CHALLENGE BASED LEARNING GEOSCIENCE: STUDENT-ORIENTED TEACHING FOR DIGITAL MAPPING

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ABSTRACT:

This essay presents Challenge-Based Learning with a student-oriented perspective in Geoscience showing how digital mapping constitutes a useful tool for teaching geomatic, geographical, urban and tourism disciplines. Focused on real-life case studies, it stimulates students to acquire integrated hard and soft skills in an active and collaborative way, to let them be protagonists of their educational path. The learning strategy adopted within some master's courses at the University of Bergamo (Italy) is presented with the aim of offering an overview of its usefulness in the context of Geospatial Information Science for spatial planning, in respect of the environment and its ecosystems, of the bio-diversity of the territories and, also, of the vocations of a place and the communities living it. All these aspects are addressed through the use of cartography, intended not only as an Euclidean system of representation, but also as an interactive archive of spatial, geographical, environmental, socio-economic and human information in continuous transformation and evolution. In the master's courses in "Geo-urban Planning" and "Planning and Management of Tourism Systems", the Challenge-based learning and the student-oriented approach are experimented through the use of real-life case studies and collaborative processes and mapping to transfer Geosciences competencies and allow students to adopt measures for urban regeneration, landscape enhancement and slow tourism promotion.

1. INTRODUCTION

Innovative education in Geoscience is one of the main challenges in contemporary University degrees in many domains such as Geography, Urban Planning, Tourism Management and Planning, seen especially in the light of the Spatial Turn (Nordquist, 2013). In the last decades, many disciplines in fact have moved towards the use of geo-referenced data and adopted Geographic Information Systems even outside the traditional disciplinary competencies of geomatics, geography, cartography, and topography, thanks to the spread of technologies and educational programs centered on Geomatics in many university degrees in an interdisciplinary perspective.

Geoscience offers a variety of opportunities to students coming with a background from different areas of study, and especially from the Humanities, offering them the opportunity to combine hard skills in the use of Geographic Information Technologies and digital technologies and soft skills related to historical, social and territorial approaches to spatial analysis. There are many interesting research experimentations combining hard and soft skills and considering the great potential of intertwining Geomatics, Engineering and Geographic methodologies (Burini, Ciriello, Ghisalberti, Psaila, 2018) and, then, the academic world needs more and more specific reflection on this kind of collaboration.

Especially considering contemporary polycrises – such as environmental, pandemic and geo-political crises –, it is more and more necessary to offer young generations some complementary competencies strongly connected to the needs of inhabitants, communities and stakeholders. Challenge Based Learning (CBL) "focuses on relevant real-life, authentic, open-ended challenges to trigger learning" (Van den Beemt, Van de Watering, Bots, 2022, cit. p. 4) and therefore, it is a perfect approach to combine the offer of hard and soft skills, responding to specific social and territorial needs coming directly from the society. Increasingly, university programs should be flexible to face societal complex challenges. Challenge-Based Learning (CBL) is an educational concept shaping these open and flexible programs and made possible thanks to the adoption of a student-oriented approach – within collaborative learning techniques (Barkley, Cross, Major, 2004) – which considers students the main protagonist of a multi-disciplinary teaching where their elaboration and active participation contribute to the development of new solutions for real problems coming from the society they live in.

Our contribution is related to the experience that the authors have had in the last decades in the domains of geo-urban planning and tourism planning and management, considering the importance of Challenge Based Learning and the adoption of a student-oriented approach and its value in transferring hard and soft skills in Geoscience.

The educational strategy adopted within some master's courses at the University of Bergamo in Italy integrates the concepts and notions of Challenge Based Learning and collaborative learning, applied to different contexts of study. In fact, as we show in the first paragraph, in master's degrees in Geo-urban planning we offer an overview of the great usefulness of Cartography in the Geospatial Information Science and, particularly, of the digital mapping teaching approach. An application of spatial planning based on the temporary reuse of the urban spaces, by applying the analytical hierarchical method of decision making processes addressed in (D'Urso et al., 2018; D'Urso M.G., Masi D., 2015), is dealt with in the second paragraph. Specifically, we present results, associated with the application of a multi-criteria analysis to a study-case of the urban regeneration of a municipality in a district of the northern Italy, first presented in [D'Urso M.G., Rasera S. 2022, XXIV ISPRS Congress hold in, Nice (FR) 6-11 June 2022].As we demonstrate in the third paragraph, we also

investigate the student-oriented approach to transfer Geosciences competencies with a focus on 3D Mapping for urban regeneration, within master's degrees in Geo-urban planning integrating geographical analysis with urban planning skills. In the fourth paragraph, we finally focus on the importance of teaching approaches and methods related to collaborative processes and mapping, as well as geolocated guides, as important set of competencies to be given to students to adopt measures for landscape enhancement and slow tourism promotion, within master's degrees in Planning and Management of Tourism Systems.
We, therefore, present the theoretical and methodological framework followed and we evaluate outcome-based learning objectives of different master's degrees offered at the University of Bergamo. This approach demonstrates that the Challenge Based Learning approach in a student-oriented perspective Geosciences is in line with the call towards enriching students in an active way with the skills and competencies necessary to address real-world problems of complex Earth systems with communities' participation.

