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Geodesign as a Framework: Study Cases of its Implementation from the US, Brazil and Italy

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Abstract. This paper focuses on the adoption of the geodesign approach, including methods and tools, in spatial planning and design courses in higher education with an international comparative perspective. The comparative review is based on four case studies developed implemented in the US, Brazil and Italy. They were developed by the authors of this article in order to showcase the differences in the implementation and use of geodesign framework, scenario planning and newly developed web-based tools. The comparison and discussion of case studies demonstrates the possibility and potential of applying geodesign methods at different a variety of scales, with different approaches and with different participants. The paper concludes with reflections of the taken approaches and a discussion.

Keywords: geodesign, scenario planning, environmental planning, geospatial technologies

1 Introduction

The main goal of this paper is to comparatively review different case studies in which geodesign framework was used in the process of designing for the future of the studied place. The case studies are coming from US, Brazil and Italy and serve as examples of how geodesign can be taught in studio classes and regular classes at the corresponding universities. Geodesign is generally understood as a a set of techniques and enabling technologies for planning of a sustainable future of built and natural environments. It represents a process that integrates project conceptualization, analysis, design specification, stakeholder participation and collaboration, design creation, simulation, and evaluation (among other stages). The most prominent and widely applied methodology in geodesign was suggested by Steinitz (2012). The value of the Steinitz' framework for geodesign is arguably in its robustness and flexibility for it can be applied in diverse workflows and technology settings.

The study case of the City of Ames (Iowa, USA) shows a combination of scenario planning (Avin 2012), geodesign framework (Steinitz 2012) and innovations. It concentrates on three systems including energy, transportation and mobility and green infrastructure. The study case of Belo Horizonte (Brazil) proposes an expanded and very innovative version of the geodesign process based on their own research and development (Moura and Freitas 2020, 2021). Based on their experience, they present an improved version of the framework with the goal to consider specific needs for conceptual, methodological and technological improvements and advancements aiming to meet the needs of adaptability and flexibility of geodesign workflow.

These ideas are the result of many workshops conducted in Brazil by Moura development (Moura and Freitas 2020, 2021). The study cases of Cagliari and Potenza (Italy) demonstrate the use and implementation of Steinitz's framework (2012) as suggested by the author, without any further adaptation or change. All case studies were studied in the courses and studios to teach urban planners and designers how to use geospatial tools and data and apply geodesign methodology to design for sustainable future. This paper summarizes the experience gained in these courses.

2 Geodesign in higher education: a comparison of international experiences

Geodesign as a subject in university curricula is novel as, with some notable exceptions, does not have a long tradition. It can be defined as a set of methods, techniques, and enabling geospatial technologies that can be hat are well suited to work or simulated working with multiple stakeholders. They can be added to the teaching about planning and design for the future at different scales.

At Iowa State University (ISU), a course on Geodesign was first offered in 2017. It was initially designed as an experimental course to test whether students would enroll and find value in taking the class. The course was appreciated especially because it was included as an elective course in the GIS Minor approved at ISU in 2014. Students are, in general, eager to learn new software skills and this course offered substantial experimentation with geospatial data, the use of GIS software and learning about geodesign as a framework and methodology. Pedagogy in this course is generally based on selecting a study case, studying geodesign as a methodology and process-oriented framework, discuss the framework, and work with geospatial data and software. The experimental course was then changed into a regular elective course. In 2021 it was renamed to Geodesign: Planning for Sustainable Futures and dual listed as an undergraduate and graduate course.

At the University of Georgia, the idea of Geodesign has been embedded in several Urban Planning and Design Studios as well as Landscape Architecture Studios. It has also been applied through a program called NASA Develop, in collaboration with the Department of Geography. Some of these projects with NASA Develop date back to 2014, while the projects in Coastal Georgia were conducted since 2015, in collaboration with the Coastal Regional Commission of Georgia (Rivero et al 2015, 2017, 2018; Smith et al. 2020).

