Design for quiet living: tracing the development of projects in noise-affected areas with software-based data

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Design for quiet living: tracing the development of projects in noise-affected areas with software-based data analysis and visualization

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ABSTRACT

The study is set within the Science and Technology Studies perspective, which see architecture as a product of collective action and advocate for a deeper understanding of the mutual influence of architecture process and laws. In particular, the work focus on a dwelling project in a noise-polluted area in Turin and examine how noise policies and mitigation solutions affected the process.

The case-study is analyzed through qualitative analysis of interviews and documents, conducted through CAQDAS software Atlas.ti. Themes and codes are inductively derived from the collected material and organized following concepts developed by Actor-Network Theory studies.

The outcomes of the analysis are firstly visualized through Atlas.ti and Node XL. However, since software-based visualization were judged insufficient for a complete understanding of the process, a second phase of the work was developed to design maps that could answer to specific questions, on the basis of the data extracted in the previous phase. The paper is therefore concluded assessing the insight that could be provided on the specific case study as well as strength and drawbacks of the analysis and visualization methodology.

Keywords: Controversy mapping, Noise mitigation policies, Software-assisted analysis

1. INTRODUCTION

Environmental noise is nowadays widely recognized as one of the challenges of contemporary cities (1), with consistent impact on human health (2). A good amount of research has therefore been dedicated, in the last years, to investigate the contribution that urban spaces(3) and building (4,5) design can have on noise mitigation.

However, to the authors' knowledge, very few research has been dedicated to investigate how the implementation of noise mitigation policies works within the empirical complexity of real case studies and which are the factors that can contribute to the acceptance or refusal of different mitigation solutions. Scholars who have assessed the problem with respect to other codes (6,7) and metrics (8,9) have put in light how such insight can be useful for both designers and policy-makers, arguing that design proposals and policies actually evolve in mutual relation (6) and that "technical solutions are more likely to be successful when they are developed with an awareness of the ways in which contingencies enable and constrain the uptake of such solutions, and of where additional support or regulation might be required"(8), opposing to views "that lack sensitivity to the complexity of regulations and the contexts in which they take shape"(6).

On these basis, the present research investigates the application of noise mitigation policies in the case-study of a urban dwelling development in a noise polluted area in Turin, which is nowadays acting as "leader city" (10) in Italy. The aim is to bring out and depict concerns that develop along the process, proposed solutions and actors that are mobilized in the process.

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In this work, therefore, the "hard science" perspective of cumulating quantitative data is abandoned, in favor of the engagement of "thick descriptions" (11) of specific cases.

The research adopts the perspective of Science and technology Studies (STS) (12–14), which has been used in the field of architecture to describe the project process as an evolution of a technical object (15,16). In particular, within the field of STS, Actor-Network Theory (ANT) (17–19) perspective sees the development and production of a building as the result of a network of people and things (human and non-human actors) (20,21) that evolves in time.

ANT founder Bruno Latour challenged designers, advocating for visualizations that could create a new "visual vocabulary" (22), that will represent not only the "matter of facts", which are the given, immutable objects, but also the "matter of concern", that is "what happens to a matter of fact when you add to it its whole scenography" (23) or, in other words, what happen to a building when you add "[…] the angry clients and their sometimes conflicting demands […] the legal and city planning constraints […] the budgeting and the different budget options [etc]"(22).

The *controversy mapping* approach (24–26) was developed from ANT as a pragmatic approach to this challenge, and visualization tools have been developed to visualize the network of human and non-human actors that gather around specific projects or specific controversies (26). However, as pointed out by Armando e Durbiano (15), the network visualization, although extremely effective to grasp an overview of how different actors gathered around different concerns in a controversy (27), fail to be efficacious when the need is to use this cartography "directly for design objectives" (15), The "all-encompassing description" provided by the "panopticon" of the cartography of controversies(15), needs to be cut through a definite perspective.