2. CARTOGRAPHY AND DIGITAL MAPPING IN STUDENT-ORIENTED TEACHING

The student-oriented approach at the University of Bergamo has required, since the beginning, a different mode of teaching Cartography, hard science of Geomatics, mainly due to the presence in the classroom of a consistent part of the students having a humanistic background. Students would have understood little of analytical formulas and complicated cartographic projections involving many charts and mapping of the different regions of the earth. For this reason, it has been necessary to introduce, besides all the concepts of the traditional cartography based on the Euclidean approach, the teaching of an interdisciplinary approach to Cartography arguing and providing evidence for the topology and the fractal nature of maps and digital mapping. Geographic features or phenomena can be addressed either on an individual base (with scale) or scale free as a synonym of fractal and scaling.
Conversely, a fractal can be simply conceived as an ensemble or patterns including by far more small things than large ones, e.g. more small geographic features than large ones on the earth surface, or by far more large-scale maps than small-scale maps describing a geographic region. What makes reality suitable to be mapped, large-scale maps prone to be generalized, and cities imageable is the underlying fractal structure of geographic features, both natural or anthropic. The beauty of maps is strictly correlated with their intrinsic fractal nature. That's why it is necessary to introduce some basic concepts of fractal analysis, such as self-similarity, recursion, scaling ratio and scaling exponent, in order to prove that fundamental concepts of digital mapping and Geographical Information Systems (Goodchild, 1987) as well as long-standing map-making practices such as series maps subdivision, visual hierarchy, fully embody the fractal thought.
The most important feature of maps is to represent the entirety of the territories and to discard trivial things. More importantly, a recursive relationship characterizes different scales of maps: for example, a map 1:1M contains four maps of 1:500K and 16 maps of 1:250K. The recursive relationship is the key aspect of the fractal nature of maps, being also closely related to other fractal concepts such as self-similarity, scaling ratio (or equivalently, similarity ratio), and scaling exponent (or fractal dimension). Classic examples of fractals are represented by the Koch curve and the Fibonacci sequence (Mandelbrot B, 1982).
The Koch curve, invented by the Swedish mathematician Helge von Koch in 1904, represents a recursive process, according to which the result of the previous iteration represents the input of the subsequent iteration (Figure 1 for the first three iterations). Importantly, the i-th order iteration curve is embedded in the (i+1) -th curve (i=1,2) thus forming the cascade structure of the Koch curve. The scaling exponent of the curves decreases from bottom to top. Another good example of a fractal structure is the Fibonacci sequence: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89,…, in which each number (excluding the first two) is the sum of the previous two. A further interesting property of the Fibonacci sequence is the so-called 'self-similarity', i.e. the ratio between two subsequent numbers progressively approaches the golden ratio phi = 1.618 a quantity that is called more generally," scaling ratio". This self-similarity property is evident in the rectangles, since all rectangles are self-similar to the largest one as a whole when they tend to have the same length-to-width ratio.

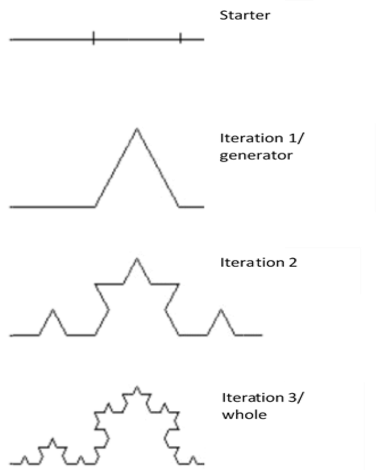

Figure 1. Koch's cyclic curve
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It is possible to note that while generating the Koch curve, the line segment is decreased by one-third; i.e. the scaling ratio that remains the same for all iterations. Hence every part of the Koch curve is self-similar to the whole curve and is not arbitrary. Actually, should this part be not self-similar to the whole, the part would be not rightly defined. Stated differently self-similarity indicates that part has the same shape as the whole (Jiang , 2016). The aforementioned fractal concepts, i.e. recursion, scaling ratio, self-similarity, and scaling exponent, are closely interrelated. The recursion helps to explain the generation process of the Koch curve; the scaling ratio helps to generate smaller structures that are self-similar to the whole. Fractals seen in nature and society are not strictly self-similar, but statistically self-similar and do fall within a limited rather than infinite scaling range. Hence it is possible to note that, in nature, curves mainly appear as clouds or convoluted coastlines, as shown in Figure 2.