In Brazil, geodesign was applied in urban design teaching, focusing on the process of co-creation in collective reading and planning of a study area. Several studies were developed within the urban planning courses held at the Geoprocessing Laboratory, in the School of Architecture, Federal University of Minas Gerais, Brazil. Between 2016 and 2020, the Geoprocessing Laboratory was involved in 43 geodesign workshops, working on 35 projects. Of these projects, 28 were proposed and conducted by the laboratory coordination, 4 were proposed by other researchers with their support, and in further 3 cases the members of lab acted as participants. Of the 35 experiences, one was developed in analog method, one in ArcGIS (ESRI), one in CityEngine (ESRI), and 32 on Geodesignhub (Ballal, 2015). After each workshop, the coordinators applied questionnaires or made notes about performances. Based on the acquired experience, a web-based platform, called GISColab, was developed to apply the principles defined as values to be respected: adaptability, flexibility, and scalability (Moura and Freitas, 2020, 2021). From 2020, with the creation of GISColab, 31 more workshops have already been carried out using the newly developed framework on the new platform. Since then, Brazilian studies are putting their efforts in methods and applications to include geovisualization, in order to enhance the reading of the place. The studies analyze reports based on reality, mental maps, and digital representation. The Geoprocessing Laboratory is constantly working on the improvements of the web-based platform, based on the structure of a Spatial Data Infrastructure (SDI), that can communicate with other web-based applications compliant with the OGC (Open Geospatial Consortium) standards. The main idea is to connect to different tools in a continuum of improvements, respecting interoperability between machines and people. The bibliography produced is available on the website (https://geoproea.arq.ufmg.br/).

In Italy, the implementation of the geodesign approach as defined in the introduction dates back to 2016, although earlier research and education academic experiences in the last two decades or so can be considered earlier examples of the approach, which set the ground for the adoption of a more formal methodology at a later stage. The first pioneering course with a formal denomination as geodesign in Italy was introduced at the Faculty of Engineering and Architecture of University of Cagliari in 2016, and it is currently a major for the BSc students in Architecture and for the MSc Students in Civil and in Environmental Engineering. An account of the evolution of syllabus of the geodesign course at the University of Cagliari was given by Campagna (2017). Since then, extensive international and local research projects and education were carried on, which produced on the one hand research and applied studies and on the other hand BSc, MSc and PhD theses, respectively (Campagna, 2016; Campagna and Di Cesare, 2016; Campagna et al, 2018; Cocco et al, 2019; Campagna et Al, 2020; Campagna 2022). Other examples of geodesign adoption in academic research and education in Italy include the University of Basilicata, and more recently the University of Naples Federico II (Somma et al., 2022). In addition, geodesign tutorials were introduced since 2020 at the PhD winter school on Research methodology in social sciences, urban studies, and spatial, planning (https://researchmethodologyws.org) at the University of Florence. With regards to its implementation in Italy, in the next section, two case studies of application of geodesign in education at the University of Cagliari and at the University of Basilicata are presented.

3 Selected case studies description

3.1 Combining Scenario Planning and the Steinitz's Geodesign Framework: Study Case of Ames, Iowa USA

This study case was concentrated on a small college town, the City of Ames in Iowa, USA. The main systems considered in the study were transportation and mobility, energy and green infrastructure. The goal was to apply the existing Geodesign framework (Steinitz, 2012) and combine it with Scenario Planning, as proposed by Avin (2012) and Goodspeed (2022). Two groups of students, one from Iowa State University (ISU) and the other one from the University of Georgia (UGA) collaborated on this project. The students were tasked to develop future scenarios for the city of Ames (2035, 2050). In addition, it was also tested how the use of online tools would improve the collaboration of two groups of students: one with local knowledge (ISU) versus a group working remotely with no previous knowledge of the study area (UGA). Both groups had good technical knowledge in urban planning and GIS.

The first part of the analysis used the Generalized Framework for the Futures Planning Process as suggested by Avin (2012, p. 110-111). It is based on identifying issues/trends, values/goals, possible/likely futures and desired futures. In the next step social, technological, economic, political, and environmental Driving Forces were identified. Identification of the Stakeholder Values included values identified for the Government Residents, and Environment. The identified Driving Forces were accompanied with a scenario narrative and basic scenario features as suggested by Avin (2012, p. 120).

Based on this initial analysis, the focus moved to the specifics of each of the selected thematic areas or systems. Three groups of students in Iowa, and three in Georgia were formed to concentrate on the suitability analysis for each of the three systems: transportation and mobility, energy, and green infrastructure. They worked on the acquisition of geospatial data, then they identified criteria for the suitability of newly planned infrastructure, and eventually performed a suitability analysis. The results of the suitability analysis were locations, paths, and areas allocated to the planned developments.