In this work, we focus on the restitution through visualizations of the investigated projects, aiming to define maps which are "integrative use" media (28), that is, visualization that provide a new perspective on a project, "un-black boxing" (20) what might seem a static building, hence generating new knowledge and understanding, providing an "intellectual technology" (19) which might help future choices on similar case studies. The different sections of the paper show how the research for such visualization evolved, through software-assisted analysis of data and hand-drawn maps. The conclusions discuss then the insight that could be provided on the specific case study as well as strength and drawbacks of the analysis and visualization methodology.

2. METHODOLOGY AND RESULTS

2.1 Case-study and data collection

The selected case-study is a dwelling project in a transformation area in Turin, Italy. The case-study worked as a sort of "pilot" for the city, since the approval of the zoning-plan variations that started the development process was adopted in the same period in which the Local policies, which included specific rules for the transformation areas, were issued. The late integration of mitigation solutions within the process, together with the location of the area in an environmentally-protected zone, determined a number of controversies linked to the fact that few modifications could be done in the building and hence mitigation solutions at source had to be implemented.

Following a procedure which is often used in ANT-based studies (29–31) the main part of data was obtained through verbatim accounts of real-life interviews along with genuine documents"(30).

The first phase of data collection consisted in conducting interviews with the main stakeholders, while the second phase of the data collection was then conducted in the archive of the environment area offices in Turin, to reconstruct all the exchanges which had took place between the office and the proponents(15). After the archive consultation, the number of interviews was expanded through the use of short consultations with focused questions.

2.2 The "crafting" of descriptive tools – stay grounded on words, organize them

Following one of the indications given by Venturini (25) within the controversies mapping approach, the mapping process was started as soon as a general understanding of the process was gathered through the first interviews with the main stakeholders. Indeed, as indicated by venturini "the task of *unfolding the complexity* of controversies should never be separated from the task of *ordering such complexity*." (25)

The aim of the mapping, as in the *controversies mapping* approach, was to stay close to the words of the actor, hence make the information, such as matter of concerns and involved human and non-

human actors, inductively emerge from the collected interviews and documents (24).

This approach is very similar to the "open coding" or "exploratory analysis" which is applied in the first phases of qualitative analysis methodologies, such as grounded theory (32,33) and applied thematic analysis (34), in which labels are associated to excerpts of texts, and modified as more texts are analysed.

Therefore, the analysis of the collected material and the first phases of visualization were conducted through the use of CAQDAS (computer-aided qualitative data analysis software) specifically realized for similar analysis. In particular, it was used the software Atlas.ti v.8[3] which, although expecially created for grounded theory application (35), due to the freedom it gives in the creation and organization of codes systems, as well as in the elaboration of different kind of documents, it has been used in different qualitative analysis methodologies, including ANT-based researches (36).

It must be pointed out, however, that although CAQDAS software facilitate the ordering, connecting and analysing of documents which is necessary in qualitative analysis methods, they do not substitute at all the researcher in defining and constructing the system of codes and themes which are extracted from the analysed documents.

Figure 1a shows a screenshot of the software interface, in which the documents are analysed and excerpts of documents (=quotations) are selected by the user and associated to codes created by them. On the left column, a navigator allows the user to explore and order the elements. In the central area is the document which is being analyzed. The excerpt which is highlighted is a quotation, to which have been linked a code and a memo (codes and memos can be seen in the right column)

It was therefore established to combine the inductive extraction of codes with the definition of few broad but clear levels of analysis, in which to develop the code extraction.

Since ANT methodology and *controversy mapping* approach give a lot of freedom to the researcher in defining the methodology of inquiry and data elaboration (24,36), the panorama of researches which have tried to develop schemes and visualizations based on ANT perspective is, although not so vast, quite heterogeneous (27,37,38). The different levels of analysis that were defined from a selection of the schemes found in literature is:

- **Step 1**: the process as a series of *matter of concern* that develop in time (27,39):

In this phase, the corpus of collected documents was analysed looking for emerging themes of discussion. Excerpts of documents that discuss the same concern were "tagged" (40) with the same code. The software Atlas.ti allowed then to connect the different texts excerpts (=quotations) between them through the use of hyperlinks (41) which define the type of relation between the two quotations (="expands", "contradicts", etc.). Through the visualization tool of the software s then possible to visualize how a specific debate evolved around a concern and how interviews expand what can be read in the documents. Figure 1b shows an example of visualization of the quotations that discuss the concern "Monetization of the sound absorbing asphalt" and the documents from which such quotations were extracted.

