ISSN: 2639-7455

Research Article

Earth & Environmental Science Research & Reviews

The Data Mining Test: An Unexpectedly Effective Tool to Promote Soft and Hard Skills, In Earth Sciences

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Submitted: 12 Jun 2022; **Accepted:** 20 Jun 2022; **Published:** 25 Jun 2022

Citation: *SS.Occhipinti (2022). The Data Mining Test: An Unexpectedly Effective Tool to Promote Soft and Hard Skills, In Earth Sciences, Eart & Envi Scie Res & Rev. 5(2): 34-43.*

Abstract

This article presents a recent experience of the serialization of new educational tools and approaches, which became necessary because of the pandemic, and the need to work online. As it is well known, the use of 'distance learning' has had several consequences. It has required everyone, teachers, and students alike, to acquire new digital skills: it has entailed psychological disadvantages, such as social isolation, and didactic-educational ones, such as a lack of transparency in the recognition and certification of skills, knowledge, and abilities, which are difficult to measure behind a screen. But it has also required teachers to renew their methodological approaches and to make the best possible use of the tools offered by the new technologies.

In Earth Sciences, as in many other disciplines, the frontal approach is the easiest and traditionally most used, especially in front of a silent and dark screen, where the students on-line are represented just by letters or symbols, but it is certainly the least effective in engaging and exciting students. The endless virtual tools available on the web, films, animations, presentations can partly help the teacher to overcome this obstacle, but they cannot replace educational approaches of active teaching, which allow to develop the students' interest in this field of knowledge and promote skills.

In this research we aimed to build models and paths that use data readily available on the web, such as maps, apps, images, useful for the development of hard skills related to Earth Sciences, but also soft skills, such as critical thinking, problem solving, digital literacy, increasingly required in the world of work.

The tool used is the Data Mining Test, a tool that requires commitment and practice in its implementation but is very effective. The research is underway, but the results of the first experiments are proving interesting.

Keywords: Data Mining Test, soft skills

Introduction

The purpose of this research is to present the results of a process that has been developed in recent years, consequently to the need to use new educational tools imposed by the pandemic. This has required a great deal of effort on my part and a new point of view because my personal experience in the teaching-learning process and in the outreach field, with the aim to raise awareness of Earth Sciences, prompted me to develop particularly easy-to-use, hands-on tools, as they allowed to develop skills different from those, that students acquired using new technologies. In addition, I had to verify that not only the students have greater skills than I have in the field of new technologies and therefore I was hardly able to present and even less to build tools that really attracted their attention, but above all that their daily use of these tools made them 'ordinary". The film, even of a spectacular event, hardly caught their attention and it was even more difficult to invite them to reason, to analyze the phenomenon, to develop hypotheses and generalizations.

In my many years of experience, the use of hands-on tools, complex, rough, or even trivial, the application of problem-solving approaches, case analysis, tools and methods that were not exclusive, but embedded in a fragmented and varied lesson made teaching and learning more effective. Manipulation, observation, analysis, reasoning, abstraction, typical steps of a problem-solving process, have been developed through the creation of models to be built, touched, verified, with which to simulate phenomena through non-Galilean paths [5], as they are not repeatable, not reproducible as volcanoes, landslides, earthquakes, meteorological phenomena, climatic variations, and related consequences.

Over time, different paths have been tested with overall positive results, always with investigative and problem-solving approaches, but using digital tools. Paper and digital maps were compared, as well as the observation on site with aerial photos, finally landslides were studied with the use of all available online resources, but always integrating hands-on-tools. The need to use "distance learning", because of the lockdown imposed by the pandemic, has required experimenting with new tools. Moreover, the web offers almost infinite resources, data, maps, cards, virtual 2 and 3D models.

This research, born on the occasion of the National and International Olympiads of Earth Sciences, which required to carry out tests using online resources, continued trying to develop a test model,which required students to extract data, then to carry out a Data Mining Test, in compliance with already formalized international standards already applied in particular in ICT and engineering (2,3,8), while it was not possible to find bibliography in the Earth sciences field. The aim of the research is to develop models easy to be implemented, which could use digital data of simple and open accessibility, easily analyzed by students, of varying complexity for the different levels of school, but that would prove to be effective for recognizing students' skills.

In consideration of the type of test, which already provides data, not much knowledge is required, while hard and soft skills are required, recognized, and certified. The student is required to be able to recognize and build relationships, but also to identify useful data and distinguish them from redundant ones, connect the causes of phenomena with their effects, identify significant variables, solve problems, as well as know how to communicate effectively, respect deadlines and even know how to work as a team. Experimentation is underway, but the first data are proving interesting and effective results.

A Brief Overview: Difficulties in the Teaching-Learning of Earth Sciences

Numerous studies and related publications in the field of Earth science education, particularly in Italian schools, but also in other contexts, have shown how this discipline remains, even though environmental problems are increasingly evident and, on the agenda, little and badly considered, even though numerous goals of the 2030 Agenda refer to environmental issues, entirely consistent with the aims of teaching Earth Sciences, while precisely through this teaching they could raise awareness and sensitivity among students and civil society.