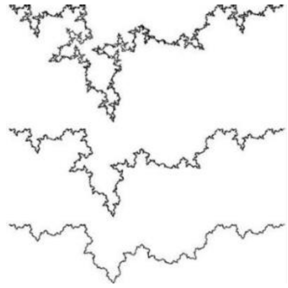

Figure 2. Three statistical Koch curves.
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Elements of a map are organized hierarchically through color, line thickness, and the size of symbols conformally to the so-called "visual hierarchy", i.e. a basic cartographic principle both for map design and map reading. Stated differently, elements of a map are not necessarily displayed at the same visual layer. For example, Google Maps uses yellow, white, and grey mixed with the line thickness to show the three hierarchical levels of streets at the city scale. Visual hierarchy reflects the fact that there are far more small things than large ones on a map, and, thus, it embodies some fractal thought. Most important things (which are usually very few) should appear at the highest visual level, followed by those that are less important.

Visual hierarchy enables one to read a map as a whole rather than an ensemble of mutually disconnected elements, forms, and shapes. The reason for this consists in the fact that the whole is more than the sum of its parts so that the fractal nature of maps and mapping allows for holistic view of looking at what is to be mapped.

Cognitive mapping can be viewed as an extension of ordinary map-making in which topology and semantics, typical characteristics of the fractal approach, play a very relevant role. For instance attributes of a city such as the largest, the most popular or the most meaningful represent a cognitive map of cities. Analogously, being the oldest city carries the highest semantic meaning.

Geographic systems are complex and the classical Newtonian physics is not suitable to fully understand their complexity.

A map is a model or an approximation of reality, rather than an image or a mirror of reality and its fractal nature differentiates maps from other graphical or pictorial representations thus making cartography special.

Despite the pervasiveness of high-resolution satellite images of the earth surface, both topographic and thematic maps remain largely irreplaceable. This is due to the fact that satellite images are not maps, since they do not involve mapping processes such as generalization, classification, and symbolization. Specifically. generalization and classification are shared by cognitive mapping because cognitive maps tend to be schematic rather than detailed, and topological or semantic rather than geometric.

In other words the power of maps lies in the model view rather than the image view. In conclusion the fractal structure is ubiquitous not only in rocks, rivers and watersheds, mountains, islands and coastlines but also in man-made artefacts such as cities, streets, buildings, social media, the Internet and the World Wide Web. All of these constitute targets to be mapped in current cartography.

Cartography is primarily founded on Euclidean geometry since geographic features are represented using geometric primitives such as points, lines, and polygons. In addition Euclidean geometry, focusing on individual scales, prevents us from detecting the underlying scaling pattern across all scales. Shifting from geometry to topology or from geometry to semantics helps us to see the underlying fractal structure or the recurring scaling pattern of by far more small things than large ones. Maps, to a great extent, are to reveal the underlying scaling structure, so that, in general, the scaling, can be formulated, non only as a law of cartography, but also of geography.

Usually, geographical spaces are organized hierarchically, so that smaller units are contained in greater units.

A problem arises when measurements of different areal units need to be mutually related statistical analysis since the results related to each unit can be different. This is called MAUP which means Modificable Areal Unit Problem. In line of principle, statistical inference cannot be simply mutuated from one level to another or from an aggregated scale to an individual one. The rate varies from one level to another and from one configuration to another. The most accurate indicators are for the smallest units. A switch of results between scales, either up or down, is impossible, unless a relationship between statistical inferences and scale changes can be established. The advent of big data has changed the scenario, since data are individually based and the unit is univocally determined. Just the geographer Tobler, at the beginning of the 1970s, theorized the first law of geography as "Everything is related to everything also, but near things are more related than distant things" (Tobler, 1989). Finally, determining how the positions of geographic features are related and determining the relationship between the statistical inferences and the scale, within a range of scales, represent an interesting challenge for future studies.

3. DECISION MAKING PROCESS IN THE SPATIAL PLANNING

Urban regeneration of the cities is changing its approach focusing basically on the new concept of the temporary reuse of the spaces, in particular the abandoned or obsolete sites, in contrast with the traditional approach based on demolition and consequent construction. Specifically the issue of transforming the urban space is addressed by adopting multi-criteria methodologies that represents an essential tool to support decisions by means of solutions able to reach objectives of strategic planning, according to territorial, economic, environmental, and social criteria. To this end Analytic-Hierarchy Process (AHP) is a specific instance of a general method that assigns weights and quantities of an element as a function of the category under consideration.