- **Step 2:** the matter of concern as a series of actions which are done to move toward a "closure mechanism" (16):

In this phase, each of the excerpts which has been coded with a code that indicates a matter of concern is analysed again, in order to code for different actions which are done by the involved actors to move to a "closure mechanism", that is, to reach a solution of the controversy and stabilize a certain decision. Drawing from the concept of *translation* defined by Callon (42) and from an inductive construction of categories, the actions are then classified into a reduce number of categories of action. Figure 2a shows the categories of actions and how they can be connected to the translation phases.[4]

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[3] The software MaxQDA was also tested in the starting phases of the analysis. The two software have very similar features. In this case, upon a more developed visualization tool of MaxQDA, was preferred Atlas.ti due to the possibility it gives to create permanent link between quotations and to link memos to all the different elements of the software(codes, quotations, etc.). However, a detailed comparison of he two softwares is out of the scope of this paper.

[4] A bigger version of the images can be find at https://zenodo.org/record/3236512#.XPGbIfZuI2w

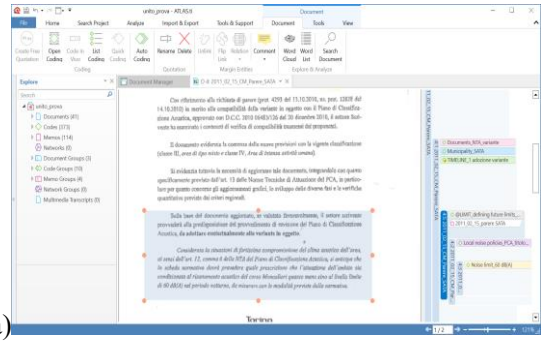
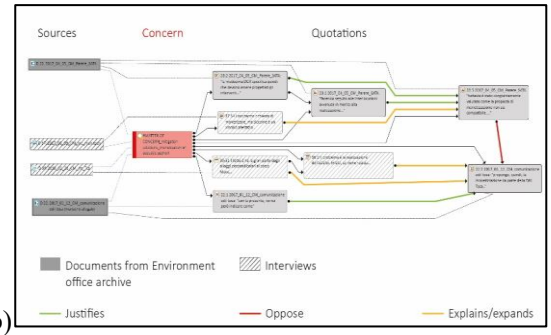
(a)  (b) 

Figure 1 – (a) Atlas.ti 8 user interface. (b) visualization of the debate around the concern "monetization of the acoustic asphalt".

- **Step 3:** the action as a gathering of different human and non-human actors

In this phase, each excerpt coded with a code referred to an action was analysed again in order to extract the human and non-human actors which were involved in the action (e.g. laws or policies which allowed for the refusal of a certain solution, data that supported the decision, etc.). Moreover, while the coding process was evolving, the codes referring to different actors were organized into categories, inductively derived from an analysis of the code system.

Table 1 shows an example of an action with the corresponding codes that identify human and non-human actors involved in it. The category assigned to each actor is also indicated. The memo attached to the action code, shown on the right, provides a description of how each actor was involved.

