

‘Informal Infrastructure’ of Prototyping: Practicing Organisation by Performing Materiality

Sandra Fernández García and Francisco Sánchez Valle 

Abstract:

In recent years, sheltered by the so-called ‘ontological turn’ in the social sciences, organisational analysis has paid special attention to artefacts. Nevertheless, there is still a dominant account grounded in a dichotomist view of the subject-object relationship either in teleological (mind-body) or in hylomorphic (form-matter) terms when analysing organising practices. On the contrary, our argument is based on non-dualistic approaches in an attempt to foreground relational aspects of practices.

From a practice-based approach, the article addresses the role of three ‘prototypes’ aimed at the management of the ‘air’ by citizenship, in the re-configuration of bodies, technics and ethical-political engagement. Specifically, it focuses on the normative dimensions of organising by which knowledges, materials and values converge in the open-ended process of *prototyping*. The argument is deployed by relying on qualitative research based on multi-sited ethnographic fieldwork, developed both at different workshops and by online ethnography.

The main aim of the article is to show how bodies and artefacts are mutually in/trans/formed when negotiating the social implications for the ontological category of ‘air’. In doing so, the concept of ‘informal infrastructure’ is proposed to account for those practices (which appear somewhat contingent, mundane or, at best, taken for granted) by which agents do not only commit to a particular ethical implication embedded in the category of ‘air’, as a symbolic result, but also to distinctive ways of practicing organisation as a political process of performing materiality. To this end, adopting the analytical concept of ‘informal infrastructure’ allows to simultaneously consider both the formal and informal aspects that emerge in these collaboration-driven practices, as well as to address their effects on the maintenance within and expansion into other networks.

Somatechnics 12.3 (2022): 162–184

DOI: 10.3366/soma.2022.0386

© Edinburgh University Press

www.eupublishing.com/soma

Keywords: ‘informal infrastructure’; prototyping; ethnography of infrastructure; organising practices; sociomateriality; ontology.

1

Introduction: *Things* and Organising

5

In recent years, the ontological status of materiality and consequently its role in social action has become an object of analysis *per se* in social sciences and humanities. Terms such as ‘materiality’, ‘objects’, ‘things’, ‘artifacts’ and ‘matter’, considered to be transformative in many ways, have populated both theoretical and methodological analysis of social realities. The choice and use of each of these analytical concepts direct both the epistemological focus and the methodology of analysis since they are grounded in distinctive ontological commitments.

10

Within the anthropological discipline, these empirical studies have been traditionally approached from the field of the so-called material culture. Though such a heterogeneous denomination has become a collection of diverse topics, all these works share a common concern, namely: the object-subject relationship. As Christopher Tilley has pointed out, material culture ‘is a relational and critical category leading us to reflect on object-subject relations in a manner that has a direct bearing on our understanding of the nature of the human condition and social Being in the world’ (Tilley 2007: 258).

15

20

In the 1980s, the Actor Network Theory (ANT) proposed taking the actions of humans and nonhumans – ‘actants’ – as equivalent. Machines, animals, humans, artifacts and so on, populate our world by establishing networks through their relations – alliances. It is precisely through these relations that the actants acquire *reality*. Perhaps ANT’s most controversial claim is that the very distinction between nature and society is a result of such alliances and not a pre-existing fact (Latour 1999). In the 1990s, the so-called ‘ontological turn’ aimed to challenge the interpretative univocity of objects of study through the multiplicity, not only of ways of knowing, but also of producing and practicing. Terms such as ‘performativity’ (Barad 2003), ‘hybridity’ (Haraway 1985) or ‘enactment’ (Mol 2002) have emerged to account for this variability, thus emphasising the role of social actions and interaction in the contextual production of meaningfulness (realities). Proponents of such a turn aim to challenge the hegemony of interpretations – deemed as mental meanings – of a supposedly natural world – considered as material significances – grounded in the dualism nature-culture (Henare, Holbraad and Wastell 2007).