In various articles and research, I have highlighted how the lack of culture of geosciences has important consequences: in the collective sensitivity towards environmental problems, in the perception that natural phenomena, the same natural disasters are part of the inevitable transformation process of the Earth's surface, in the awareness that anthropic action is an acceleration factor of this natural evolution. The responsibility for this lack of sensitivity is largely attributed to the school, where Earth Sciences remain at the lowest rung of the science hierarchy, but also to other causes: the fragmentation of the disciplines that make up the Geosciences, each with its own specialists , the lack of a solid epistemology, the Nature of science which, despite its complex nature, as it is made up of disciplinary branches closely intertwined with each other, has not yet managed to build a culture of complexity, which, moreover, is its node founding. Understanding the concept of complexity, recognizing the relationships that bind the different natural systems together, identifying the interweaving that exist between disciplines, regardless of scale, space, and time, are fundamental skills that can grow through the study of geosciences.

It is worrying, and surprising, to discover that geoscientists themselves are sometimes not aware of the potential of the discipline: while obviously aware of the scientific value and importance of research in all fields of geosciences, perhaps concentrated on the focus of "hard contents" of the discipline, do not grasp the educational and skill-building value, hard and soft. Perhaps there is a need to change the point of view of the teacher, of the science communicator, there is a need for a broader vision, perhaps a little blurry of scientific content, but more aware of the educational and training value of the skills that can be derived from the teaching-learning process of the geosciences. In previous works [3, 7] it has been possible to demonstrate the effectiveness that teaching activities in the field of geosciences, proposed with enquiry methods, using inductive approaches such as problem solving, going beyond the historically established scientific method, can increase significant competences in students, which can be used both in the field of geosciences and across disciplines, as well as in soft skills. The use of hands-on, laboratory activities, and operational tools as input for the analysis of cases, for the formulation of *driving questions*, for the construction of learning paths and processes, and for the acquisition of skills was effectively interwoven with the methodological approaches tested. But the pandemic context has imposed new challenges.

Looking for effective use of online resources.

The wealth of tools available on the web has often been pointed out to me as a more effective alternative to the laboratory practices that I have experienced and practiced for a long time. It is undeniable that the web offers infinite tools, easily accessible, easily used, easily transformed into learning objects. Observing a video of a volcanic eruption, the devastating effects of an earthquake or a tsunami, simulating orogenesis or plate movements in the context of global tectonics are undoubtedly effective tools for understanding phenomena and effective objects of learning, if of course observation is followed by moments of in-depth study or schematization aimed at understanding, analyzing, synthesizing, abstracting, and generalizing the phenomenon, and then arriving at memorization.

If it easy to understand how the same tools enable the acquisition of skills, hard ones, closely linked to knowledge, but also soft ones, much more difficult is to monitor the knowledge and skills acquired. The use of online Google forms, the sending of screenshots of students' papers to the teacher were widely used tools:

but something did not work if knowledge levels are proving inadequate, if the necessary skills are partially or even completely absent. It was necessary to find different tools, by looking around and perhaps turning to the world of work, where knowledge, but even more hard, soft, and transversal skills were required. The need to carry out some necessary online tests, such as the national phase of the Earth Science Olympiad, the practical, manipulative, field test, which I have been involved with for some time, and which under the conditions of the moment could certainly not have these characteristics, required experimenting with new resources.

Previously it was possible to verify that online tools, so easily accessible to students, such as Google Earth or Google Maps and the infinite opportunities they offer, are not so friendly to students, who rarely make effective use of them, except for passive use: to be guided, to receive information, times, distances..., to locate even famous places that their lack of knowledge of geography does not help them find [7].

So, I started using resources accessible online, downloadable from various geoportals, maps, maps from historical archives: geological, geomorphological, risk, spatial and environmental information. It is relatively easy to obtain information elements, among all those available, because they are grouped by thematic category, by type of resource and by period of publication. Obviously, just as in front of a thematic map the students found themselves in difficulty at first glance, less or more serious depending on the themes proposed, also in front of new tools, albeit conveyed through technologies, PC screens, in daily use and of which they feel 'masters', they needed time and support to 'metabolize' the resource. In addition, it is necessary to transform these resources into effective assessing and evaluation tools, through the implementation of tests, possibly easily constructed, for transparent and objective evaluation of both knowledge and skills.

Previous Experiences: Data Mining as a Possible Solution

A huge amount of data is available on the web, data that however requires powerful tools for analysis and processing, either through dedicated software or simply through the human mind. This dualism has been described in some specialist literature as *a situation rich in data but poor in information, hence knowledge.* There are databases and data warehouses full of data, but the overriding need then becomes how to analyze the data [2, 3, 8].

Data mining emerged in the late 1980s and continues to flourish in the new millennium. In all areas of knowledge, science in particular, scientists and university professors have been researching, analyzing, and finally developing tools to go from data to knowledge. Data mining, literally from the English data extraction, is the set of techniques and methodologies aimed at extracting useful information from large amounts of data (e.g., databases, data warehouses, etc.), through generally automated or semi-automated methods for scientific, commercial, industrial, or operational use, techniques and tools that enable companies to predict future trends and make more informed business decisions.