Based on the data integration and analysis (representation and process model) and suitability analysis (evaluation model), the groups developed scenarios of the future development. ESRI's GeoPlanner as a geospatial tool enabled them to sketch the proposed solutions and ideas. The software can integrate geospatial data on different layers and add options for sketching, design, and evaluation of scenario impacts. A new template was created for the project to be able to include the specific features related to the selected systems. The proposed scenario elements were included in the design as GIS objects and used for further analysis in a GIS.

ISU group developed three scenarios in mixed teams. The teams negotiated and ended up with a unique scenario that included the selected features and proposals from all three scenarios (Fig 1). Central to the final scenario are the following features:

greenways interconnected parks and opened spaces, green roofs, green streets, permeable surfaces, green/complete streets, bike sharing and e-bikes stations, photovoltaic bike lanes, electric scooters and charging racks, advanced bus stops, piezoelectric speed bumps and sidewalks, piezoelectric roads/highways/railroads, the geothermal plant, equitable Investment in vulnerable and disadvantaged communities with a focus on environmental justice.

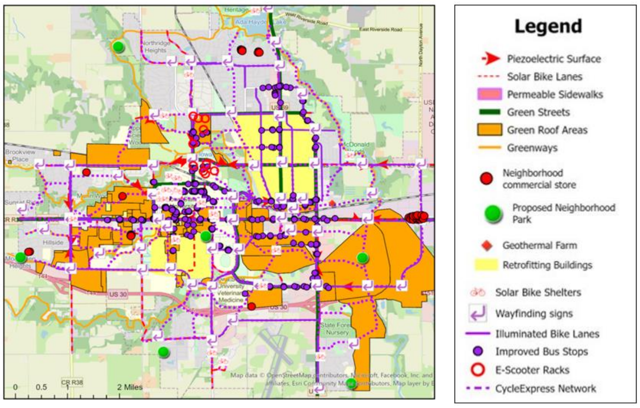

Fig. 1. ISU final scenario

At UGA, the students developed and documented their process using ArcGIS Hub Geodesign in Ames (arcgis.com). After developing suitability analyses for each of the three systems, two groups were formed, each of them incorporating a collection of innovations and strategies.

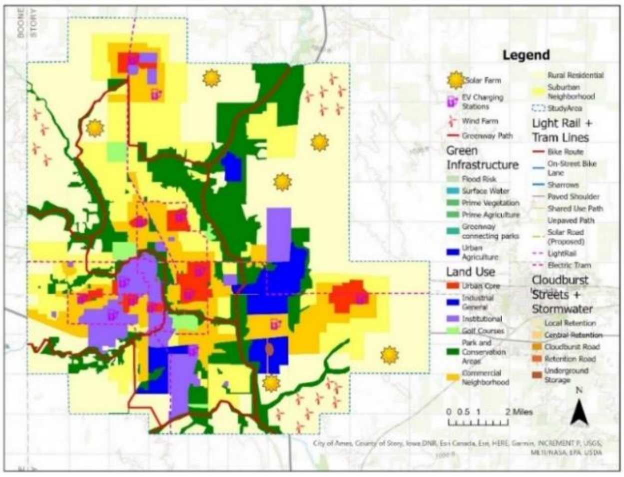

Fig. 2. The UGA final scenario

Group A focused on strategies related to the increase and improvement of public and active transportation, investment in CyRide (local bus), methods for micro-mobility (bikes, scooters, etc.), investments in the existing infrastructure, needs for building retrofitting and road maintenance, and transition to clean energy including natural gas, solar and wind energy. Group B focused on increasing transportation infrastructure connectivity that facilitates public transit and active transportation, encouraging population growth with specific focus on retaining residents ages 25-34, preparing for large population increases due to climate migration, promoting green energy industry and infrastructure through policies, programs, and physical builds, and integrating green infrastructure principles into development.

Both groups used a matrix to conduct negotiations and identify compatibilities and conflicts among them. A synthesis map of their proposal, considering proposals on Land Use, Clean Energy, Mobility and Transportation, Cloudburst Street System and Stormwater Storage is presented as final scenario in Fig 2.

Both of the final scenarios were derived in the process of negotiation among the groups. The negotiations were based on an impact matrix. The elements of the developed scenarios that had the most positive impacts were then selected to be included in the final scenarios. Both classes presented these final scenarios in the final round of discussion with expert feedback included.