In the management of urban spaces, the unit basis is intended as the dimension of the areas to be reused where the activities, actions, functions are put into practice by the community. According to the French geographer-urbanist Jacques Levy the public space is considered as a place where people move freely. Within this context 2 matrices can be identified, one called "of the movement" and the other called "of the contact", where the people interact freely, creating also the conditions to transform the same space. Coherently with this approach the methodology proposed for the re-use of the urban space is multidisciplinary and includes the needs of the users and community.

Specifically, this topic, that is also the subject of a master's thesis, employs an integration of the probabilistic method denominated "fuzzy logic" and the decision making approach applied to the urban planning (D'Urso M.G., Rasera S., 2022).

The analytical hierarchical process assigns weights to each criterion and sub-criterion according to the priorities stated by the decision makers and inserts within a decision tree, a general objective and a number of the choices of a sample of users and citizens.

Using fuzzy logic, the multicriteria analysis allows us to address situations characterized by a high number of options and variables that produce divergent results, looking for the best solution for each considered criterion and sub-criterion.

3.1. Decision making process in the urban planning: a study case in a municipality of the Milan district

The proposed multi-criteria approach is based on a hierarchical analytic process that selects the "best choice" among a set of alternatives formulated by a sample of users, stakeholders, managers, administrators, young people randomly chosen from the community

The model consists of several levels:

• the upper one contains the analysis of the problem and the definition of the objectives;

• the second level contains the different criteria that represents the judgement or rules useful to test the desirability of decision

alternatives, including both the concept of goal and that of attribute;
• a third level contains the class of the sub-criteria relative to each criterion where the content and the meanings of the fundamental topics are detailed;
• the fourth level contains the implementation of the solution, the results and the alternative suggested by the matrix decision;
• the results that must be controlled and monitored are included in the last level.

In the study-case described in sequel, the choice among the selective alternatives will be oriented to achieve the most economical and optimal compromise (D'Urso M.G., Rasera S., 2022). Thus, given an initially complex and poorly structured problem, a hierarchy dominance will be created, i.e. a reticular structure made of almost two levels that will contain all simplifying elements of the problem. This methodology allows one to organize the several themes involved within the urban re-use process, by means of a structure that may be modifiable as a function of future changes.

The case study focuses on Bareggio, a municipality in the district of Milan, an urban area having a complex, multifunctional character, that includes several economic and social dynamics.

A complex system of more extensive spatial relations characterizes the territory of Bareggio: considering the urban environment as a whole, starting from the large territorial systems a very close relationship between the natural and anthropic landscape and the supra-local mobility system can be observed.

The recovery of disused areas in the municipality of Bareggio provides the starting point for urban regeneration, since this allows for significant reduction in land consumption, though not affecting the social and economic development of the town. Moreover, this guarantees robust responses to the demands of new urban development models, fostering new standards of quality of life and focusing on functional mixes of housing, services and economic offer. These objectives have been pursued in three transformation areas (Fig.3) characterized by special features:

- Ex Cartiera: the area including the disused industrial plant of the Ex Cartiera area, lies near the central square and is surrounded by several residential structures. The structure, originally housing a spinning mill for paper production in the 1940s, has been abandoned since the early 90s.
- Ex Sapla: building is a disused industrial area, close to the historical fabric of the city centre and borders, on the western side. Together with the Ex Cartiera area it defines a single project system.
- Ex Alma: is located along Via Papa Giovanni XXIII, Via XXV Aprile and Via Armando Diaz, occupying an area of 11,000 m^2. The area involves a disused industrial area bordering with an agricultural land and is in close proximity to the city center.

Each social component (private individuals, public authorities, associations, citizens) was deeply involved in the participatory process. In this way it was possible to identify the main criteria and sub-criteria of the multi-criteria model, providing a structure capable of responding to local needs, as described in Figure 4.