Data mining is one of the fundamental disciplines of data science that uses advanced analysis techniques to find useful information in data sets. It consists of five main elements:

1. Extracting, transforming, and entering transaction data on the data warehouse system.
2. Storing and managing the data in a multidimensional database system.
3. Clean, prepare and transform data.
4. Data analysis by modeling, classification, and prediction.
5. Presentation of the data in a useful format, such as a graph or table, but also a report or an exposition.

This procedure refers to the process of sorting large datasets to identify patterns and relationships that can help solve business problems through the analysis of these data but can be applied to any type of data if it is meaningful for a targeted application. Finding solutions to problems through data analysis, extracting meaningful data into a database or data warehouse, or even simply into graphs and tables, cleaning the data, analyzing the data through modeling, classification and prediction, and re-processing the data to present it in a useful format, are all steps that require high and specialized skills, information that is useful when selecting personnel, for passing an examination. Therefore, a model was developed and tested by experts in the field to test a candidate's knowledge prior to recruitment based on data mining. It was therefore named the Data Mining Test.

The Data Mining Test in Schools

The literature on DMT is highly specialized, with experience in the selection of high-level personnel, especially in private companies, which require the candidate to be equipped with the necessary skills, hard and soft. In the context of education, obviously, the skills required and therefore the levels of complexity involved are necessarily lower, suited to school levels, age, and objectives to be achieved.

In the teaching / learning process, we can adapt the formal protocol of the DMT to the needs and to the different levels to be developed:

a. research / identification of information, whether a database, a graph, a table, or even a map,
b. analysis of the case, problem, or phenomenon,
c. strategies for identifying useful / required data,
d. identification of links and relationships between information, summary of results,
e. display of the results, through appropriate tools, reports, graphs, tables, or Google forms.

It is therefore a metacognitive / reflective learning process that requires the teacher to identify the most effective methodological approach and the skills that are required of the student, both IT and transversal: understanding of the question, accessing the correct database, graphics, image, analyzing the question, the answers do not necessarily have to be acquired directly from the online data, but may require links, insights, disciplinary skills. Finally, processing and synthesis skills are required to return a clear and complete product, whatever the form of presentation requested or identified as most suitable. The purpose of the research was to identify tools, to build tests that differ strongly from the classic google multiple choice module whose use has spread in recent years, from competitive tests in which a good dose of luck and risk can sometimes be more effective than the ability to reason, understand, analyze, abstract, etc.: building a DMT that meets these needs is not easy.

First, the data available on the web, maps, tables, graphs, images, are only the basis on which to build the assessment and evaluation process. Furthermore, the objectives of knowledge and understanding must be clear, appropriate to the level, to the times, to the foreknowledge. Above all, skills and competences that must be brought into play, promoted, and finally evaluated must be clear and finally, the test construction process must be closely intertwined with the student's measurement / evaluation process

In the construction of this research various examples have been built, tested randomly, with interesting results, but the process of experimentation, analysis and data collection is still ongoing, being a relatively new method of verification, very different from what I have personally experienced.

On the other hand, the experiences, and examples of DMT that can be found in the literature concern very distant fields, such as IT companies, hospitals, from the needs of measurement and evaluation of students in the school context, both by level of complexity and by discipline. Nor is there in this research the presumption of wanting to build models that can be used in contexts other than school and in fields other than Earth sciences. of the various elaborated examples and the numerous experiments carried out, this article presents some cases that have proved to be particularly valid. In the choice of cases, the following was considered:

- the variety of topics,
- the accessibility of data to the various sites through links or the quality of those provided directly in the test - the variety of documents / data available on the same focus, through which it has been possible to develop effective links or construct complex analyzes,
- the different degree of complexity of the tests, in relation to both the skills required and the level / age of the students to whom the test was proposed.

What we have tried to build is a model, a kind of protocol that helps build a DMT, regardless of the data to mine. The first problem to be faced was the search for cases, of geological-environmental problem situations, of which various types of data are available, which consider the "case" from different points of view and with diversified approaches, so as to be able to organize a DMT sufficiently varied and articulated, which requires the student to examine images and recognize significant environmental aspects and characters, to observe tables and to process data, to recognize trends in graphs or functions and to make calculations, to formulate hypotheses .....

Analysis of Some Cases

Some cases are proposed, simple examples that concern different situations, both from the point of view of the phenomenon and the environmental context, and above all from the type of data and the source from which it is taken but structured following the same model. All sources have been contacted in advance to have access to the data, which in any case are public. Obviously, all the data can be downloaded from the web, even if it was considered useful, for the structure of the test, and to "lighten" the text, directly provide some images or cartographic extracts, which at times are not easily downloadable.

In this case, it is not essential that students know the basic elements of the territory, such as its geology, its geomorphological evolution, the factors that may have triggered a particular phenomenon: the passage from chance, to data, to the analysis of problems, the answer is relatively straightforward. Obviously basic notions of Earth sciences are necessary: from global dynamics and orogenesis, to volcanism to glaciations, climatic variations, and global warming; or more in detail the characteristics of a generic landslide, the terminology of the parts and the triggering factors. It is not possible to analyze the data relating to a specific phenomenon if the phenomenon in general is not known.