3.2 Geodesign in urban design teaching: the process of co-creation in collective reading and planning of the central area of Belo Horizonte, Minas Gerais, Brazil

In the Brazilian case study the goal was to teach the role of urban planner as a a) decoder of collective values, doing field capture of data based on cognition and perception, and registering information in a Volunteered Geographic Information (VGI) platform called ViconSaga (which is a VGI application, developed by Marino (2018) at the Rural Federal University of Rio de Janeiro (UFRRJ, https://www.viconsaga.com.br); b) a technical analyst of values related to cultural, social and environmental information using geoprocessing models included in ArcGIS (ESRI); c) a conductor and participant of a co-creation process of ideas, based on ideas, proposals, discussions and votes gathered in a Geodesign workshop (GISColab - UFMG); d) an authorial creator that develops the design respecting the expectations resulted from the co-creation in previous stages.

The challenge addressed in the study is the proposal of integrated actions according to a workflow that included different geospatial technologies. It started with identifying the place by analysis of perception and cognition using a VGI tool, followed by the construction of diagnoses by special analysis using geoprocessing applications. The maps and data produced were organized in a Spatial Data Infrastructure (SDI) using the web-based platform GISColab. In this platform, a geodesign workshop for co-creation of urban design proposals and measurement of impacts was conducted, including the application of established indicators, and the negotiation of a final design.

The objective of the study is of a didactic nature, for teaching urban design at a local scale, applying the completeness indicator principle, which meets environmental, place and movement values. The novelty was to explore different resources of geospatial technology in an integrated and planned workflow, feeding the Geodesign Platform GISColab, in which the stages of co-creation of ideas were carried out.

Students were initially trained in regulations and legislation related to urban planning and design, and in spatial reading processes through perception and cognition. They did fieldwork and recorded information and images using their cell-phones for feeding VGI in the ViconSaga application. Next, an evaluation of the area was carried out using spatial analysis models by geoprocessing using ArcGIS/ArcMap (ESRI). The information collected in the field, together with the collection of analytical maps, were made available in the web-GIS application GISColab based on an SDI architecture. Students took part in a geodesign workshop using the GISColab platform using the characterization and analytical data.

The workshop itself was conducted in four meetings, in which the participants worked in the stages of reading enrichment (reading the information in an integrated way and recording notes), drawing diagrams of ideas (points, lines and polygons with titles and descriptions), recording debates and comments on the ideas, running impact analysis based on the achievement of established goals (dynamic graphs of compliance with the requested 12 indicators related to completeness indicator principle) and voting (decision for the ideas chosen by the majority).

After the co-creation and co-decision workshop, each student individually developed an author project, detailing one of the designs from the previous stage. Students learned about the relationship between shared designs, resulting from collective decisions, and author designs, as a creative response to previously agreed values.

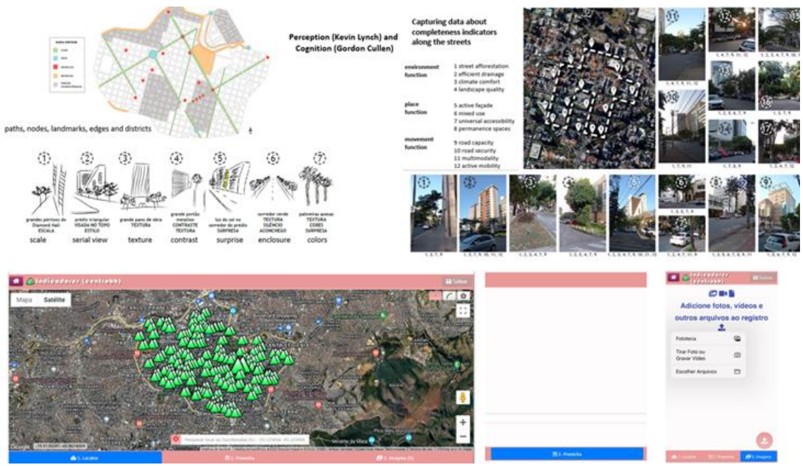

Fig. 3. Field camp – data capture and registering in VGI – ViconSaga

In the first step, in the field camp that enabled them to capture data and read the territory, the students applied the concepts of perception (Lynch, 1960) and cognition (Cullen, 1961). While capturing the image and the soul of the city, they also registered examples of twelve variables of the completeness indicator index describing qualities of the place according to environment, place, and movement values. They imported the data in the ViconSaga application directly from their mobile phones, or by using the browser of their computers (Fig. 3). As ViconSaga is an excellent example of a resource based on interoperability, data produced were easily organized in GISColab.