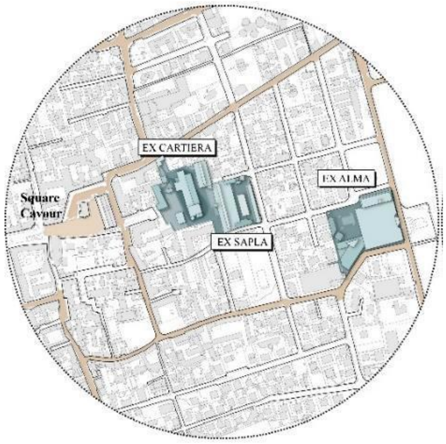

Figure 3. Location of the intervention areas

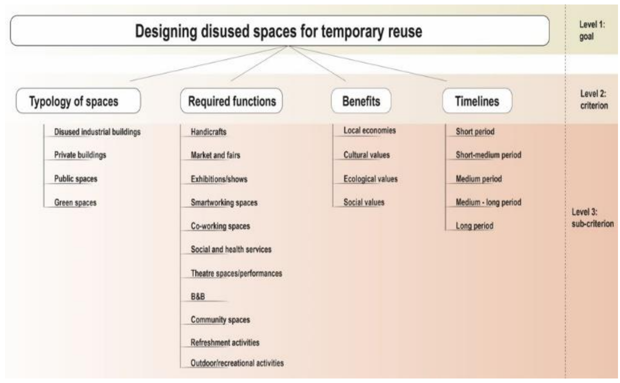

Figure 4. Hierarchical structure of multi-criteria model

Assembling a matrix of pairwise comparisons, a multi-criteria logic was exploited to structure the model; its use required to select a suitable number representatives belonging to social institutions and citizens in the municipality of Bareggio.

31 users (actors) were asked to quantify, through pairwise comparisons, the dominance (membership) of the 'criteria' and 'sub-criteria' selected in the model and expressing the values through Saaty's intensity scale, i.e. three numbers corresponding to different degrees of judgement for each criterion, as shown in Table 1.

An ensemble of people, an age ranging from 23 to 60 years and potentially covering a set of factors affected by subjective choices, was interviewed to collect the necessary data. Please, notice that, in the construction of the matrix of the pairwise comparisons people were asked to express, by assigning numerical values ranging from 1 to 9, how much 'criteria a' was dominant over 'criteria b', and returning, expressing so, for each line of the dominance matrix, the dominance of weight of each criterion.

The general matrix of criteria TYPOLOGY OF SPACE (C1), REQUIRED FUNCTIONS (C2), BENEFITS (C3), TIMING (C4) has been constructed.

	C_1	C_2	C_3	C_4
C_1	**1; 1; 1**	**1; 2; 3**	**4; 5; 6**	**4; 5; 6**
C_2	**1/3; 1/2; 1**	**1; 1; 1**	**4; 5; 6**	**3; 4; 5**
C_3	**1/6; 1/5; 1/4**	**1/6; 1/5; 1/4**	**1; 1; 1**	**1; 2; 3**
C_4	**1/6; 1/5; 1/4**	**1/5; 1/4; 1/3**	**1/3; 1/2; 1**	**1; 1; 1**

Table 1. Matrix of pairwise comparisons of criteria

In conclusion, examining the outcomes of several project alternatives, established on the basis of the multi-criteria model applied to the different contexts and as a function of the economic estimate of the interventions, was possible to state that the Ex Sapla area represented the area having the greatest feasibility of interventions for the following important aspects. Assuming stable the costs related to the realization of the works, the Ex Sapla area is resulted the most suitable solution for a project of temporary reuse of spaces. Actually, the area involved in the interventions related to the Ex Sapla area is substantially smaller than that concerning the Ex Cartiera and Ex Alma areas. In addition, it presents a more diffused involvement of human resources, the maximum exploitation of environmental resources in relation to a greater recovery of land, returned to green space and, finally, an optimal and greater re-adaptation of the existing volumes. Moreover, the proposed spaces and functions are in perfect agreement with those predicted by the multi-criteria model in spite of the limited surfaces available. Ductility remains medium-high, with different spaces available. Finally, costs estimate for the Ex Sapla area exhibits a lower impact with respect to the other analyzed areas, thus providing the spaces suitable to activate the interventions requested by the citizens. (Fig.5). The proposed works and associated costs could have a general decrease if the internal and structural conditions are favourable to reuse, leading to a reduction of the general economic estimate. As a matter of fact, the Ex Sapla buildings have been used until the most recent years portending a better structural state.

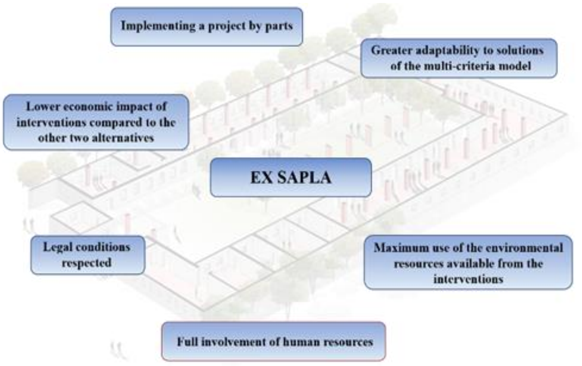

Figure 5 : Optimal choice associated with the AHP process

4. STUDENT -ORIENTED TEACHING, GEOSCIENCE AND 3D MAPPING FOR URBAN REGENERATION

4.1. Geoscience and the student-oriented approach

The "student-oriented" approach – also known as student-centred or learner-centred approach (Mohan, 2018) – is a collaborative educational learning tool (Barkley, Cross, Major, 2004) giving students the opportunity to be the protagonist of their cultural and educational path. Therefore, from the very beginning of their university education, students are asked to identify and follow their own interests and to actively focus on specific and concrete case studies in order to get hard and soft skills useful for their future jobs on the territory and with inhabitants.