The Choice of the Location

The examples proposed are relating to the regional territory of the Aosta Valley, because the tests were proposed and students of the territory, and because the data can be easily downloaded or viewed by the regional platforms (ARPAVDA, Functional Center, website of the VDA Region, as better specified for each case), and finally because my knowledge of the territory allows me to identify more attractive and richer in links cases.

However, it is believed that similar databases can be found everywhere, in different regions or countries: it is sufficient to search for them or request access.

Methodological Approaches and Analysis of the Results

Obviously, each DTM can have different characteristics, in terms of duration, difficulty, number of documents and questions. For the cases proposed, a model was used that refers to the literature and to tests already experimented. Each DMT requires approximatively 45 minutes; to be solved, uses a variable number of documents, links, images, not exceeding 6, and is made up of not more than 20 questions, which can be open or closed questions. The proposed cases are examples and of course are not described in detail but for guidelines, but many others could have been tested and could effectively represent useful examples. The phenomena that characterize them are in fact well represented and allow numerous predictable and unpredictable connections with other phenomena of the Earth Sciences, as well as with other areas of the natural sciences and with strong relationships with human history. They were tested with volunteer students with interesting results, both to assess the level of skills and the effectiveness of the test itself.

1st example: Global Warming and Impact on a Glacial Reservoir

general theme: *global warming and its impact on water reservoirs through the analysis of a glacier whose data is known, as it is one of the most studied glaciers in the region, the Rutor Glacier.*

The case

The Rutor glacier, in the Piccolo San Bernardo Mountain sector, with its 8.4 km^2 surface area is the third largest in Valle d'Aosta and one of the most representative in terms of geographical position, morphological and glaciological characteristics. The Rutor glacier is located on the northern slope of the homonymous relief and has a north-northwest exposure. It occupies an area between 3400 and 2500 m altitude. The glacial apparatus is divided into two sectors by the rocky spur of the Vedettes du Rutor. The mass balance of the Rutor glacier is carried out by ARPAVdA and the Safe Mountain Foundation on behalf of the Autonomous Region Valle d'Aosta.

Overall aerial view of the Rutor glacier, with its proglacial lakes

Below, in the center, the lake of Santa Margherita, a morainic dam, subject to numerous "ruptures" during the Little Ice Age with alluvial consequences for the valley; further to the right, Lake Serachi, enlarged with the retreat of the glacier in the early 1900s. The intense retreat of recent decades has brought to light the buried remains of an ancient bog that formed several times between about 10,000 and 5,500 years ago, between the end of the Great Ice Age and the Holocene Thermal Optimum. The glacial front, in a milder climate, must then have been further back than the current one and probably rose 100-200 m higher, and the area in front of the current front edge must have appeared as a deposition zone for sediments and organic material.

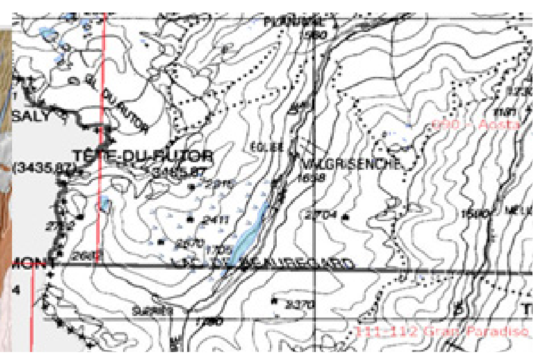
Data and Questions

Images of the Rutor glacier from different years are provided. (1919, 2005)

Several questions can be asked:

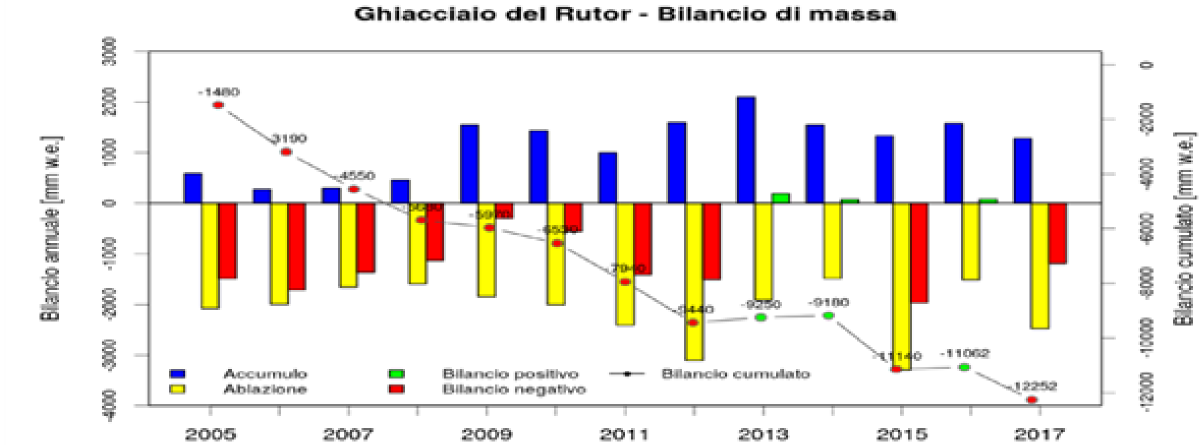
- the identification of the moraine front,
- the origin of the glacial lakes,
- hypothesis on the evolution of lakes,
- hypothesis on the reasons why this glacier maintains a consistent volume of ice compared to other glaciers in the Alps.