In the second step, the students developed a technical analysis of the place, applying geoprocessing models in ArcGIS (ESRI) and carrying on twelve spatial analyses including: 1 street afforestation, 2 efficient drainage, 3 climate comfort, 4 landscape quality, 5 active facade, 6 mixed use, 7 universal accessibility, 8 permanence spaces, 9 road capacity, 10 road security, 11 multimodality, and 12 active mobility. (Fig 4). The maps were organized in GISColab web-application (Moura and Freitas, 2021).

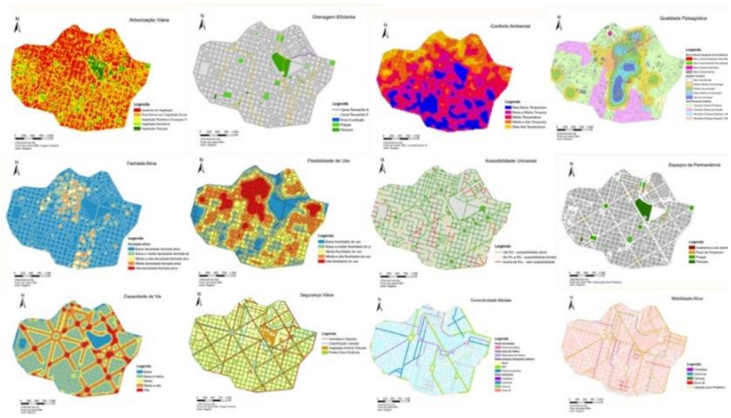

Fig. 4. Spatial Analysis Maps

In the third step, with all data produced organized in GISColab web application, the students took part in the geodesign workshop to learn about the process of co-creation. They proposed ideas in diagrams (points, lines, or polygons) including their descriptions and justifying their contribution to each of the 12 completeness indicators. Ideas were displayed for the discussion. A final design was composed, with the support of a widget to analyze the performance and the achievement of the goals. (Fig. 5).

Fig. 5. Geodesign workshop to co-create designs reaching proposed goals

Finally, in the fourth and last step, the students developed authorial drawings as solutions to the negotiated design. In this process they learned about the role of reading the territory, constructing common solutions, and acting as a creative designer. (Fig. 6).

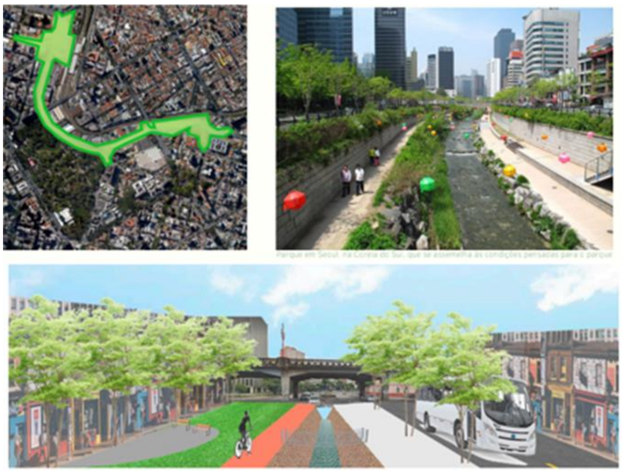

Fig. 6. Examples of authorial drawings

3.3 Geodesign studio on the Metropolitan City of Cagliari, Italy

The case study of the application of a geodesign studio in education at the University of Cagliari presented here dates back to the autumn 2018. It was developed as a case study of the International Geodesign Collaboration (IGC), following its standards (Fisher et al, 2020). The study area was the Metropolitan City of Cagliari (MCC), including 17 municipalities which host about half-a-million population. The study itself was adapted to an education setting from a previous research study (Campagna, 2016; 2022b).