25

30

35

40

Also in organisational studies, the traditional dualistic-humanistic view has influenced many theoretical approaches. In order to go beyond

this view, Eric Trist and Jen Bamforth coined the term ‘socio-technical systems’ to highlight the interdependence between technological artifacts and organisational work (Trist and Bamforth 1951). In this line, subsequent studies that have paid attention to materiality within organisational phenomena have focused mainly on two distinct trends: 1) those that have taken as their unit of analysis the formal structures of organisations and focused mainly on technological change through the implementation of new technologies; and 2) those studies whose unit of analysis is individual members for addressing the use/interpretation of concrete technological artifacts when carrying out organisational tasks.

At the core of all these heterogeneous works lies a common concern with relationality. While this relational approach can take many different and varied forms, as we have seen briefly above, what is at stake are the different configurations or relational conditions on which *things* acquire distinctive significance. In this task, the work of differentiation between subject and object is crucial because it establishes the ground on which relationships are to be placed. Nowadays, an important role is still occupied by the mediating function assigned model assigned to artifacts which is grounded in a dichotomic view of the subject-object relationship. Relying on ‘media’ as the ontological conditions of being from which material reality shapes organisation, some authors (Beyes et al. 2020: 505) have proposed a media-technical *a priori*. Nevertheless, this approach overshadows the entanglement of bodies and matter, which is highly problematic (Radomska 2018). In the polarization between mind and matter, the materiality of objects is reduced to understanding them as that which is bounded by a physical stability (Leonardi 2012: 29), as an artifact has been brought about by pre-existing ideational forms in the mind. By privileging mind over matter, bodies are reduced to rationality. This kind of hylomorphism implies that the very notion of material culture ‘rest[s] on the premise that as the embodiments of mental representations, or as stable elements in systems of signification, things have already solidified or precipitated out from the generative fluxes of the medium that gave birth to them’ (Ingold 2007: 5). However, this stabilized character of materiality does actively participate in the configuration of lived experiences so material properties are intrinsically linked to those of environment. As Penny Harvey and Hannah Knox claim, following Tim Ingold’s arguments:

rather than attending to how persons relate to things, we might think instead of environments as spaces of action and experience in and through

Practising Organisation by Performing Materiality

which persons and things take on significance, uses, possibilities in relations of mutual specification. What something is, what its qualities are, is then figured as an outcome not a precondition (Harvey and Knox 2014: 7).

To overcome dualistic standpoints, by which the social and the technical are interdependent realms, Wanda Orlikowski proposed the term ‘sociomateriality’ to show the constitutive character of both elements: ‘the social and the material are considered to be inextricably related – there is no social that is not also material, and no material is not also social’ (2007: 1437). Following Tim Ingold (2010), and Penny Harvey and Hannah Knox (2014), we have chosen the term *things* to refer to the constituent relational character of material participants – included bodies – which emerges as they inhabit an environment, in the task of addressing social transformation in terms of resistances, capacities, limitations and potentialities. From this sociomaterial approach, the article proposes the concept of *informal infrastructure* to overcome the dualistic standpoint when it comes to address the social role of *prototyping*. Thus, we assume that this co-constitutive approach helps us to trace the story of prototyping.

After introducing the methodology, we move on to introduce the concept of *informal infrastructure*, which comes from the conjunction of Leigh Star’s approach to *infrastructure* and Niklas Luhmann’s concept of *informal structure*. We then set out the distinctive features of prototyping as appropriated by the social sciences. Through the descriptive analysis of three related prototypes, we proceed to deploy our argument, namely that bodies and artifacts are mutually in/trans/formed when negotiating the implications of the ontological category of ‘air’ through the process of prototyping as a political process of performing materiality. The three projects referred to in this paper focus on ‘air’ management in the city. The first, *In The Air* (ITA) was a visualization project on the microscopic agents of the city’s air aimed at individual and collective awareness and decision making using the City Council’s already existing pollution detectors. Through this first case, it is argued that collaboration shows up as the master narrative of prototyping, which settles the conditions for recursive practices at global reach via sharing networks. As a continuity of ITA, the project *Glob@s* was launched as a home-made kit for measuring, revealing and sharing data on polluting gases in the air with a child-friendly interface. This second prototype, as a direct consequence of the formal order deployed on ITA, helps us to understand the relevance of the informal infrastructure of prototyping for coping with failure events through sociomaterial repair work. Thirdly,

Air Quality Egg (AQE) was a prototype aimed at measuring air quality locally and uploading data to the network. Through this third case we will see how informal infrastructure results in an artifact that prioritizes ethical commitment through user technology engagement over functions. Finally, it is suggested that adopting the concept of ‘informal infrastructure’ allows a critical approach to technology without disregarding concerns about the entanglement of bodies, matter and technics.