Some topographic and geological maps are provided, here very small but it can be enlarged and the links are provided. Several questions can be asked



- identify the heights of easily identifiable places (a refuge, the dam, the top of Rutor Mount)
- follow the layout of a path and the difference in height
- evaluate the surface dimension represented with the symbol v (a reference scale is given), recognize the phenomenon and hypothesize the consequences

A graph is provided, representing the historical series of mass balances from the hydrological year 2000 - 2001 to 2007 is provided, in image or in link.



Several questions can be asked:

- to interpret the data in the graph, in particular the meaning of the blue and yellow lines. *In this case it was relatively easy to understand that the blue bars show winter accumulation, and the yellow bars show summer melt. The net balance is shown in red if the glacier loses mass (winter accumulation less than summer melt) or in green if not.*
- to interpret the meaning of the red dot line, which indicates the cumulative balance and shows the total mass lost by the glacier since the start of the measurements. *Most of the bars relating to the annual balance are red, indicating that glaciers have lost mass in recent years in line with what has happened in the Alps and in general on a global scale.*
- to compare the accumulation and volume of ablation and from which year significant changes occur
- to analyze the negative balances. *Students must understand that negative balances are not necessarily caused by the reduced winter rainfall, by the accumulation of snow but were mainly caused by the high summer temperatures which favored its melting, alternatively by the reduced winter rainfall which limited the accumulation or more easily, and more easily understood by the concomitant occurrence of both phenomena.*

Finally, students are requested to formulate hypotheses on the progressive melting of the glacier and on the possible consequences:

- on the water reservoir,
- on the morphology of the surrounding area,
- on the stability of the slopes,
- on the vegetation cover,
- about man and his life: tourism, cultivation, use of the soil.

2nd example: Natural Risks, Wooden Cover, Geology in nearby but Different Valleys

general theme: *geology and geomorphology as factors conditioning the structure of a valley, natural risks and in particular landslides*

The case

The analysis, and comparison, between two adjacent valleys on the orographic left of the Valle d'Aosta. is proposed. They are two well-known valleys, the Lys Valley, and the Ayas Valley, typical valleys transversal to the Alpine chain with a North-South trend. Despite being neighboring valleys, located at the same latitude, with the same exposure, both culminating in the North in the Monte Rosa Group, whose peaks reach more than 4000 meters, Breithorn (4165 m), Pollux (4090 m) and Castore (4225 m), present very different characteristics.

Even, if they both are characterized by forms linked to the action of glaciers, such as the glacial threshold present at the entrance of both valleys, a morphological step deeply engraved in the rocks at the confluence between the lateral glaciers and the Balteo glacier, which in this terminal part of the Valley had accumulated during the last glaciation, till 12000 years bp a thickness of hundreds of meters, the structure of the valley is deeply different. Images, topographic maps, geological and risk maps are provided, here very small but can be enlarged and the links provided.

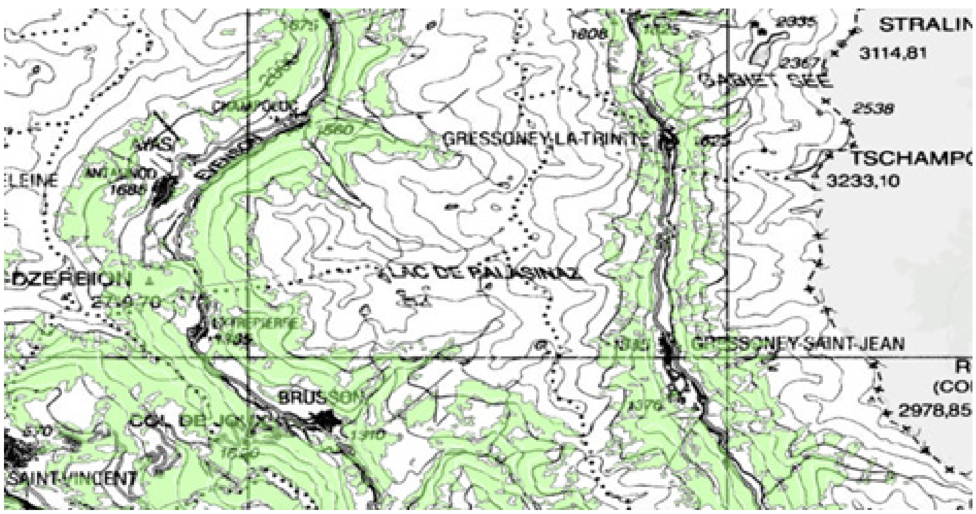
Data and questions

Images of the two Valleys are provided representing two examples of panoramas of the valleys, on the left the Lys valley, on the right the Ayas valley, in which some similarities and some differences are highlighted.