While this case study is presented in more detail in Campagna et al. (2019), the main features of the study are summarized below. It involved two classes of students (i.e., 58 master students in Civil Engineering, and 76 bachelor students in Architecture). They worked in tight coordination on a multiscale design studio. The students in engineering concentrated on an 80x80 km area including the whole MCC. The students in architecture worked at a larger scale (i.e., smaller area) on a 20x20 km area in the South-East of the MCC. All preparatory data, information, and knowledge (i.e., the Steinitz framework's representation, process, and evaluation models) that supported the design was prepared in advance by the instructors who coordinated the study. Each class worked during 5 sessions, 3 hours each, and the final design scenario based on consensus through negotiation was achieved in 15 hours. The two classes worked in parallel. The engineering class, working at smaller territorial scale, started first so that the second class could take their recommendations on board when designing at a more detailed scale. This enabled them to make the two designs consistent. The design was organized in the following ten systems (i.e., the nine IGC standard systems, plus one additional system which were locally relevant): Water Infrastructure, Agriculture, Green Infrastructures, Energy, Transport, Industry and Commerce, Residential Lower Density, Mixed-housing, Institutional, and Cultural Heritage. In addition, according to the IGC guidelines, the students developed scenarios for 2035 and 2050, with different rates of adoption of technology innovations in the systems design (i.e., non-adopters, late-adopters, early adopters) as shown in the example in Figure 7. While the data preparation was done in ESRI ArcMap, both of the design workshops were supported by the Geodesignhub planning support system (Ballal, 2015).

The workshops produced five scenarios each, consistent within the larger and the smaller areas, and for the two timeframes. Figure 7shows the maps of the final scenarios, their impact models, and a 3D representation for the MCC South-East study area.

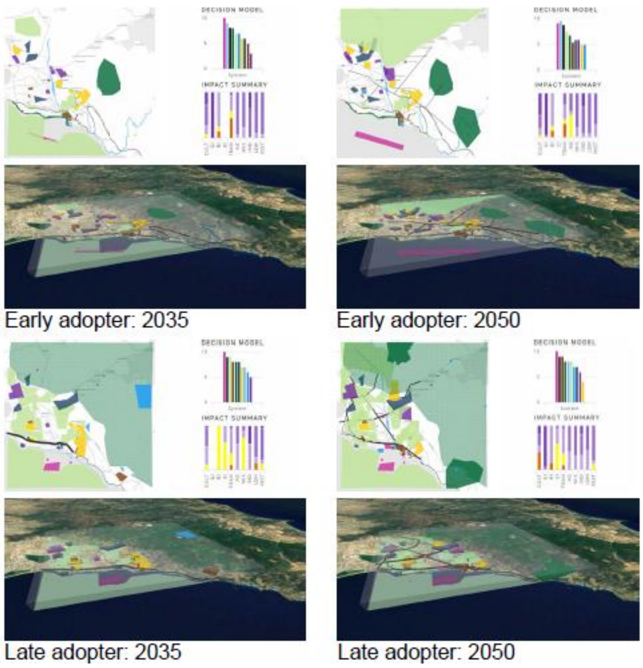

Fig. 7. Scenarios for 2035 and 2050, early adopter and late adopter

Overall, in a very short time (i.e., 15 class hours) the students who had no previous knowledge of spatial planning and design could learn about territorial planning issues, geodesign methods (i.e., collaboration, negotiation) and technology with a very steep learning curve. They found the collaborative (geo)design experience novel and stimulating. It could raise their knowledge of systems design as well as their awareness on environmental planning issues. This can be considered a very successful teaching experience as the results in terms of learning were above expectations. Limitations included the quality of the final design which left space for improvement; however, the learning focus was purposely on the process methods and technology. In addition, the students were involved only in the framework intervention phase (e.g., change, impact, and decision models). Possible improvements for further development included involving the students in the preparation of the evaluation model, which was eventually implemented in 2019 in a new Geodesign Lab course; and the possibility to involve them in a real-world case study, which is currently under development. Later in 2021, the MCC geodesign study eventually was applied in a real-world planning process, when representatives of the 17 municipalities of the MCC participated in a geodesign workshop within the making of the MCC Strategic Plan, which was adopted a few months later.

3.4 “Political Academy”: a geodesign case study at UniBAS

A relevant Geodesign application realized at University of Basilicata regards the “Potenza 2050 – Political Academy” (Scorza, 2020b). The research project was based on two main steps involving different focus group: the first includes the students of the “Territorial Engineering” class (Environmental and Civil engineering MSc); the second involved representatives of the Municipality of the City of Potenza.

The Potenza Political Academy Geodesign Workshop, held on 17th January 2020, aimed to deliver components of an urban development strategy in accordance with EU urban development public investment program of the Integrated Territorial Investment of the City of Potenza (ITI). The ITI was based on a self-defined strategy to implement UE cohesion funds for urban regeneration and development. It represents an innovative procedure of program management that transfers the managing authority responsibility from the Regional Government to the Municipality. The implementation of this program became a critical stage of planning where the Municipality obtained the resources to realize an extensive regeneration program including public infrastructures and services. Such background fits with geodesign scope to define, through a negotiated approach, a strategic development masterplan on the base of a pre-defined set of intervention areas and budget.

