A Didactical Framework to Experiment the Potential of Visual Languages in Engaging Social Complexity.

1 - Introduction

Development models often apply expert knowledge to social needs using a top-down approach, thus rendering these models insufficient in coping with the issues of a complex world. Effective changes in social systems arise from iterative and dialogic processes in which information and knowledge are exchanged between heterogeneous actors, building a common background that enables a shared hypothesis.

The design approach involves the ability to select results from various disciplinary fields, activating a trans-disciplinary circulation of concepts. Designers should use their skills to facilitate the emergence of a system, rather than concentrating on finding solutions to specific and well-identified problems. The focus should be on developing tools that can be self-adaptive, continuously modifiable and improvable by utilizing the ongoing process of wicked problem transformation. Social complexity requires new processes fundamentally attuned to the social and conversational nature of decision-making and design work; these processes should enable an increasingly valuable interaction level and dialogue among the actors of a social system.
And considering the Design discipline in respect to language, Communication Design could allow for the creation of visual and interactive languages relevant to the representations of Complex systems, thus creating shared visions within multi-actor contexts. In this sense, communication design can facilitate dialogues within participatory actions, and verify the potential of communication artifacts in supporting and externalizing sustainable and self-adaptive learning processes.

Therefore, the possibility of consciously facing social issues and orienting the behavior of complex social systems could benefit from the use of communicative tools and methodologies, thus supporting collective learning processes and building a common vision, shared by various stakeholders. Engaging complexity calls for visual languages.

2 – The role of Communication Design within the Complexity Framework

The centrality of communication and learning processes in dealing with complex systems - especially social ones - has been explored and criticized in several domains in different disciplines: from the theory of social systems (Luhmann 1984) to knowledge management (McElroy 2000). How these processes should be handled and shaped in order to be able, effectively and collectively, to drive and orient the evolution of a complex social system is a subject that is less explored and less clear.

We believe that communication design capabilities go beyond the general approach of taking into account complexity and developing a systemic perspective, and then examining the limits and opportunities of such a system. The type of communication design we are advocating includes the skills to concretely and actively insert, in every kind of process that aims to confront complexity, an intervention that enables a system change. In its evolution, the design field has defined itself as a cross-field discipline with different competences, addressing interdisciplinary issues, and often developing, by the creative recombination of knowledge units, the ability to create connections and new ties, thus giving shape to innovation. The design discipline creates innovation by pursuing relationships and combining the usual elements in a new way. Design has the capability to foresee, represent, and potentially visualize a complex of elements and relationships. Zurlo (2007) summarizes design capabilities as, *see* (understanding the context), *show* (visualizing the information) and *foresee* (making critical predictions), thus communication design is able to make complexity visible, understandable, accessible, and more easily practicable.

The importance of the concept of shape grounds the systemic thought that moves the focus from single parts to the whole, and sustains the need to understand the specific configuration of relationships (*pattern)*[1]. Understanding and intervening in a complex system requires the perception of the system as an integrated structure, and understanding which properties characterize the whole system, rather than belonging to any one specific component…those properties that emerge from the relationships and the interactions between single elements.

In our research, and in students activities, we assume the idea that the distinctive pattern of a complex system belongs to the visual domain of networks: it's the common organizational structure that belongs to all living systems, as Capra (2001) recalls: "Anytime we observe a form of life, we observe a network pattern […] the life pattern, we can say, is a network pattern that is able to self-organize".

To make the complexity of a system visible means to show what is latent; a fundamental step to enable access and intervention to the system itself. Both design disciplines and complexity theories refer to the domain of possibility and the hypothetical, and the specific contribution of design bases on the ability to both make a pattern visible and to assume the point of view of users: a user centered approach that produces prototypes as cognitive tools, for testing activities and reflective learning (Cottam and Leadbeater 2004):

> *Designers make problems and ideas visible, creating frameworks to make visual sense of complex information, and quickly sketching ideas to share work-in-progress with others. Making even intangible concepts visual creates a common platform for discussion, avoids misinterpretation and helps build a shared vision.*

The teaching and research program we propose explores and develops the visualization of networks, their features and dynamics, with the aim of educating designers in the exploitation of visual languages in dealing with social complexity. We intend to amplify the peculiar competences of designers to perceive and make visible those complex structures and concepts.

3 – The DensityDesign Laboratory: complexity, density and communication design

DensityDesign Lab was born in 2004 as a didactic initiative with the aim of developing experimental visual representation languages, to facilitate the sharing and the development of knowledge within groups of heterogeneous actors engaged in a complex system.
Let's imagine a decision-making table around which different stakeholders sit together: students are asked to define the concept and the design of communication artifacts intended to visualize the system as a complex whole, to create a common knowledge base for different actors.