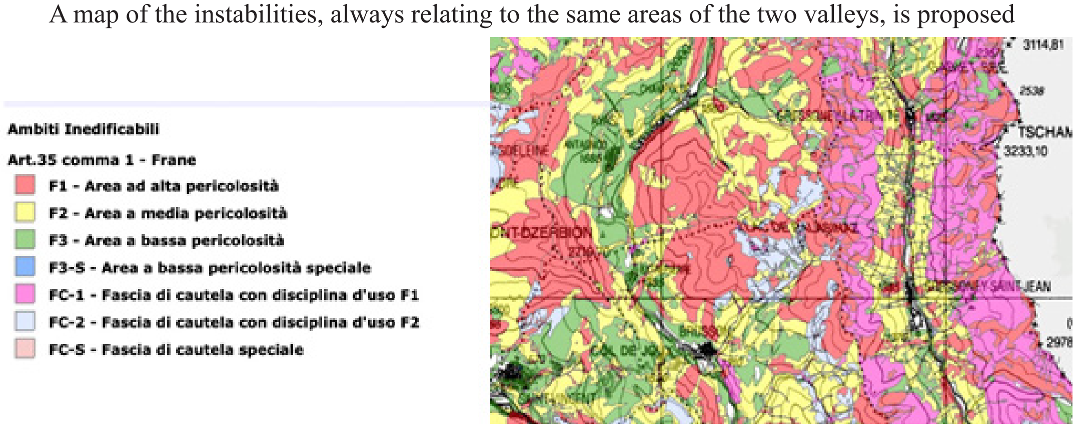
Several questions can be asked:
● what similarities and what differences can be immediately grasped in these two images of the two valleys,
● which morphologies seem to prevail in the two images.

A map of the wood cover is provided,



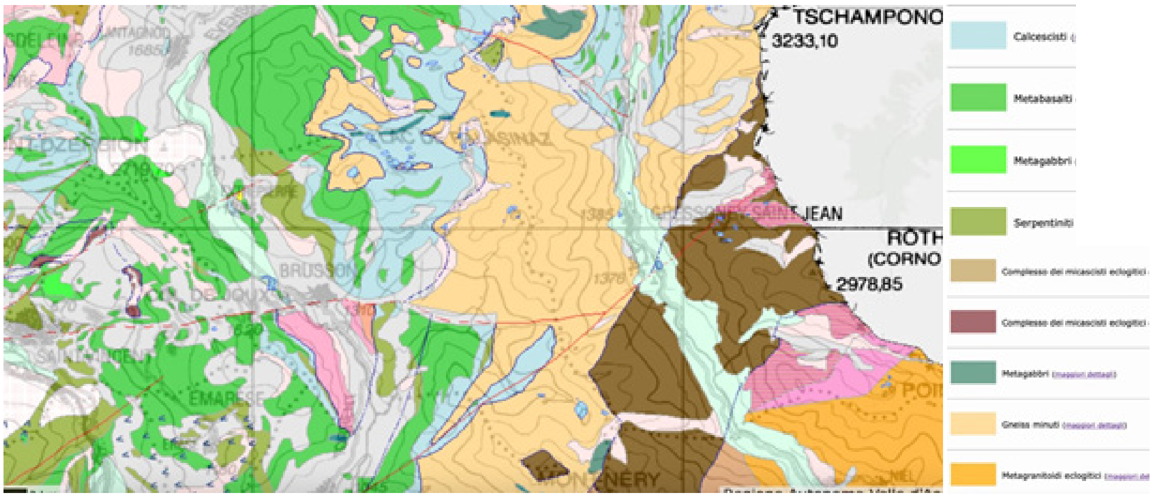
Several questions can be asked:
● the wooded cover has the same distribution in the two valleys,
● The slopes of the two valleys have a symmetrical coverage,
● which shares are indicatively affected by the wooded coverage,
● to what cause a possible lack of homogeneity can be attributed.

A map of the instabilities, always relating to the same areas of the two valleys, is proposed



Several questions can be asked
● what are the prevailing colors in the Lys valley, on the right,
● to which phenomena (see the legend) they can be attributed
● what are the prevailing colors in the Ayas valley,
● To which phenomena (see the legend) they can be attributed.

A geological map in provided, of the same area



Several questions can be asked
● what differences are evident in the colors of the geological map of the two valleys
● which color / rock prevails in the Lys valley,
● what color / rock prevails in the Ayas valley,
● the different types of rock may have influenced the shapes of the territory,
● Formulates a hypothesis on which rock can determine sweeter shapes and therefore a wider valley and which rock can determine more rugged shapes and therefore determine steeper shapes on the slopes.