Table 1 – Human and non human actors associated to the action "Modify limit/request_ 55 dB(A) at facade

actor	category	memo
DPR 142/04_art. 8	National noise law	*Environmetn area modify limit to 55 dB(A) a façade* *PCA_art. 8 sets limit of 55 dB(A) at facade* *DPR 142/04_art. 8 and PCA_art.5 legitimates the requests of Environment area* *"Zona Urbana di Trasfromazione" determines application of PCA_art.5* *Noise reduction -5 dB determines the prescription of Noise limit 60dB(A)_at side road* *Acoustic model provides result of Noise reduction -5 dB* *Noise limit 55 dB(A) at facade determines the prescription of Noise limit 60dB(A)_at side road*
"Piano di Classificazione Acustica"_art.5	Local noise policy	
"Piano di Classificazione Acustica"_art.8	Local noise policy	
"Zona urbana di trasformazione"	Other local policies	
Noise reduction – 5 dB	Noise data	
Noise limit_55 dB(A) at facade	Noise limit	
Noise limit_60dB(A) at side road	Noise limit	
Environment area	institution/organization	

The initial aim in the research of a visualization method was to obtain a network visualization, such as the ones which have been used by different ANT-based research, also in the field of architecture (26,31). The maps were then derived from both the network visualization tool of Atlas.ti itself, as well as through the Excel plug-in NodeXL. In this case, a code co-occurrence table is exported from Atlas.ti and imported in NodeXL. Each actor constitutes a node and the thickness of the tie represent the number of co-occurrencies. The plugin also allows to "collaps" all the nodes belonging to the same category into one single node, hence allowing for a simplified visualization in which the it can be seen which are the leading categories of actors. Figure 5b shows the network of actors involved in the first phase of the project (adoption of the zoning plan). Each node represent a category of actors, while the thickness of each edge between two nodes represent the co-occurrences of actors belonging to the two categories.

However, this network visualization resulted to be too "omnicomprensive" to describe the process in a way which could be strategic to answer to specific questions and inform future processes (15).

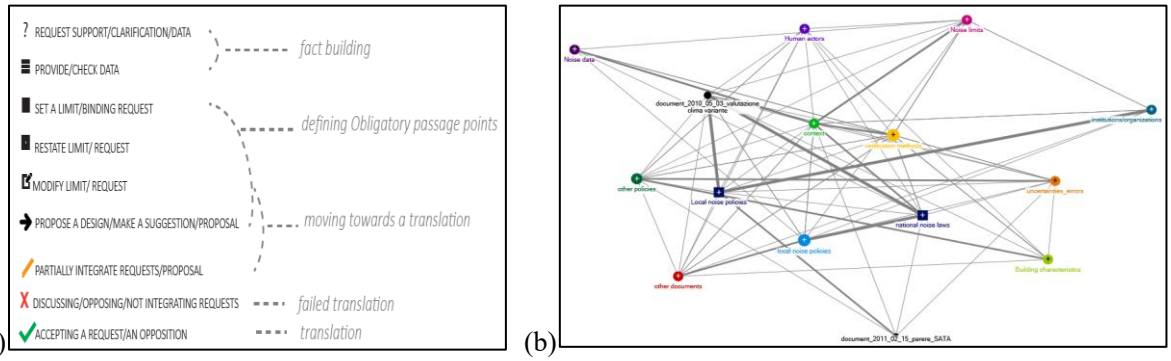


Figure 2 –(a) categories of actions. (b) Node XL elaboration of the network of actors involved in the first phase of the project (adoption of the zoning plan). The Fruchterman Reingold algorithm is used.

2.3 The "crafting" of descriptive tools – visualize the process, focus on specific questions

Since the results of the previous phase, allow setting the basis to analyze and reconstruct a project process, prove to be not enough to restitute it, in the second phase of the work it was decided to go back to hand drawings, taking advantage of the freedom it gives in the spatial organization of elements and in the test of different layouts and graphical codes.

The visualization of the project process was structured in a basic framework which allowed then for the definition of zooms on selected parts of the process, in order to answer to specific questions.

The basic framework develops in time on the horizontal axis, while on the vertical axis has tree levels: the actors and the documents through which they act: reports, official evaluations, but also informal communications or in-person meetings of which there are recalls in documents or interviews (43) the concerns that develop during the process; the effects on the process. At a first level of analysis is therefore possible to see which human actors and documents are involved in the different phases of the project and which types of problems arise. Figure 3 shows a schema of the basic framework (a) and the resulting map on the selected case-study (b).