The resulting communication artifacts cannot be considered as the solution to a wicked problem: mostly they are cognitive tools that are supposed to contribute both to better understanding and better acting, taking into account - through the visualization - both uncertainty and unpredictability.

3.1 – Density method: from graphs to diagrams

The communication artifacts designed by students during the laboratory are conceived as negotiation and decision-making tools. Communication design builds, through a visual language, the dialogical tools that allow the depiction of a common and shared understanding, and the emergence of common interests and goals in multi-actor contexts. From the beginning we

1 Capra says: "In the study of structure we misure things. But schema cannot be weighed: they need a visual representation. To understand a schema, we need to draw a configuration of links and relations. In other words, structure entwines quantity, and schema is more related to quality" Capra, 2001.

designated these artifacts with the generic term of *maps*, which evolved through the support of doctoral research[2] into the concept of *diagrams*. The etymology from the Greek διαγραμμα, DIÀ (through) GRÀMMA (sign), is open to the widest visual opportunities, and includes those communication artifacts that have a revealing ability - such as maps, scenarios, schemas, storyboards etc. - and represent the *visions* behind visualizations.

In our meaning, diagrams provide the system with an understandable and sharable shape that can overcome the constraints related to technical and disciplinary languages. Diagrams can visualize not just quantitative data, but also ideas, concepts, point of views and perspectives, as well as qualitative and value assets of complex systems observers. Beginning with a review and interpretation of insight into diagrams emerging from architectural research, we underline four important characteristics of diagrams (Corbellini 2007):

Condensation: diagrams can manage huge amount of data and information, and can demonstrate connections between elements that otherwise would be difficult to understand.

Connection: diagrams are able to express relationships between non-homogeneous data and information, encouraging unexpected interpretations and perspectives.

Proliferation: diagrams enable dialogue and inspire different ways to approach the problem setting and the understanding of systems; they are also fertile narrative devices.

Inexactitude: the construction of diagrams always displays a partial and non-comprehensive description of the system. Acting within complexity requires considering the impossibility of reaching an exhaustive knowledge of the system in which one operates. This difficulty could be overcome by developing strategic stances that allow for the ability to face system changes and their evolution, and are also the opportunity to visualize complex information referring, not solely to the communication of quantitative information, but also to intangible values and qualitative data. In this sense, it's necessary to emphasize that for designers, diagrams always represent a process of choice between the representation of certain things, and the renunciation of others. It's a political action, intentional, and arbitrary, and an aspect that clarifies and pinpoints the designers' responsibility when constructing visual representations.

The diagram takes the Deleuzian meaning of *conceptual device, abstract machine and proliferating machine, enabling method*, and *discursive instrument*. Through diagrams, the visual language demonstrates the shift from product to process, the movement "from the sensible to conceptual, from symbolic to syntactical" (Corbellini 2006), and from visualizations as a result, to visualizations as a process (attitude).

The methodology through which we approach the representations of complex systems is based on the visualization of (a) actors (people and organizations), (b) the relations between those actors and (c) the pattern of flows that involve those actors, defining also information *graining*, the boundaries of the system (*framing*), and the size and perspective of observation (*scaling*) (Scagnetti et al. 2007, Authors et al. 2008).

This is the approach that grounds our practice; the ability to reconstruct the schema, the shape of the system, and the entwining of connections and influences, even if the full potential of diagrams has not yet been fully exploited. Barabasi (2005) states, "networks are just the schema of complexity, the basic mechanisms. In order to describe the society we have to hold the links of the social network with the actual dynamic relations between people".

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2 Gaia Scagnetti, 2009, The design practice of complexity. Communication atlas for sustainable social system integration. Author3, 2010 expected, Seeing what they are saying: diagrams for socio-technical controversies

3.2 DensityDesign tools: diagrams as a cooperative visual device

The interest in diagrams is less about the result itself, but rather as a visual/discursive tool and the generator of dialogical actions. Diagrams are not a final solution, but are instruments for better framing an issue. An apparatus in the hands of the visual designer, diagrams enhance not only the designers' own ability to see, but also enhances the vision of others by creating a collective vision of a form that binds the different elements of an issue or complex system; a precious skill when addressing contemporary problems that require a more participative and collaborative approach:

> *To speak of a problem and to engage with solving it is to engage in a conversation among stakeholders (people who care about the outcome). In my thinking about wicked problems, I like to introduce the notion of 'social complexity' as inseparable from problem wickedness. There are no single stakeholder wicked problems. (Conklin, Basadur, VanPatter, 2002)*

To make visible the relational structure of a complex system, and to describe the dynamics that animate this structure, by combining various tools and visual patterns, is what communication design can add in order to facilitate the exchange between stakeholders, enable negotiations and mediations and enlighten common visions and intents. It's a relevant contribution, acknowledged by Burkhard (2004):

> *You don't so much "solve" a wicked problem as you help stakeholders negotiate shared understanding and shared meaning about the problem and its possible solutions. The objective of the work is coherent action, not final solution. Thus, Rittel and Webber's contribution was well ahead of its time, and is now finally helping us understand why communication and collaboration, more even than creativity, keep emerging as critical to success on large projects.*

The design of diagrams, and a diagrammatic approach, are primarily useful for the design process itself, especially when faced with complexity: "The emerging horizon of the designer depends mainly on the capacity of building and improving the perception of the complex reality, even before building and improving the skills to address it" (Pizzocaro 2004). Some of the proposals that drive the continuous redefinition of the design discipline, bestow the field with the duty of diffusing and making more accessible the design method itself: the development of "open" languages enabling the participation of non-expert users in producing diagrammatic visualizations, is tangible evidence of the enlargement of the communication design domain.

4 – The structure of the Density framework

Since 2004, we have defined and improved the processes of building and structuring visual languages. The methods and procedures of visual analysis, and representations of complex systems have undergone continual improvement over the last five years, and with the development of specific conceptual and operative tools, the initiative has recently reached a more ripened stage (2009). The following section briefly describes the process utilized during the laboratory's activities, and includes the presentation of some artifacts along with descriptions of sample results.

4.1 – Visualized data, information and knowledge

The potentialities of visualization are experimented in two complementary domains: 1) the visualization of Data, Information and Knowledge (DIK), 2) the visualization of the structure of complex social phenomenon (structural visualization).

In the first domain, the students work to improve the cognitive processes that transform data into information, and information into knowledge. Within these processes, any visualization acts as a translator: it identifies and visually represents relationships between data and information, in order to communicate it and leverage knowledge. In the second domain, the focus is on the form of social phenomenon, assuming that understanding a system means understanding its form, and understanding form means to see and visualize a pattern. In this domain, visualization aims to amplify the *pattern finding* human capability (Ware, 2004), connecting the actors and/or the forces that drive the complex system or the dynamics of social phenomenon.

In general, the perspective of complex systems is recognized as the best occasion in which *“to observe the social world and its’ making of. […] According to this approach, nothing can attain a collective existence without being the result of a collective work and controversies are the settings where this work is more visible”* (Venturini 2009). With this feature, any actor within a complex system is continuously involved in data production, information gathering, and knowledge exploitation, in order to support and nurture his own position and interest within the collective undertaking. Data, information and knowledge are the structural and basic elements of representation theories, and in a general way, of the communication and cognitive disciplines. The connection among these elements and visualizations is a key issue in the communication design field.

Any kind of discussion and research that tries to better redefine the role of visualization within the evolution of complexity cannot avoid a clear reflection about the role of design in the process of transformation from, and to, data, information and knowledge. The distinction between these three elements still remains commonly confused. Data and information are sometimes intended as synonymous, and information generally converges with the concept of knowledge.
Timetables, for example, are basically lists of data. These raw — and thus disordered — data about train numbers, departure times, arrival times, and routes, etc., become information when they are structured, passing from a state of high entropy to a state of low entropy.

The timetable example illustrates the role of communication design as a tool for sensing, retrieving and using data. In fact, once data has been organized the second step is represented by the user's assimilation and interpretation. Thus, it emerges that information and knowledge do not represent the same notion. Only thanks to previous knowledge, an internalization or interpretation process, are we able to contextually comprehend a message by transforming the information into further knowledge, thus allowing for action. In this way we can define the second difference between information and knowledge (i.e. knowledge as action).

A Pyramidal hierarchy is often used to represent the relationship between data, information and knowledge (Awad and Ghaziri 2004; Bellinger, Castro, and Mills 2004; Chaffey 2005), yet a flow representation better depicts the relationship between these elements (Cooley 1987; Choo 1996; Jacobson 2000; Bellinger, Castro, and Mills 2004). For this reason, understanding the transformation from data to information is a fundamental matter: the way data and information are presented is of crucial importance in enhancing, understanding and facilitating effective action. Knowledge can be externalized in books or documents (thus turning into information) but can be represented only by experience: *“knowledge is a fluid mix of framed experiences, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers”* (Davenport and Prusak 2000).