In Geoscience this approach allows students to be motivated and to improve their cognitive achievements. Once they are composed in groups, they can increase individual accountability and reduce competitiveness becoming more and more collaborative and getting not only cognitive frontal notions but also teamwork soft skills (Mitchell, B., Reed, M.G., 2001).

Students are asked to choose their own theme of interest in order to apply the concepts learnt through frontal teachings. At the same time, they try to solve spatially related problems contributing to link research and teaching. Then, they are guided by teachers and trainers into an interdisciplinary perspective to get a general view of territorial context and to deepen a specific perspective.

4.2. Teaching methodologies for a student-oriented approach in Geo-urban planning master's courses

The master's course in Geo-urban planning of the University of Bergamo aims, on the one hand, at presenting real-life examples in specific territorial contexts as objects of Geosciences project works during each academic semester.

First, at the beginning of the semester, teachers identify a collective case study focusing on a theme and an area – in a multi-scale perspective – that have already been the object of ~~a~~ research and a field analysis. Then, teachers collaborate with external and international experts, as well as with Institutional representatives, for illustrating the collective case study and its spatial analysis, implying students in different themes interactions, and stimulating their reflections on multi-scale stakes and conflictual situations for mobile and local inhabitants. Afterwards, students are accompanied to field areas by teachers to critically observe the territory, inquire local actors and talk to inhabitants about the emerged dynamics. Finally, students are asked to organize in small groups and are guided by teachers and class trainers to focus on single aspects of the shared real-life example and to co-create their project work reports and portfolios.

This collective learning is the base for the following individual and interactive activity focused on specific case studies. Through didactic labs conducted by researchers, students learn Geosciences technical systems – such as GIS-Geographic Information Systems, graphic 3D rendering and video-making – through a reflexive approach to spatial analysis and stakes detection. Then, they choose their internship in a public institution or a private enterprise, where they can identify their individual case study to visit for a spatial analysis with inhabitants' implications. The internship allows students to focus on a specific area and theme, and at the same time, guided by a supervising teacher and a territorial expert, it aims at collecting documents, plans, statistical data and field information to use in the final dissertation.

On the other hand, this master's course in Geo-urban planning aims at giving students an interdisciplinary perspective. Their cultural and educational path combines digital mapping, and geographical analysis with urban planning as basic integrated learning. Then, step by step, it interacts with different other disciplines such as history, economics, law, statistics, and so on, in order to identify a research domain of interest for students so that they are more motivated and stimulated. So, this interdisciplinary approach gives students the opportunity to acquire a wide perspective in real-life case studies and conflictual dynamics, integrating hard and soft skills. Moreover, it allows them to choose one specific discipline to deepen in a spatial perspective, according to their individual propensity and interests, in connection with their different previous education.

4.3. Students and 3D mapping for urban regeneration in the Italian region of Lombardy

An example of student-oriented teaching in the master's course Geo-urban planning concerns urban regeneration and soil restitution in the peripheral areas of Bergamo. These themes and areas were chosen by teachers as project works in 2020, as they were the object of previous research (Ghisalberti, 2018). They were tools for collaborative educational learning, allowing students to acquire technical skills in Geosciences from a reflexive perspective.

In this context, the Rifo-3D map was used to give students' groups a basic knowledge of urban regeneration needs and projects in Lombardy, the most populated region in Northern Italy, and especially in the town of Bergamo, one of the most productive and dynamic. At the same time, it aimed at giving students consciousness of the complex communication mechanisms within interactive mapping systems, as well as a focus on landscape vision implications as Geoscience technical skills in a reflexive perspective (Ghisalberti, 2021).

As shown in Figure 6, the Rifo 3D map represents both brownfields and abandoned areas (orange color) and obsolete public buildings (blue color) in connection with all other constructions (grey color) underlining spatial complexity. Moreover, this map can influence space conception and direct urban regeneration interventions, constituting a platform for inhabitants' inclusion in decision-making processes as it gives quantitative (number, distribution, volume), and qualitative (structural features and environmental characteristics) information and it can imply a collaborative updated function.