3rd Example: The Action of a River- The River Ayasse

General theme: *all mountain valleys are born from the combined action of the glaciers and the river, that occupies the axis of the valley and affects its slopes.*

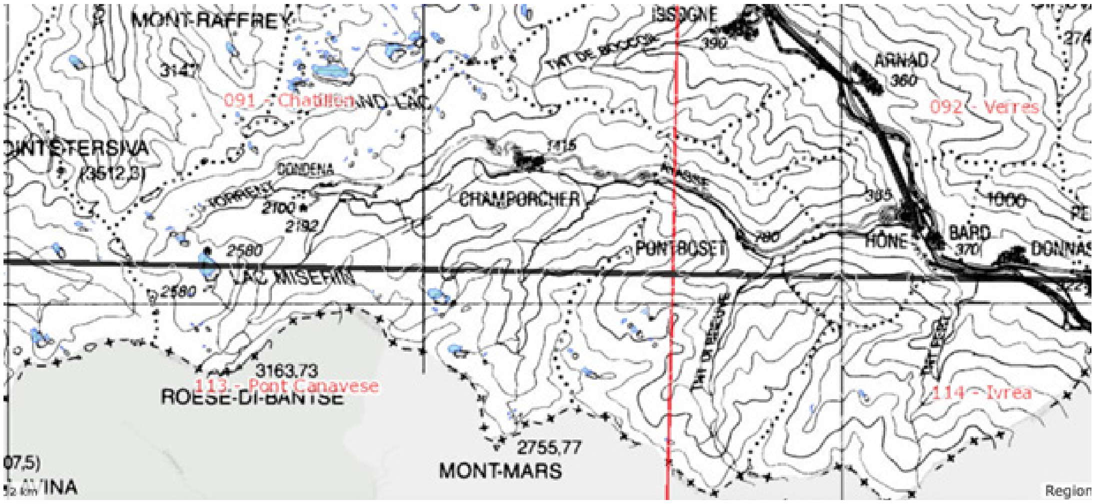
The case

The Valle d'Aosta Region has mapped the risk on fans of many rivers, in order to reduce the potential risk from debris flow (phenomena of mass transport), with hydrological studies of rivers basins.

First, it is necessary to determine the hydrographic basin, that is the topographical area delimited by a watershed, in which the surface waters of origin converge towards the same watercourse. It is then necessary to know its morphological parameters: average slope, and length of the mainstream present within the hydrographic basin. Having determined all these parameters, it is possible to calculate the flood hydro gram using one of the methodologies found in the literature, The Ayasse is the first river we meet on the left side of the Aosta valley, it springs from the waters of Lake Misérin and, after about 24 km and having crossed the entire Champorcher valley, flows into the Dora Baltea near Hône. The Ayasse stream has deeply engraved the rocks of the Champorcher valley, forming ravines of remarkable beauty. A medium-sized river has been proposed as a case study, particularly interesting for the amazing shapes it has affected along its course but also because it is responsible for numerous calamitous events: there are data dating back to 1700, which recall rock collapses, shore erosion, floods, debris flows.

Data and questions

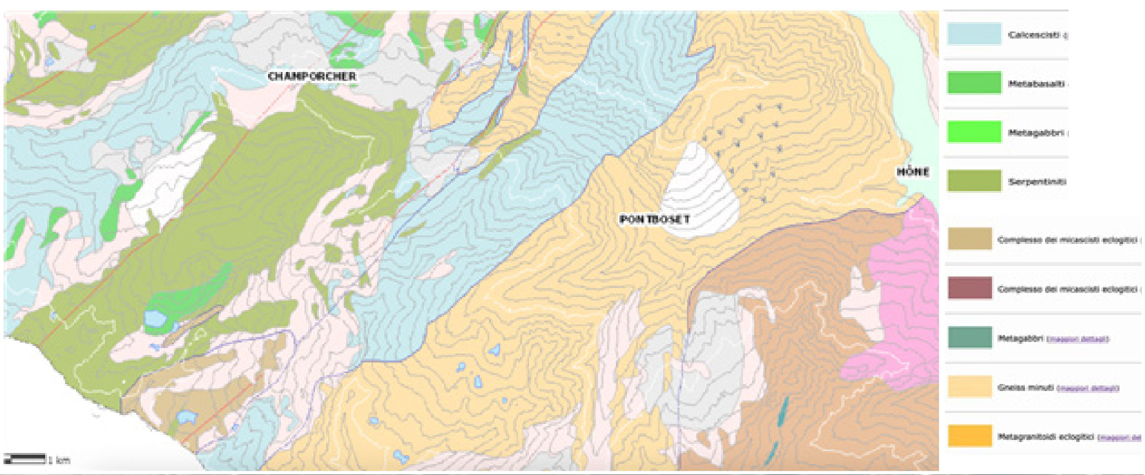
A topographic map is provided, to analyze the watershed and stream data, here very small but it can be enlarged, and the links provided.