Knowledge can be seen as an interpreter in the transformation of data to information; information can be extracted from data only through knowledge. Even though it's not hard to imagine a designer visually representing data and information about controversies, the problem arises when trying to visualize the knowledge produced by the actors of a complex social system.

We have to come to terms with the impossibility of visualizing knowledge, per se, or of considering it an instrumental, operative and reproducible object as it is defined by some knowledge management research lines. Still, we can represent it. However, visualization can only be given by representing knowledge in action, tracking back to the last step of the flow, the one that leads from information to knowledge (i.e. from knowledge to information).

Visualizing, communicating and sharing knowledge means to engage in a process opposite to that of natural acquisition, taking in a contrary direction the data, information, and knowledge continuum. Knowledge has to be converted into information so that it can be transferred and transformed into a physical and visual artifact. Thus signifying that every graphical representation is a visualization of information.

4.2 – DensityDesign experiments and outcomes

Over the years, the number and typology of the didactical modules have been refined, along with the range of disciplines that have been involved and integrated. The choices have been made primarily according to the results of two activities: a) internal discussions with professors of other disciplines (i.e. Statistics and Semiotics) about the outcomes produced by students and, b) the collective discussion sessions organized at ENEA (the National Agency for Energy and Sustainable Development) during the development of Alessio Romeo's Master thesis, "Sistema Energia Italia: Progettazione di un dispositivo comunicativo per i processi decisionali inclusivi" *(Italian Energy System: Designing a communicative system to support inclusive decision-making processes)*. During these sessions, stakeholders from the Italian energy system were asked to depict possible scenarios through the collective discussion of the system maps produced within the thesis work (see fig. 5a, b, c).

In the first stage of the Density Design didactical framework, students were asked to identify a social system, about which they were passionate, and to then gather data and draw a description of that system. The students designed the diagrams, providing a visual representation intended to provide a comprehensive description of the system, in order to better depict its current configuration and dynamics. These kind of maps supported the next design action: using their maps the students would articulate a communication design strategy relevant and useful to the system dynamics, and then return to the diagrams to depict the impact and the new configuration of the system after the interventions. At that stage, the basic intention was to reflect on the selective processes that give shape to a map, and to refine the visual language and empower the ability of representing these different views by the exploitation of details.

A more reflective capability has been explored over the years, and the framework evolved towards a more articulated definition of the visualization modules, according to the communication goals. The current structure of the framework is composed by four modules that drive students from the use of the standard techniques in information visualization, to the development of motion graphics artifacts, depending on the communicative goals. Two modules – *information visualization* and *motion graphics* - belong to the first visualization domain previously mentioned (DIK visualization); the others - *causal diagrams* and *system maps* - are expressions of the structural visualization domain, based on the need to understand the social system/phenomenon as a whole. Similarly, the impact of visual rhetoric has been introduced, in order to evaluate the potential role of visual metaphors and analogies. This distinction between the diagrammatic modules and the Infovis modules refers to the different intentions of the visualization process: diagrams exploit the system's analysis and display, while Infovis explores the narrative techniques, and the conversation between form and meaning.

Information visualization

The challenge of the information visualization module is to nurture and clarify the process of translation from data to information to knowledge. In this module, complex data sets are explored and transformed in visual representations that aim to clarify the meaning of data and make them useful to knowledge enhancement.

Our recent experiments have explored the socio-economic phenomena that present both representational and visual problems. Economic statistics involve understanding complex, multidimensional, ambiguous and dynamic phenomena, and building formal representations (models) based on statistical data. Communication Design addresses complex phenomena in order to interact with them, building multi-dimensional visual representations based (in some cases) on statistical data. The goal is to contribute to the construction of representation and visualization models, while respecting and preserving the inner structure of the analyzed phenomena, allowing users to know (or see) them as a whole.

We used official data (provided by the ISTAT) about poverty and social exclusion conditions in Italy (2007), with each of the students asked to provide a visualization about poverty in Italy, using the data as their primary, though not exclusive, source.