The workshop setup was prepared with students in a studio project where they applied spatial analysis to deliver context knowledge. Then, they acted as stakeholders in the first step of the workshop simulating the main roles characterizing a real urban development interaction: decision makers, developers, environmental activists, SMEs etc.

The second step was organized with real stakeholders, mainly representatives of the Municipality. The invited participants to the workshop were political representatives of the town council of Potenza, including the mayor, as well as technical staff of the main municipal departments dealing with ITI planning and management. Researchers, PhD students, and master students in engineering participated in the workshop as mentors, guiding actors through the methodological steps of the geodesign workflow and explaining technical analyses and the use of the online platform Geodesignhub. Posters in the room documented the evaluation maps and became a base for discussion among technicians and politicians.

The design phase and change teams’ design selection were facilitated by a positive interaction between politicians and technicians. During the presentations of the syntheses, some political conflicts arose between majority and minority groups. Finally, negotiations paid the bill of a simulated discussion delivered in a learning event. The final results of the workshop were not implemented in the ITI implementation process, but participants learned the methodological approach and the effectiveness in defining a shared development scenario for future urban regeneration programs. Additionally, it is relevant to point out how the level of interactions became not effective in terms of conflict resolution and agreement reinforcement among participants, remarking a general situation characterizing all Geodesign workshop applied in a simulated decision-making context.

Fig. 8. System evaluation poster supporting stakeholders' interaction

The first step of the workshop led by students, compared with the second one, remarked the applicability of the method to a wide scope of planning issues. The approach adopted was organized in learning by doing process. The level of personal learning derived from the participation in the workshop has not been measured by specific survey, but in the final discussion session, several positive remarks were declared by participants (i.e., the politicians). Their appreciation toward the experience mainly focuses on the applicability of the approach in real-case decision making concerning urban transformations. Participants expressed a quite evident understanding of geodesign, remarking properly on the stages of the workshop. The "acceptability of the geodesign method was demonstrated during the experience. Participants followed the workshop steps and easily adapted their way to consider the city and its development perspective according to the geodesign process.

4 Comparative review

The comparison of different geodesign studies is an interesting research issues as their number continue to grow around the world. Gu et al. (2020) proposed a first analysis in the research and education domain, while Campagna (2022) proposed a comparative review of two main real-world case studies. The latter taxonomy was adapted to this study with regards to geodesign education as shown in Table 1.

	City of Ames ISU and UGA (USA)	Central area of Belo Horizonte UFMG (Brazil)	Cagliari Metropolitan Area UniCA (Italy)	Potenza 2050 UniBAS (Italy)
Year	2022	2022	2018	2020
Goal	City of Ames: Plan for a Sustainable Future	Requalify the central area according to Completeness Indicators of streets	Metropolitan Strategic Planning	Urban Agenda (integrated investments for urban development)
Students	ISU: 3 undergraduate and 4 graduate planning students UGA: 7 graduate students (Master of Urban Planning and Design)	15 (Urban Planning lectures, BSc Architecture)	58 (MSc Civile engineering) + 72 (BSc Architecture	14 (MSc in Environmental and Civile engineering)
Stake holders	City of Ames government officials, ISU Sustainability representatives, and selected community members.	Observed and interviewed on streets	N.A: (i.e., Students played the role)	Municipality delegates (including political representatives and technical staff)
Duration	One semester; 17 weeks	4 sessions x 4 hours along 2 weeks, plus field camp	5 sessions x 3 hours along 3 weeks	1 session x 8 hours along 1 day
Technology	ESRI's Geoplanner, ArcGIS Pro, ArcGIS Online (ISU and UGA)	ViconSaga, GISColab, ArcGIS	ESRI ArcGIS, Geodesignhub	Geodesignhub, QGis
Systems	Three systems: Transportation and mobility Energy Green infrastructure	12 variables organized in 3 contexts: a) Environment b) Place c) Movement Road	10 systems: Water, Agriculture, Green Infrastructures, Energy, Transport, Industry/ Commerce, Residential, Mixed-housing, Institutional, Cultural Heritage (IGC compliant)	9 Systems: Urban water management, Urban Green Management, Energy infrastructures, Transport infrastructures - Grey mobility, Transport infrastructures -