This Geoscience technical platform makes information accessible through simple graphics, showing an interactive map as the main view on its home page. Furthermore, as the screen size is limited, it provides dynamic zoom-in/out, pan and recentering functions, to avoid excessive information density and to guarantee scale reduction and analogic accuracy as a basis for map structure.

Figure 6. A 3D mapping for urban regeneration in Bergamo (Italy) as a basis for a student-oriented approach in Geoscience (https://rifoit.unibg.it/rifo3d/)

Moreover, this map graphically renders the landscape through perspective and three-dimensional vision, putting singles users at the representation centre as social actors producing culture in their own places of life. The goal is to shift focus from material qualities of territorial elements to social complexity characteristics, assuming a landscape logic capable of restoring the cultural substance of the territory. Indeed, the three-dimensional perspective allows abandoning any claim of map objectivity given by zenith observation uniqueness, metric accuracy and linear distance and, at the same time, opening to multiple points of subjective views as the result of interpretations and, therefore, of conjectures. In doing so, mapping users become aware of the impossibility to create an objective map, as considered the Euclidean one, and of the presence of multiple representations of territory.

Concluding, this map not only gave students specific territorial quantitative and qualitative knowledge about urban regeneration in Bergamo, but it also allowed them to share a more conscious and critical, in other words, a reflexive approach to the communication mechanisms of digital mapping systems. Three-dimensional representation of territorial elements allowed students to switch from a zenith to a perspective view, and, therefore, to landscape, making a bird's flight over the town of Bergamo, which, by shifting map orientation, reproduces subjective and multiple points of view recalling local communities' identity discourse. By simulating an air flight, Rifo-3D map allows virtually reaching any building in order to see in detail each brownfield, abandoned area and obsolete public housing in strict connection with their territorial context (Fig.7).

Therefore, students – together with teachers and class trainers – collectively experimented a real-life mapping system and become aware that Geosciences, far from giving only mere technical skills, can create territorial operators such as Rifo-3D map, influencing social behaviour and facilitating communication between the different actors (Institutions, stockholders, stakeholders, inhabitants, and so on) involved in urban development project and regeneration processes. They can constitute a useful platform to activate inclusive decision-making processes, based on the idea that collaborative cartography is a complex system. Moreover, they intervene in the communication between actors with different interests, and it strengthens the connections between actors on the territory, albeit with different strategies and skills (researchers, administrators, entrepreneurs, inhabitants, and so on), consolidating existing networks and spreading research knowledge.

5. COLLABORATIVE PROCESSES, MAPPING AND GEOLOCATED GUIDES FOR LANDSCAPE ENHANCEMENT AND SLOW TOURISM

5.1. Geoscience and Challenge Based Learning in Tourism Studies

The adoption of Geoscience and Challenge Based Learning in master degrees on Tourism Management and Planning aims at transferring to students hard and soft skills for understanding how to plan and manage forms of slow tourism, with respect to United Nations Sustainable Development Goals. Thanks to the use of smart technologies, such as systems enabling the real and virtual accessibility of the territories, students can reflect on the possibility of enhancing the importance of landscapes and territorial knowledge - often handed down orally as a custom of local communities - as a development engine for areas usually characterized by unattractive adjectives, such as "fragile", or "marginal", or "remote". The methodology adopted at the Planning and Management of Tourism Systems master's degree at the University of Bergamo is divided into modular phases which, through a student-oriented approach, gives students competencies of both hard and soft skills for facing global issues in tourism, for example strategies for shifting from crisis to recovery after a global crisis (Burini, Pyne, 2020).

From what hard skills are concerned, students participate in class workshops for the use of GIS and cartographic technologies, as well as of digital geolocated open software apps for creating visual and audio guides of destinations. They also acquire soft skills thanks to Challenge Based Learning, during traineeships or workshops organized with the collaboration of local public and private organizations and stakeholders. In this second typology of learning experience, students contribute to fieldwork activities, and participatory processes in order to collect data, to interview local stakeholders and to understand the vision and the needs of different stakeholders living in the analyzed spatial context. These projects can transfer important competencies for understanding inhabitants' needs, for investigating the peculiarities of the landscapes and for understanding the different forms of traditional knowledge of local communities, in order to enhance them through the use of smart technologies and mappings.