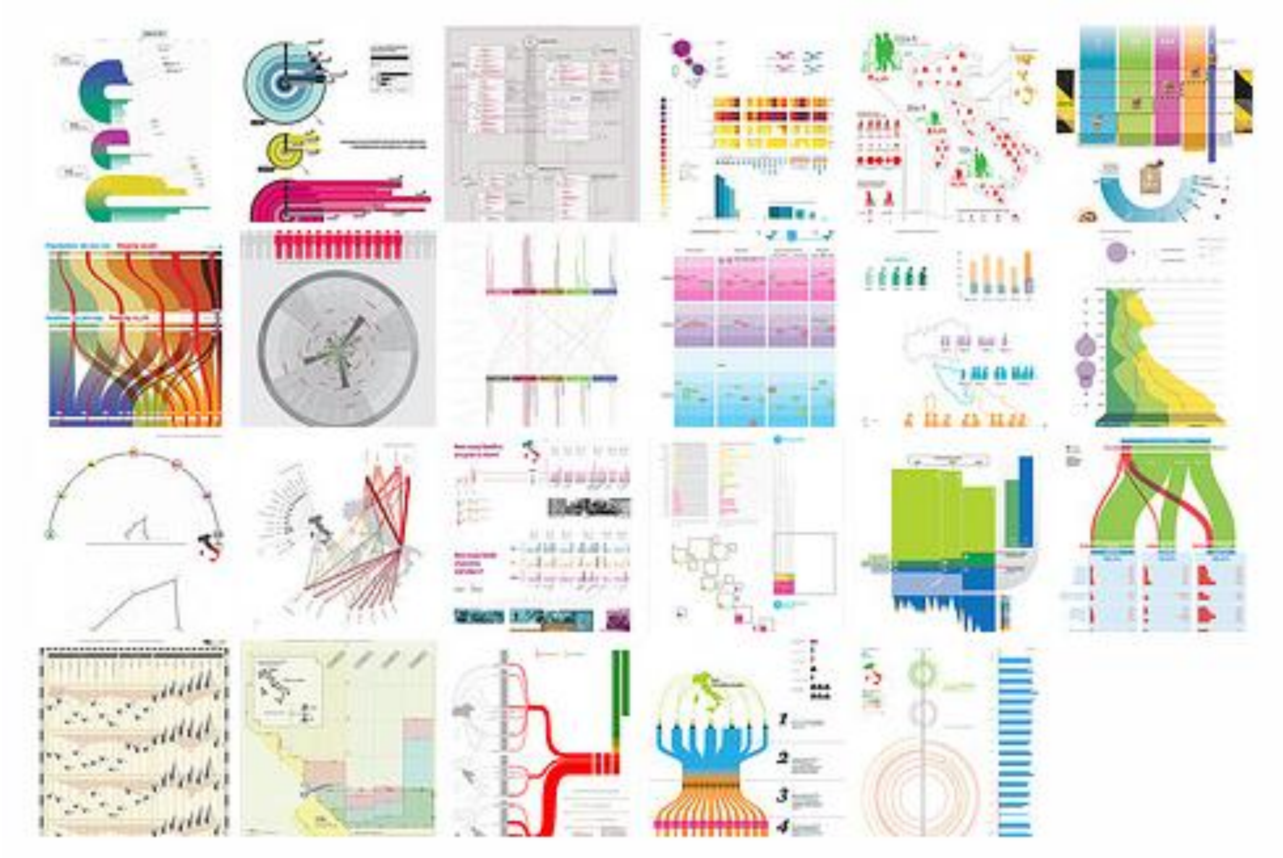

Figure 1 –from data to information: an overview of the different maps designed with the ISTAT italian national report about poverty

Exclusion is a socio-economic status that refers to people located at the margins of society, because of their economic, psychological, physical, and/or cultural conditions. To evaluate the forms and intensity of exclusion requires models that consider a multitude of dimensions, for the determination of poverty status cannot be reduced to a simple and single indicator. The representation of socio-economic problems is not reducible to a single problem or purely algorithmic technology, not because of lack of quantity of data, but rather because complexity, multi-dimensionality and ambiguity are difficult to reduce into algorithmic computations.

This module requires the development of new visual grammars and communication tools that do not superimpose artistic elements, over the representation of the phenomena, but rather build narratives deeply consistent with its inner structure. Visualization artifacts, diagram and maps, have to *respect* the robustness of the scientific approach to phenomena, while remaining *consistent* with the structure of the cognitive and logic capabilities of the observer.

Causal diagrams

The module of casual diagrams is a structural visualization tool that aims to fully describe the actors and variables of a system, and to exploit their influence and directions. It is a kind of representation that better describes the structural part of the system, pointing out the elements as single and detailed, as well as the main structure and influences. At this stage, students were required to split into groups, and select one specific topic from within the wider poverty framework, and to further develop their visualization. Casual maps are necessary to fix the mechanism of the system, and they are the primary schemas in the understanding of system behavior.