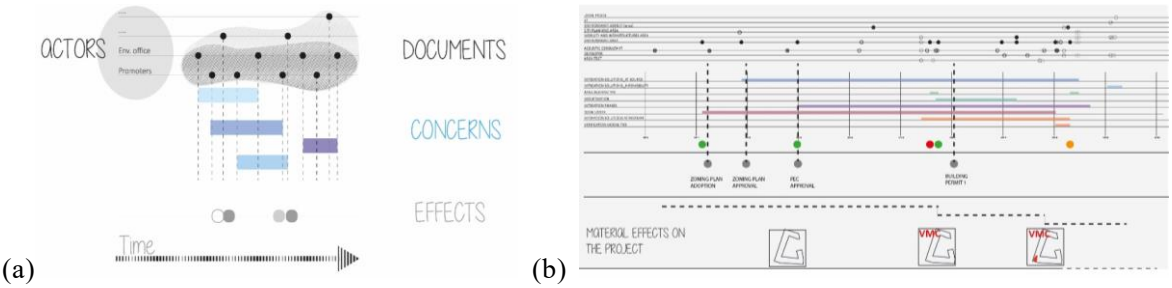


Figure 3 –(a) scheme of the "basic framework" map organization (b) "basic framework" map on the selected case study.

Three type of zooms where then identified and tested:

1- Diachronic zoom: one of the concern is selected and examined with respect to which actions are done and why. In particular, the map presented focus on mitigation solutions at the receiver and explores which solutions are accepted or discarded and why (i.e. which actors are involved in the decision).Each successful translations, defined by the integration of a certain solution, determines a material effect that modifies project, in a process similar to "exaptation" (15) (Figure 4a).
2- Synchronic zoom: the map is cut "transversally", in a specific moment of the process to explore how actions concatenated and actors aligned to reach a "closure mechanism, which determines a step forward in the process. In this case, the map examine the moment in which the first

building permit is granted (Figure 4b).

3- Following specific actors: the whole map is travelled following a specific categories of actors through time. In this case, the map focus on national laws and local policies on noise mitigation ad put in light in which phases of different matter of concern they acted (Figure 4c).