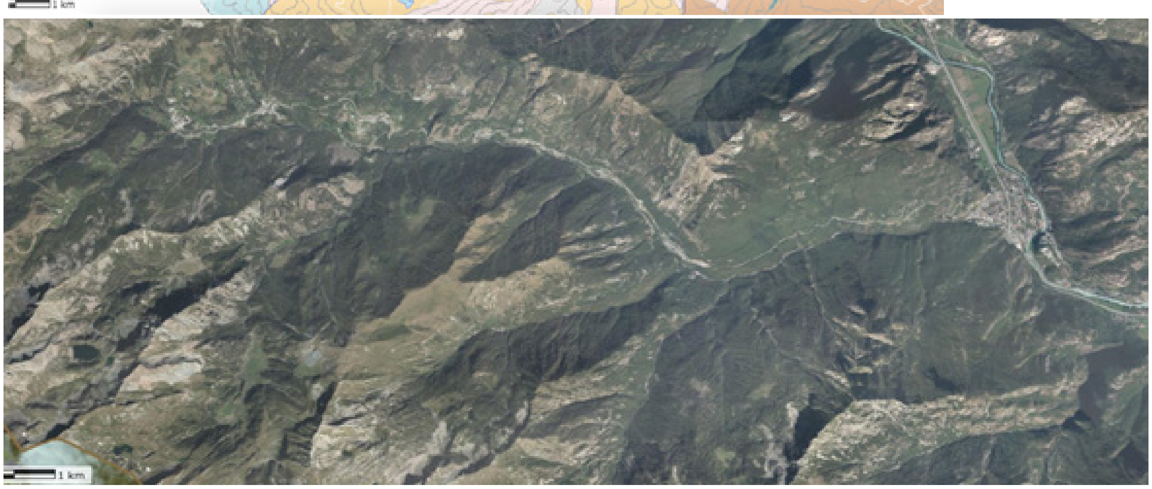


Several questions can be asked

- draw, describe, list (based on the available tools) the limits of the Ayasse river basin,
- what is (a ratio of scale is provided) the size of the basin,
- What are the maximum and minimum quotas of the river,
- which is the slope in % of the river.

A geological map is provided, with an extract of the legend and an aerial photo of the same area.

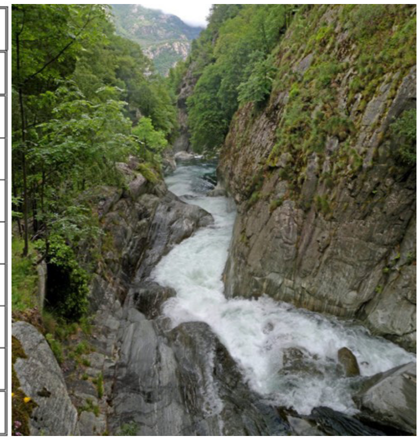




Several questions can be asked:
● recognize some of the points of comparison between the two maps: the course of the Ayasse river, the crests of the mountains,
● identify on the map some of the points in which there are contacts between different geological units: for example, minute gneiss - calcschist, calcschists-serpentinites;
● Between these two geological units, a dashed red line is marked: what does it mean and what consequences does its presence have on the morphology of the valley.

A table with the annual rainfall in three locations of the Ayasse River Valley, (data are outdated, but the trend of values has been growing in recent decades) and a picture of the Ayasse canyons are provided.

PERIODO	Hône		Pontboset		Champorcher	
	mm	gg	mm	gg	mm	gg
1921 - 1930	899.0	52	1223.0	78	1112.0	82
1931 - 1940	1151.0	83	1260.0	79	1249.0	93
1941 - 1950	911.0	73	1157.0	81	1286.0	89
1951 - 1960	987.7	77	1234.0	93	1158.4	99
1961 - 1970	876.7	74	1053.4	89	1069.5	93
1971 - 1980	1165.1	82	1352.7	92	1354.1	92
1981 - 1986	1106.0	75	1319.1	84	1677.0	96
1921 - 1986	**1009.2**	**74**	**1227.3**	**85**	**1208.8**	**92**



Several questions can be asked:
● in which part of the valley are the maximum values of rainfall,
● the valley is located on the edge of the Po Valley, which receives humidity from the Mediterranean,
● the geographic position of the valley can affect rainfall,
● the slope values of the river can affect the erosion and transport energy of the river.

Conclusions

The examples presented are obviously only models, they can be improved, following their more widespread experimentation and a more accurate monitoring of the results. Like all geological tests, which require on the one hand the ability to read maps, topographic, and geological, risks, and even before knowing their existence, at first glance they are badly accepted by students, even those who are preparing to face tests of a national level, such as the Olympics of sciences. Furthermore, it should be noted that in this article the illustrative materials proposed are small and therefore not easily understandable. The links to the materials are obviously more effective, even if they require access to links that are not always easily accessible and downloadable. The results show a good understanding of the "path" of analysis and deepening of the test, obviously with uneven results in relation to age and aptitude. While still lacking a lot of knowledge, students can highlight the possession of soft skills, in particular problem solving, digital literacy and professional attitude, which in a traditional methodological approach: frontal lesson and verification of the acquired contents can hardly to be put into use, be empowered and therefore valued and evaluated.

The DMT has therefore proved to be an interesting and overall effective investigative tool, to be encouraged by identifying increasingly targeted exploration and investigation tools; this is not intended to replace other teaching methods, such as hands-on practices, but in an educational process that sees the lesson fragmented, therefore constituted by the alternation of different methodological approaches, increasingly recognized as effective, the DTM can represent a didactic tool interesting for the development of hard and soft skills in school, just as it is happening in the world of jobs.

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