A causal loop model has been developed in order to help understand the complex systemic structure of poverty in all of its dimensions. System diagramming is here a loose term used to describe the activity of conceptually representing and visualizing a system in its constitutive elements: the elements, the relationships and the system boundaries distinguishing what does, and does not, belong to the set. The system has been visualized in a particular format: a causal loop model (or diagram). In a causal loop model, boxes represent the system's elements (factors, variables), while arrows represent the causal relationships between the two variables. The variable at the tail of the arrow has a causal effect on the variable at the point. In addition, a distinction can be made between positive and negative causal relationships. A positive causal relationship implies that both variables will change in the same direction: if variable *a* (at the tail) increases, then variable *b* (at the point) will also increase (and if *a* decreases, then *b* decreases). A negative relationship, on the other hand, implies that variables change in opposite directions. The causalities discussed so far are linear causalities (from *a* to *b*). Circular causalities (e.g. from *a* to *b* and from *b* to *a*) in systems maps are called feedback loops. They are an important feature of causal loop models because they help to explain the dynamic behavior of the system.

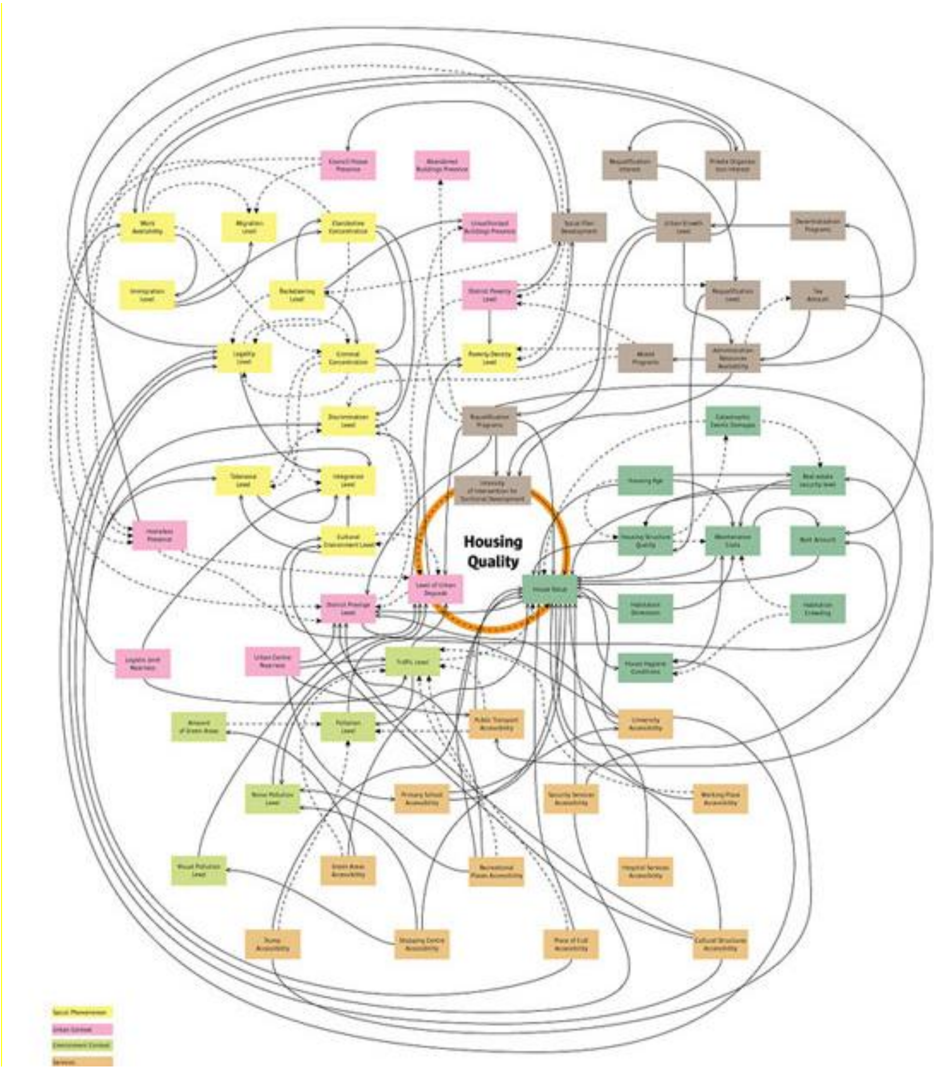

Fig. 3 –a casual diagram about the poverty system

Motion graphics

The motion graphics module mostly explores the narrative power of information visualization. In this case data become information, and then knowledge, and the visual languages are devoted to defining a relevant narrative. Motion graphic techniques are used not for the systemic representations of complexity, but rather serve as thick descriptive tools, able to reduce the distance between data, patterns and meanings within a narrow perspective of the system. Information visualization, in this case, provides a thick description of a single perspective, and visually clarifies the way in which the specific point of view is related and interconnected with the wider configuration.