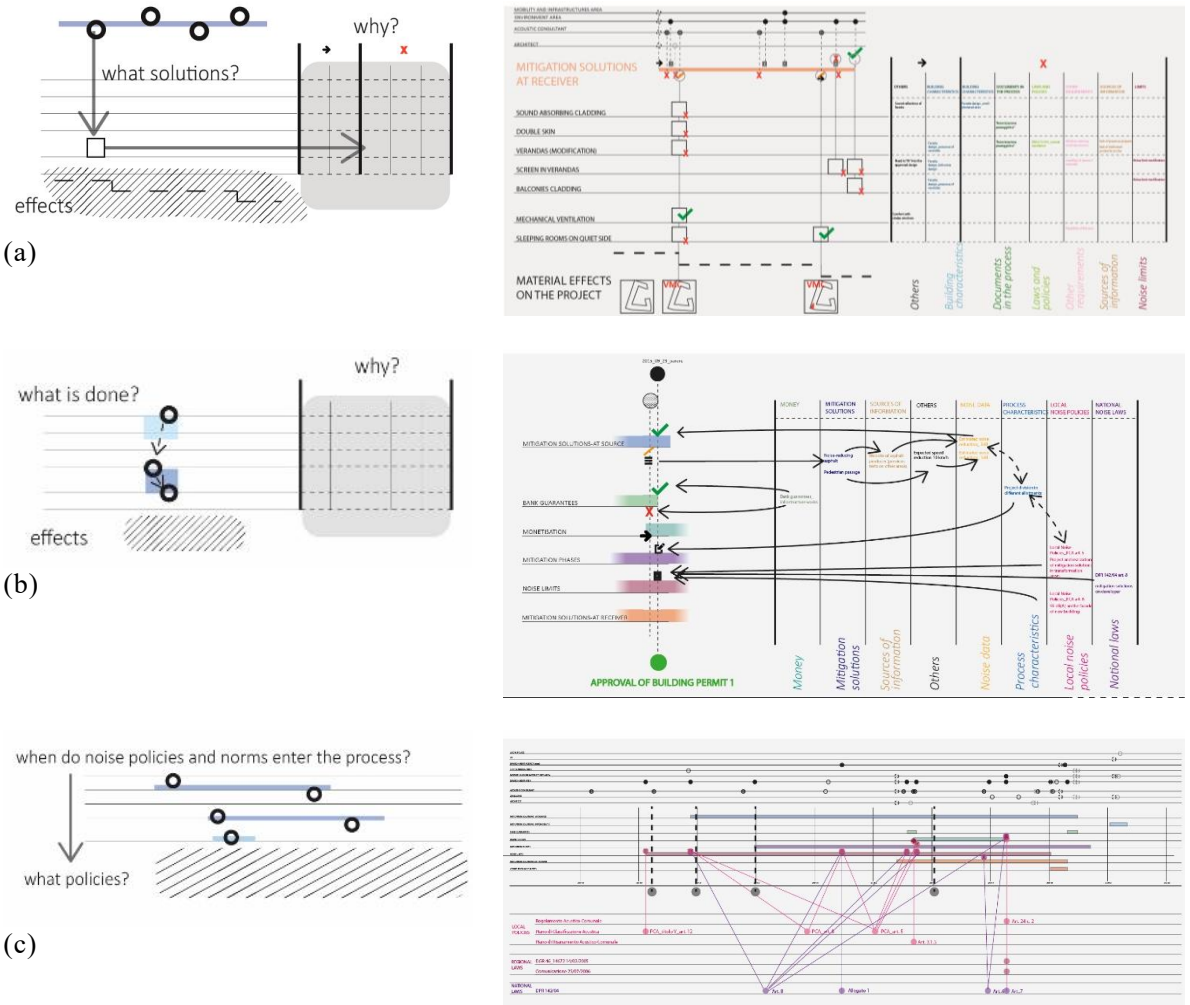


Figure 4 –(a) scheme of the "diachronic zoom" and resulting map; (b) scheme of the "synchronic zoom" and resulting map; (c) scheme of the "following norms" and resulting map.

3. DISCUSSIONS AND CONCLUSIONS

The present research deals with an analysis and representation work conducted on the process of a dwelling project in a noise-polluted area in Turin, Italy.

The aim of the work is to define a methodology to analyze the project process and to represent the complexity of the process in a way which can provide better insight on how noise policies influenced the process and what are the factors that influence the choice of mitigation solutions.

As most of the studies which engage with an in-deep description of a specific case, the aim of this study is not to find data that can lead to a generalization of findings (44). On the contrary, the aim of the study is of two kind:

1- Explore what can be learned about the application of noise mitigation policies in the specific case;

2- Define a method of analysis and visualization which may then be replicated and enhanced through the analysis of other case-studies.

With respect to the first point, the study allowed to show how noise laws only acted in some parts of the definition of noise limits as shown in Figure 4c (the controversy which is indicated with the purple bar). The controversy on noise limit is indeed closed by a decision of the Environment office

which goes beyond local policies, setting a precedent which could be then applied in future cases. This supports the view of a mutual relation of projects and policies, in which each one evolves in response to the other. A second finding is that the situation of the building market plays an important role in the application of noise policies. Indeed, the project division in allotments proved to be crucial in the granting of the first building (Figure 4b), while the need to keep the flat sizes flexible influenced the choice of possible mitigation solutions at façade (Figure 4a). This support the need to investigate how norms and policies act in a contingent, specific situation.