				Active mobility, Cultural Heritage, Services supply specialization, Building Stock Renovation, Green Stock Renovation
Live/ online/Hybrid	In person and online	Live in class and on streets	Live in class	Live in the town hall
Deliverables	2030 and 2050 Final Scenarios (one for ISU and one for UGA); 5 intermediate scenarios (3 for ISU and 2 for UGA); A collection of Suitability/Evaluation models (3 per system and per university – ISU and UGA, for a total of 6 suitability maps)	Present scenario considering and measuring the goals proposed	2035 and 2050 IGC scenarios (i.e., NA, EA, LA) at 2 scales	2050 scenario of urban development at 1 scale
Outcomes	Student exchange Learning about the process and geodesign framework Learning how to conduct suitability analysis. Focus on innovations. Learning how to use ESRI's GeoPlanner online tool. Presentation skills Conference presentations by students with stakeholders and national conference.	Learning about authorial design and design by co-creation	Fast learning curve in planning and technology	Effective learning on how to manage and interact during the process of scenario building. Effective interaction among students and Municipality delegates
Limitations	Availability of specific data Time and budget constraints Distance and costs for UGA students to visit study area more than once. Lack of tools and clear methodology for impact assessment Lack of software that would support impact analysis Lack of proper software documentation (Geoplanner) and	Time left to field camp.	Quality of design may be improved	The workshop simulated a strategic design for public investments in the city of Potenza, so the level of conflicts among participants was very low.

	relevant tutorials to use with students. Limitations to implement suitability models in GeoPlanner, except Green Infrastructure.Limited software support. Lacks documentation;			

Table 1: Comparison of the geodesign teaching case study.

5 Results and Conclusions

It is observed, from the case studies developed in the United States, Brazil, and Italy, that the instructors involved in the implementation of geodesign in their courses already had extensive experience in teaching planning, still they innovated their teaching through the inclusion of the geodesign methodology as a reliable way to improve the teaching objectives. Interpreting in different ways the geodesign framework proposed by Steinitz, the coordinators based the teaching workflow on the representation, processing, evaluation, change, impact, and decision models. Once the steps were structured, the students expanded their knowledge on how to characterize a study area, according to its potentialities and vulnerabilities, and how to produce these analyses through the use of geospatial technologies as a base to inform design.

Irrespectively whether the students already knew the study area, they expanded their understanding of territorial dynamics and of the way of interpreting and decoding its geography, moving from personal observation to structured quantitative analysis.

In the case study of the United States, the students were from different universities (i.e., ISU and UGA), which favored the understanding of the method in the representation of the study area, so that shared knowledge was built through digital representations, creating maps representing the study area. Thus, it was a way of proving the potential of organized information in representing the problem. In the Brazilian case study, the students worked in an area of their personal experiences, whose knowledge was expanded by the reading enrichment method, using the VGI technique, associated with the concepts of spatial reading proposed by Lynch (1960) and Cullen (1961). In the Cagliari case study, the students also worked in an area of their personal experiences, and the knowledge about development issues was expanded due to the wide collection of information previously built for the case study, since the same workshop took place in more than one occasion, with more than one working group. In the Potenza case study, students actively participate to the creation of knowledge.

The use of different working tools stands out, making it clear to prospective geodesign workshop coordinators that the process can be carried out with the support of alternative tools. Either desktop or web-based software were used in the stages of production of representations of the study areas and interpretive analyses (representation, process and evaluation model). To read the place dynamically, in Brazil, the ViconSaga VGI application was used. For the stages of proposing ideas (change, impact, and decision models), the groups used either the web-based resources ESRI Geoplanner or

ArcGis Hub (in the United States), GISColab (in Brazil) and Geodesignhub (in Italy). The choice of possibly platforms is flexible, and it is important to consider that, due to the expansion of technological possibilities applicable to planning, it would be important to consider options that allow greater interoperability, even allowing students to use applications of their preference in some stages of the process.

It is also worth mentioning that geodesign workshops as a whole facilitate both decision-making and knowledge building: both are considered of great value. Often, when an academic case study is developed, may not become a plan for immediate implementation, but, as learning process its value is in simulating learning and evolving of ideas. Indeed, working as close as possible to reality motivates students. In the case there is an institutional agreement, the result can be a support for institutional decision, possibly to several iterations, but in the case of a strictly academic study, it can be considered an aid for "transformative learning" (Forester, 1999). In all the geodesign case studies considered here, students and participants went beyond critical thinking, and advanced to the construction and negotiation of proposals, in a collaborative way.

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