Fig 2 – from information to knowledge: screenshot from the video Choice, motion graphics about the Poverty System and Food, http://www.vimeo.com/4002528

System maps

The final artifact discussed is the system map, which can be considered as an overall perspective of the system, a sort of bigger picture that describes the components, dynamics and contextual characteristics of a system. System maps emerge from a hybridization of the previous diagrammatic artifacts and a deep visual description of all the content; they aim to suggest the form of the system by the visualization of the found pattern. System maps don't emerge just from data analysis, but are connected to some previous knowledge that is itself depicted within the maps. They are composed of raw data and structured information and are able to finally provide a wide scale representation.

Maps are intended for an audience that is within, or related to, the system, and for those actors who operate from within the system. The maps exploit the knowledge layer related to experience, and should be able to activate dialogues and discourses about the system itself. Maps represent the final step in the cycle between data and knowledge, and transform and elaborate the previous contents in order to enrich a collaborative and shared knowledge.

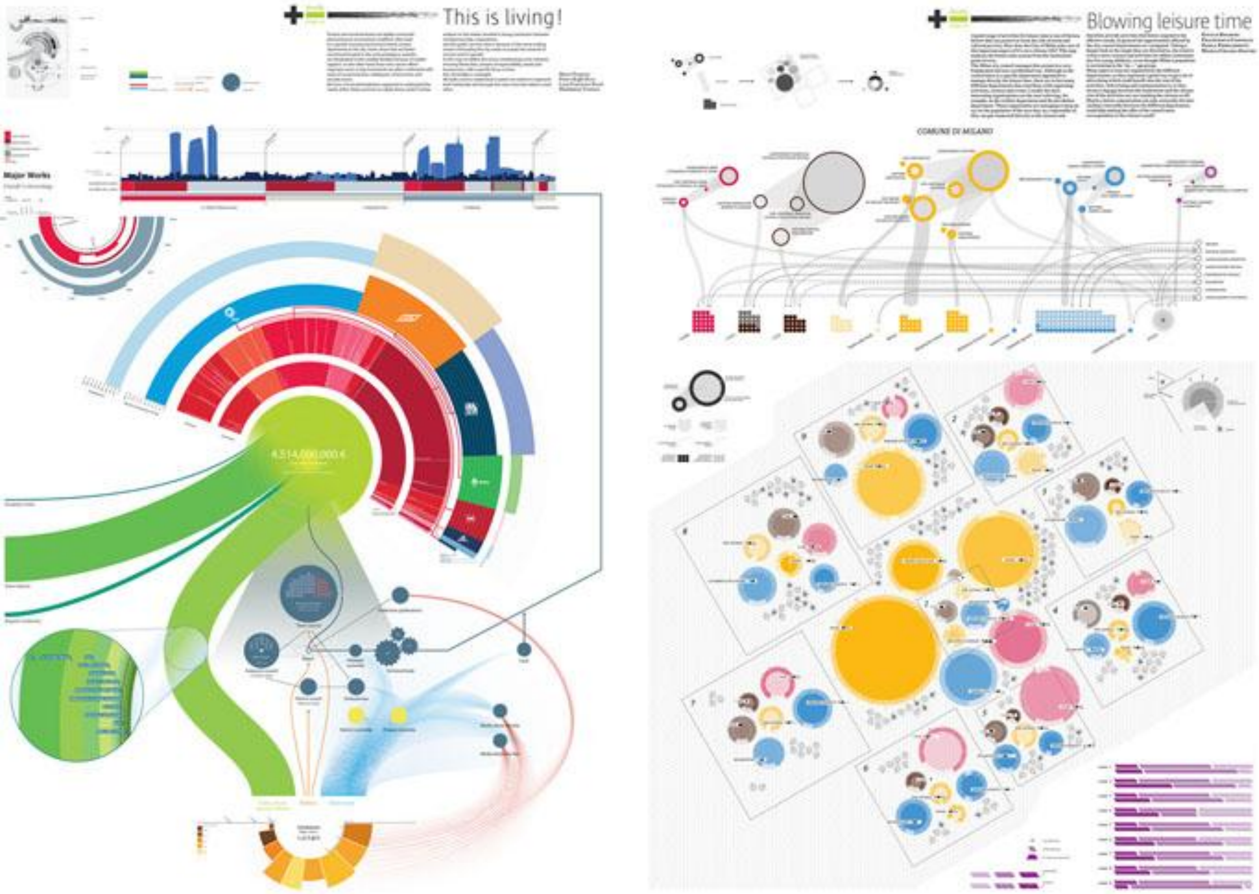

Fig. 4a,b –the system map, Poverty&Housing, Poverty&Leisure

In this module the possibility of evaluating the projects in real contexts is more relevant; finding an evaluation context for projects always means interfacing with institutions, organizations, and identitary structures, and represents a concrete example of negotiating and decision-making that is supported by visual languages. In many cases the process has been successful, and the students were able to verify the effectiveness of their own design, thereby making improvements.

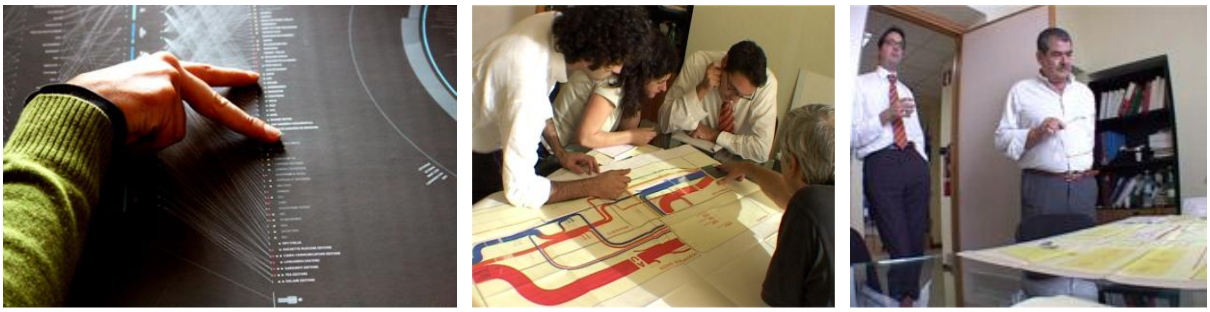

Fig. 5a, b, c: Stakeholders discussing possible scenarios based on the Energy system map at ENEA (the National Agency for Energy and Sustainable Development). Alessio Romeo, MA thesis "Sistema Energia Italia. Progettazione di un dispositivo comunicativo per i processi decisionali inclusivi" (Italian Energy System. Designing a communicative system to support inclusive decision-making processes).

Conclusions

In these pages we have tried to systematize both the theoretical and the artifact outcomes that we have experienced in the development of the DensityDesign Lab. The theory and the results are ongoing tensions that we continuously consider in our research and teaching practices, and that we mainly try to get across at concrete evaluation stages by prototyping (in case of interactive