With respect to the second point, one of the strength of the work is to assess a theme which is still rather unexplored, that is, the crafting of a methodology to visually represent a project process, wihth particular focus on a specific environmental problem and its related laws and policies. This on one side tries to answer to the request of Latour for a media which could represent a building as s complex process and on the other hand tries to make the complexity readable and to answer to specific questions of involved stakeholders, as suggested by Venturini and Armando e Durbiano (15,25). It is of course a first tentative and has a number of draw backs. First of all, the analysis, as a qualitative one, is necessarily biased by the subjectivity of the researchers (34,40). Moreover, the maps, when traducing all into codified symbols, keep us away from the materiality of the project, making sometimes difficult for the reader to witness and imagine what is visualized[5].

Nevertheless, this might be a first step to build a "body of knowledge" that can only be constructed through he close observation of many different case-studies and that will "over time, establish a knowledge that will help designers and their clients to make more informed preliminary choices" (10).

Moreover, the crafting of similar visualization devices might be useful to give indications for the future development of an interactive tool to visualize different processes in a similar way, through the analysis of selected documents.

REFERENCES

1. Douglas I. Cities: An Environmental History. London: I.B. Tauris; 2013. 384 p.
2. World Health Organization (WHO). Environmental noise guidelines for the European Region. 2018.
3. Zhang M, Kang J. Towards the Evaluation, Description, and Creation of Soundscapes in Urban Open Spaces. Environ Plan B Urban Anal City Sci. 2007;34(1):68–86.
4. Van Renterghem T, Hornix M, Forssen J, Botteldooren D. The potential of building envelope greening to achieve quietness. Build Envionment. 2013;61:34–44.
5. Echevarria Sanchez G, Van Renterghem T, Thomas P, Botteldooren D. The effect of street canyon design on traffic noise exposure along roads. Build Environ. 2016;97:96–110.
6. Imrie R. The interrelationships between building regulations and architects' practices. Environ Plan B Plan Des. 2007;34(5):925–43.
7. Imrie R, Street E. Architectural Design and Regulation. Oxford (UK): Wiley & Blackwell; 2011.
8. Lewis A. Daylighting in older people's housing: Barriers to compliance with current UK guidance. Light Res Technol [Internet]. 2015;47(8):976–92. Available from: https://doi.org/10.1177/1477153515571677
9. Lewis A. The mathematisation of daylighting: A history of British architects' use of the daylight factor. J Archit. 2017;22(7):1155–77.
10. Moore SA, Wilson BB. Questioning Architectural Judgment: The Problem of Codes in the United States. Abingdon (UK): Routledge; 2014. 295 p.
11. Geertz C. The interpretation of cultures. New York (NY): Basic Books; 1973. 478 p.
12. Sismondo S. Introduction To Science and Technology Studies. Vol. 5, Bulletin of Science, Technology & Society. Hoboken (NJ): Wiley & Blackwell; 2010. 373-376 p.
13. Felt U, Fouché R, Miller CA, Smith-Doerr L, editors. The handbook of science and technology studies. Cambridge (MA): The MIT Press; 2017.
14. Bijker WE, Hughes TP, Pinch T, editors. The social construction of technology sistems. Cambridge (MA): The MIT Press; 1989.
15. Armando A, Durbiano G. Teoria del progetto architettonico. Dai disegni agli effetti. Roma: Carocci; 2017. 528 p.
16. Pinch TJ, Bijker WE. The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. In: Bijker WE, Huges TP, Pinch TJ, editors. The Social Construction of Technological Systems New Direction in the Sociology of Technology. Cambridge (MA): The MIT Press; 1989.