5.2 Teaching methodologies for enhancing Challenge Based Learning for slow tourism promotion

Taking for granted that every phase of learning and analysis related to tourism is deeply rooted on the knowledge of the territories it is necessary to teach students methods and technologies in a comprehensive way so as to make them understand the natural and cultural resources to be enhanced for local development and slow forms of tourism and identify the most suitable people for their management (Burini, 2016). It is a question of identifying the under-valued territorial resources, usually excluded from the traditional tourist itineraries, referring to the natural and cultural resources, as well as forms of intermodal mobility, micro-business following environmental quality certifications, that thanks to the field observation and digital mapping, can be recovered and put into online systems to encourage territorial regeneration. Students learn how to identify sub-categories of resources, respecting common criteria: for the natural heritage, by respecting the criterion of international value, of the naturalistic relevance assessed by local people with reference to such as parks, reserves, natural monuments, etc.; for cultural heritage, these are resources of international importance, or of historical, artistic or aesthetic interest, or even of symbolic or social value in the local community, such as villages or sites recognized within national or international networks, castles or historic buildings, fortifications, churches, etc.; finally, cultural, environmental or trade events and manifestations useful for the promotion and enhancement of territories in a reticular and sustainable approach. From an operative point of view, the research methodology fosters the use of technical tools and methods in single modules that we can find in the study plan and also dedicated activities (workshops, traineeships, labs, fieldworks and excursions) useful for the pursuit of the objectives. During fieldworks and traineeships, the observation of the territory is done and geo-tracking methodologies are adopted. Students are accompanied by local stakeholders and resources are georeferenced using online cartographic platforms (such as Open Street Map or Google Earth) that allow students to verify the location of the various resources of the territory by checking their denomination. In the first phase, the analysis of the actors is also conducted to understand their needs with respect to local resources and to bring out the dynamics in place. Starting from these analyses it is possible to develop a geo-referenced database of natural and cultural heritage, creative entrepreneurship and sustainable mobility, as in the case of projects concerning mountain areas of the Lombardy Region, located not too far from the University of Bergamo.

5.3 The active role of students for geolocated guides for landscape enhancement and slow tourism in the village of Bossico

A case-study which is worth mentioning is the one related to the students' work conducted in the village of Bossico in the northern part of Lake Iseo, in an area which connects the provinces of Bergamo and Brescia that have been recognized Italian Capital of Culture 2023. In this case, students could have an active role in participating to a research project conducted by the University of Bergamo (Burini, 2018) and could elaborate a mapping system on Google Earth Pro and to create a georeferenced video-guide using the free app Izitravel.it. in order to insert pictures, descriptions and videos collected during the participatory process with the local community of Bossico, in order to give tourists a useful tool to explore and have an immersive experience on the most relevant aspects of the landscape, as perceived by the inhabitants (Fig.7). The sense of addressing at the same time Geoscience skills and the capacity to analyze landscapes with participatory processes within a Master's course in Planning and Management of Tourism Systems is to be traced to both the role the concept of landscape assumes in the transmission of the social and cultural values of the local communities and to its importance at an international level, as a paradigm capable of enhancing the environmental assets ensuring the pursuit of sustainable development actions (Burini, 2019).

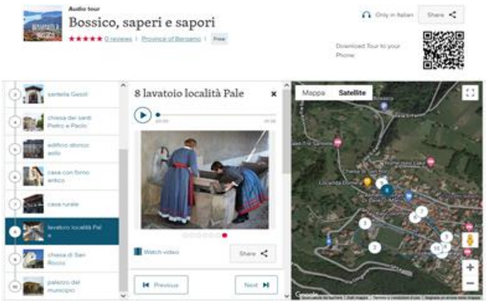

Figure 7. Screenshot of the virtual guide "Bossico, saperi e sapori" created by students integrating audios and videos in the maps https://izi.travel/en/4a28-bossico-saperi-e-sapori/it.

In fact, landscape recovery serves to protect the natural and cultural resources that represent, on a regional and global scale, the so-called heritage of a state or even of humanity. Moreover, this allow people to preserve sites and places where each community recognizes and rediscovers its own identity values, by accounting for local needs. Perception of the territory by the local communities has been recently introduced by the European Landscape Convention (2000) as a crucial element for the definition of landscapes, underlining how it constitutes an essential component of local identity. The reading of the landscape in terms of perception also constitutes a challenge of great commitment for students, as not only is it necessary to grasp the outcome of the interaction between the natural and anthropogenic components, but also the relationships that are established between the landscape and the inhabitants, both local and external (tourists), to plan and manage slow tourism systems.

6. CONCLUSIONS

What we have tried to argue is that research, didactic and experimentation about Challenge Based Learning from a student-oriented perspective is a recent and ongoing process which needs more and more reflections for analyzing its main characteristics within and between study components in university curricula and study plans. A variety of CBL characteristics related to the active role of students in Geoscience, between interdisciplinary study components, teaching methods and curricula construction, should be the right way to develop CBL in future university degrees for transferring to students both hard and soft skills able to face in particular complex global, environmental, urban, social, economic and political issues.

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