artifacts), as well as in the participation of decision-making tables. In fact, an extension of the practice of evaluation in real contexts is needed, and the trend also in publications and conferences indicates a fertile horizon in this direction. The challenges shaped by global change require a collective disciplinary engagement, and design is called, and strongly aspires, to participate in finding the solutions to these challenges.
Through the DensityDesign approach, we hope to provide those facing global challenges with a cognitive and practical set of visual tools, a generative machine that allows for a discourse about a changing system, and that facilitates a more conscious approach to complexity. These visual tools aim to originate from common objectives, and consequently develop shared perspectives.

The approach requires a continuous refinement of the nature of the team, and an open and interested attitude toward future projects. The didactical framework proposed here is intended as a multidisciplinary platform, where visual design is the core and leading discipline, complemented with the integration of semiotics, statistics and network science. In order to nurture an intersection between the disciplines, the development of the framework will follow two main directions. First, more research is needed into understanding the cognitive issues of information visualization, and the language of visual narratives. This will involve the efforts of communication design using both representation skills, and interaction and cooperative capabilities. A more unexplored, second direction, introduced through a real data set, is more technical, and involves the power of computational and semantical processing of data. A structural robustness in the framework can be achieved by consolidating the approach to quantitative data, along with the effectiveness and variety of the transformation process into visual information. This step represents a marked evolution, for the integration of other disciplines will certainly lead to experimentation with the field of computer science, to theories of network semantics, as well as social system theory, and will challenge communication design skills to constantly cross languages, from bi-dimensional illustration to interactive processing.

The more refined the process of visualization becomes; the more articulate becomes the strategy of data gathering. These are the basic tensions that we tie to the concept of visual languages as a multidisciplinary cognitive device.

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