[5] This observation in particular emerged during a discussion with prof. Albena Yaneva, in May 2019

17. Bruun H, Hukkinen J. Crossing boundaries: an integrative framework for studying technological change. Soc Stud Sci. 2003;33(1):95–116.
18. Latour B. Reassembling the social. An introduction to Actor-Network Theory. Oxford: Oxford University Press; 2005.
19. Latour B. Cogitamus. Sei lettere sull'umanesimo scientifico. Bologna: Il MUlino; 2013.
20. Latour B. Science in Action. How to follow scientist through society. Cambridge (MA): Harvard University Press; 1987.
21. Latour B. The Sociology of a Few Mundane Artifacts. In: Bijker WE, Law J, editors. Shaping Technology/Building Society: Studies in Sociotechnological Change. Cambridge (MA): The MIT Press; 1992.
22. Latour B, Yaneva A. "Give me a Gun and I will Make all Buildings Move": An ANT's View of Architecture. In: Explorations in Architecture: Teaching, Design, Research. Basel (CH): Birkhäuser; 2008. p. 80–9.
23. Latour B. What Is the Style of Matters of Concern? Spinoza Lectures at University of Amsterdam. Assen: Van Gorcum; 2008. p. 50.
24. Venturini T. Diving in Magma: How To Explore Controversies Using Actor-Network Theory. Public Underst Sci. 2010;19(3):258–73.
25. Venturini T. Building on faults: How to represent controversies with digital methods. Public Underst Sci. 2012;21(7):796–812.
26. Yaneva A. Mapping Controversies in Architecture. Farnham (UK): Ashgate; 2012.
27. Yaneva A, Heaphy L. Urban controversies and the making of the socia. Archit Res Q. 2012;16(1):29–36.
28. Gasperoni L. Diagrammatic Practices in Architectural Design. In: Pyo M, editor. Architectural Diagrams 2. Berlin (DE): DOM Publisher; p. 312.
29. Fountain R-M. Socio-scientific issues via actor network theory. J Curric Stud. 1999;31(3):339–58.
30. Latour B. Aramis, or the love of technology. Cambridge (MA): Harvard University Press; 1996.314 p.
31. Rydin Y. Using Actor-Network Theory to understand planning practice: Exploring relationships between actants in regulating low-carbon commercial development. Plan Theory. 2013;12(1):23–45.
32. Glaser BG, Strauss AL. The discovery of Grounded Theory. New Brunswick (NJ) and London (UK): Aldine Transaction; 1967. 271 p.
33. Willig C. Grounded theory methodology. In: Qualitative research in psychology. London (UK): Open University Press; 2013.
34. Guest G, MacQueen KM, Namey, Emily E. Applied Thematic Analysis. Thousand Oaks (CA) and London (UK): SAGE; 2012. 298 p.
35. Friese S. Translating the Process of Open / Initial Coding In Grounded Theory [Internet]. 2017. Available from: https://atlasti.com/2017/07/01/gt/
36. Wright S. Exploring Actor-Network Theory And CAQDAS: Provisional Principles And Practices For Coding, Connecting And Describing Data Using ATLAS.ti. In: Qualitative Data Analysis and beyond - proceedings of the ATLAS.ti User Conference 2015.
37. Payne L. Visualization in analysis : developing ANT Analysis Diagrams (AADs). Qual Res. 2017;17(1):118–33.
38. Silvis E, Alexander PM, Silvis E, Alexander PM. A study using a graphical syntax for actor-network theory. Inf Technol People. 2014;27(2):110–28.
39. Bradbury S. Interrogating the dynamics of regulations on the design of energy performance in housing. Archit Cult 2016;3(3):337–54.
40. Friese S. Computer-Assisted Grounded Theory Analysis With ATLAS.ti. In: ATLAS.ti User Conference 2015 – qualitative data analysis and beyond. 2016. p. 1–22.
41. Friese S. ATLAS.ti 8 Windows - User Manual. Berlin (DE): Scientific Software Development GmbH; 2019.
42. Callon M. Some elements of a sociology of translation: Domestication of the scallops and fishermen of St Brieuc Bay. In: Law J, editor. Power, Action and Belief: A new sociology of knowledge? London (UK): Routledge & Kegan Paul; 1986. p. 184–208.
43. Ferraris M. Documentalità. Perchè è necessario lasciar tracce. Bari (IT) and Roma (IT): Laterza; 2009. 429 p.
44. Henderson K. Ethics, culture, and structure in the negotiation of straw bale building codes. Sci Technol Hum Values. 2006;31(3):261–88.