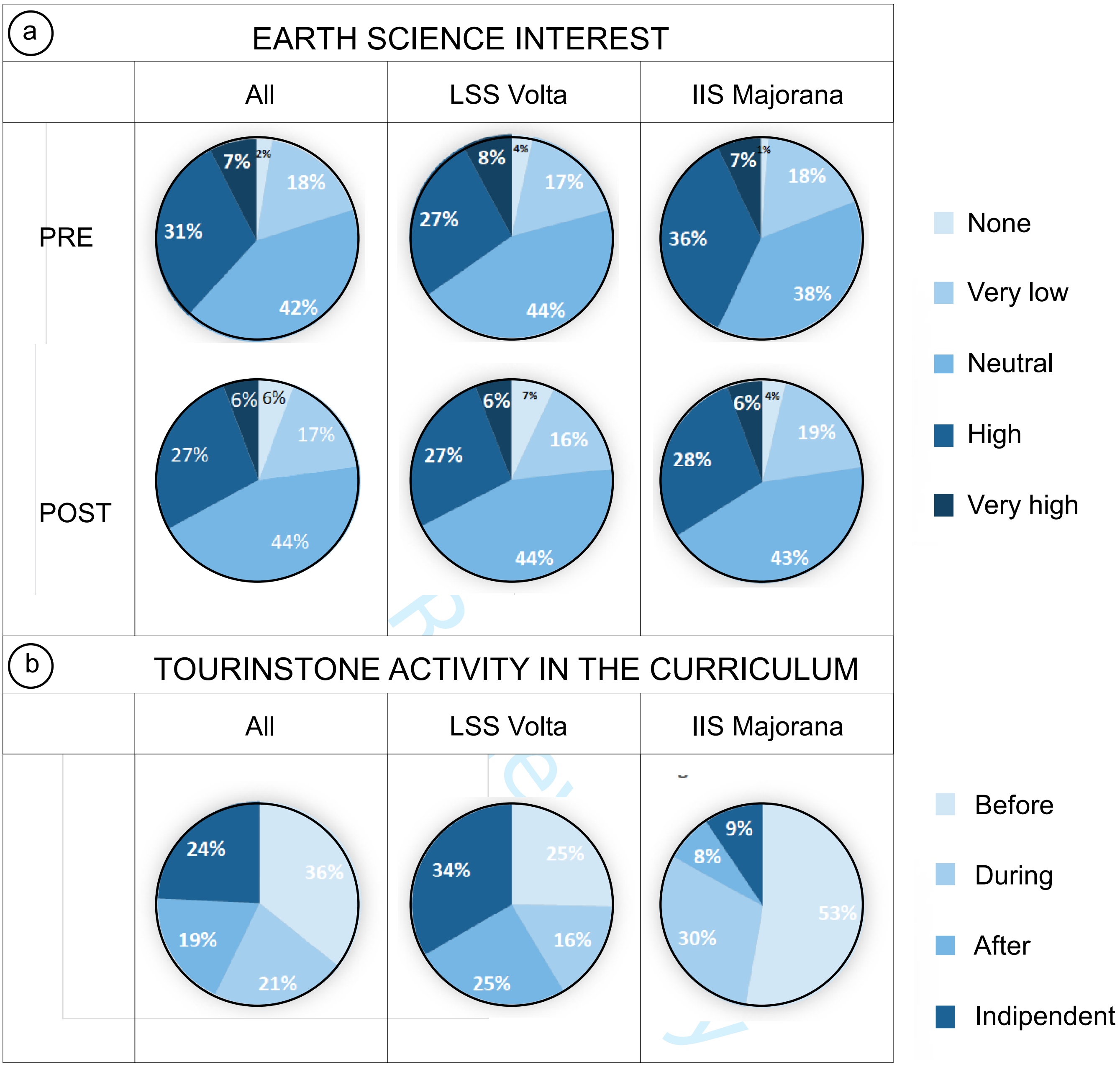
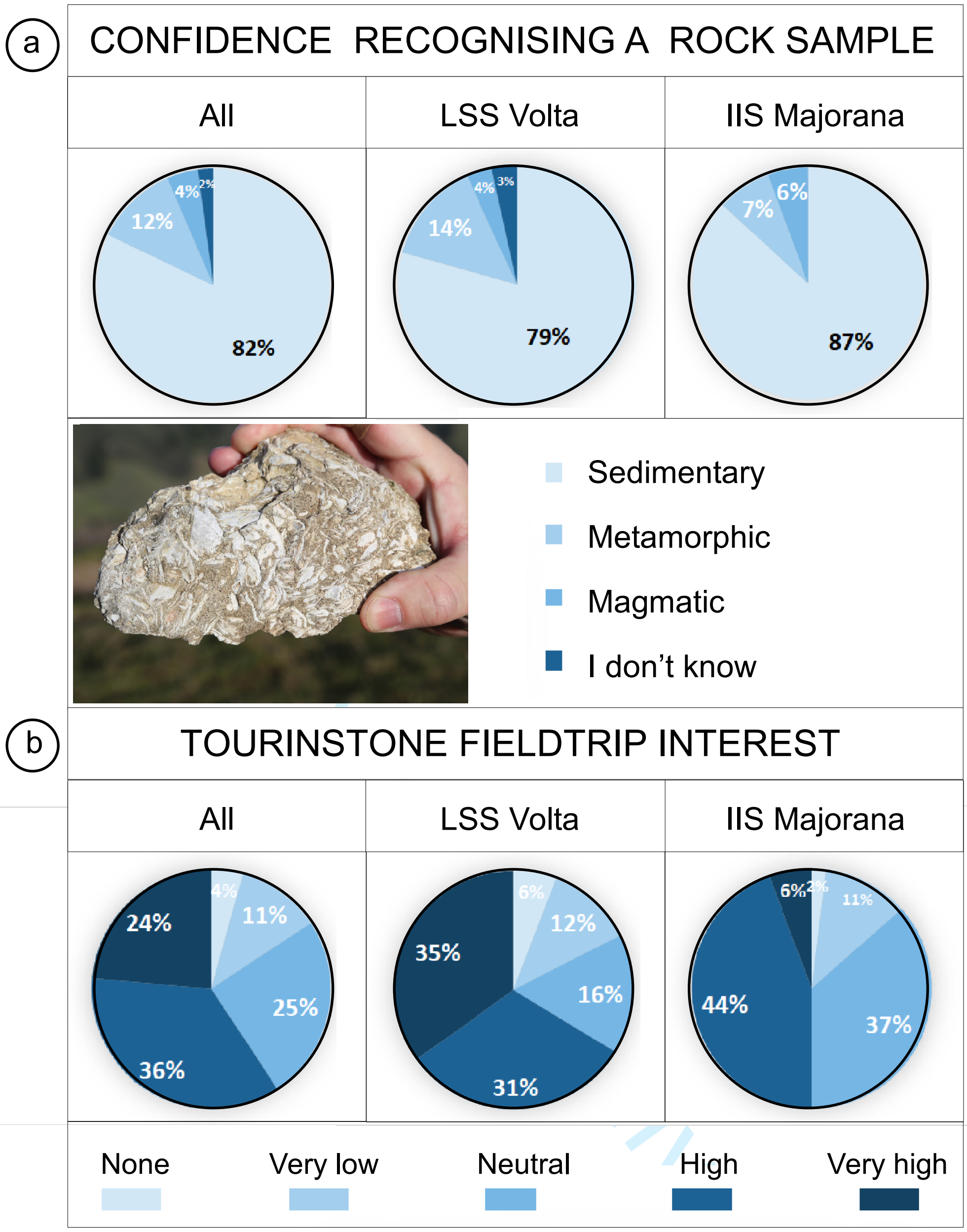
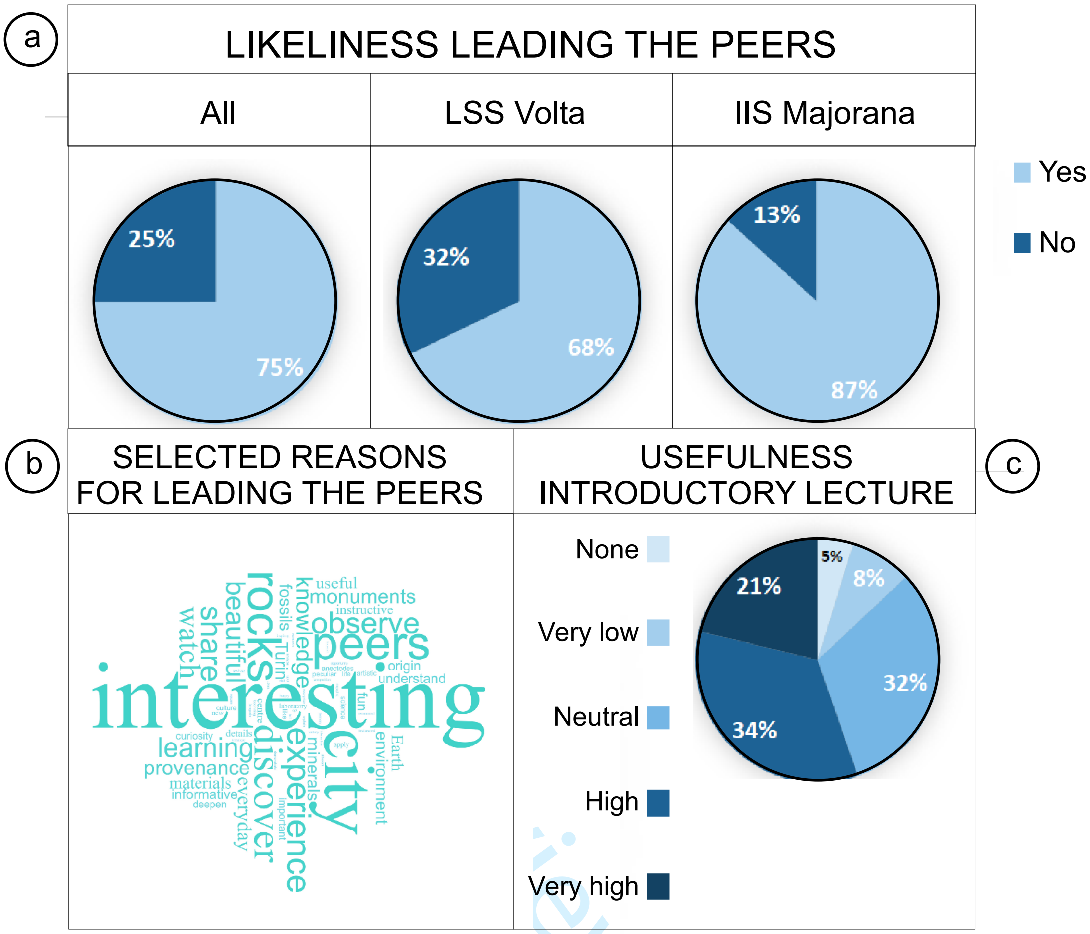

a
EARTH SCIENCE INTEREST
All
LSS Volta
IIS Majorana
PRE
POST
7%
2%
18%
31%
42%
8%
4%
17%
27%
44%
7%
1%
18%
36%
38%
6%
6%
17%
27%
44%
6%
7%
16%
27%
44%
6%
4%
19%
28%
43%
None
Very low
Neutral
High
Very high
b
TOURINSTONE ACTIVITY IN THE CURRICULUM
All
LSS Volta
IIS Majorana
24%
36%
19%
21%
34%
25%
16%
25%
9%
8%
53%
30%
Before
During
After
Indipendent


a
CONFIDENCE RECOGNISING A ROCK SAMPLE
All
LSS Volta
IIS Majorana
82%
12%
4%
2%
79%
14%
4%
3%
87%
7%
6%
Sedimentary
Metamorphic
Magmatic
I don't know
b
TOURINSTONE FIELDTRIP INTEREST
All
LSS Volta
IIS Majorana
24%
4%
11%
25%
36%
35%
6%
12%
16%
31%
6%
2%
11%
44%
37%
None
Very low
Neutral
High
Very high


a
LIKELINESS LEADING THE PEERS
All
LSS Volta
IIS Majorana
25%
75%
32%
68%
13%
87%
Yes
No
b
SELECTED REASONS FOR LEADING THE PEERS
interesting
city
rocks
peers
observe
monuments
useful
instructive
knowledge
fossils
Turin
beautiful
share
watch
origin
understand
fun
Earth
environment
minerals
experience
discover
everyday
learning
provenance
materials
informative
curiosity
details
deepen
important
c
USEFULNESS INTRODUCTORY LECTURE
None
Very low
Neutral
High
Very high
5%
8%
32%
34%
21%