Methodology

The anthropological perspective of the practice-based approach that underpins this proposal emphasizes the construction of knowledge as performative processes of interaction. Thus, any kind of knowledge not only represents, but also embodies and realizes ‘reality’ so that, to become knowledgeable ‘requires participation in interaction and engagement with the local network of meaning-making processes’ (Nicolini, Gherardi and Yanow 2003: 11). This participation is developed through ethnographic fieldwork that makes it possible to focus on practices that are thus understood as collective issues as well as to direct attention to the actions and interactions that shape entanglements in specific contexts and relations with other spaces. Thus, the study is based on an ethnographic analysis aimed at exploring the embeddedness between bodies and other things, which become co-constituted through learning practices by means of which knowledge, materials and values converge in the open-ended process of prototyping. Since prototyping practices occurs simultaneously on two layers – localized settings and Internet networks – the study consisted of a multi-sited ethnographic fieldwork (Marcus 1995) conducted in both web and physical space settings. It involved ethnographic discourse analysis, observation and participation, both in networks and in building prototype processes, as well as semi-structured interviews with other participants: collaborators, curators, tutors, artists, and so on (n=23). The fieldwork on which this article is based was part of a larger piece of research, conducted by one of us over the course of a year into iterative processes in different settings. Initially, the methodological approach was led by participant observation in a classical way – as a hallmark of the discipline. However, the ethnographer’s required self-reflexivity in fieldwork revealed a mismatch between the fieldwork dynamics and the ethnographic ones when producing knowledge. Thus, the initial approach shifted towards the *style of knowing* (Otto and Smith 2013) related to what has become known as design anthropology; that is, using interventionist fieldwork methods and iterative movements between field and studio, focused on

materiality, temporality and relationality (Clarke 2017). This methodological realignment aimed to foreground the ethnographer's participation in the field, so that ethnographic work was not limited to observing and documenting but was explicitly collaborative. So, this new approach fitted in with the specific fieldwork dynamics of prototyping by means of collaboration in multidisciplinary teams. It thus allowed the researcher to adopt simultaneously the roles of researcher and collaborator (Otto and Smith 2013: 4) in two of the three projects described below, thus working along the lines of what Caroline Gatt and Tim Ingold defined as an anthropology *on correspondence*: processual, dialogical and open-ended (Gatt and Ingold 2013).

'Informal Infrastructure'

Over the last three decades, research on infrastructures has undergone a major surge in the academic literature when addressing the complex relationship between technology, agency, materiality and social order. Susan Leigh Star and Karen Ruhleder's (1996) foundational work on relational dynamics in the formation of informational infrastructures paved the way for subsequent studies on heterogeneity of those intrinsic aspects of practice that emerge in any infrastructure. Beyond conceiving *infrastructure* as the material presence of technological systems that appear to us as stable and solid, Leigh Star's focus is on the organisational practices at the intersection of work and technology (Star 1999). As an essentially relational concept, infrastructure no longer refers exclusively to the 'what' that is, something ready-to-hand, completely transparent because we tend to take it for granted inasmuch as it works. Rather it refers to the 'when' since 'infrastructure is something that emerges for people in practice (...) it becomes infrastructure in relation to organised practices' (Star 1999: 113). This approach implies a shift from 'infrastructure as the substrate' – that is, the mere integration of different material forms which build a system – to 'infrastructure as the substance' – that is, the relational arrangements that emerge from the local practices of organisational change (Star 1999). Thus, infrastructure encompasses both structural connections at global reach and the enactment of assemblage practices of human and nonhuman actors in particular settings that are embedded distinctively 'into and inside of other structures, social arrangements, and technologies' (Star and Ruhleder 1996: 113). It is precisely this relational dimension of infrastructures which has been invoked to interpret them as sociotechnical assemblages 'through which it is possible to tease out the arrangements of people and things

and ideas and materials that make up larger technological systems’ (Harvey and Knox 2015: 5). 1

Since the formalized order does not exhaust the organisational relations of infrastructures, it is necessary to seriously consider their informal character in order to account for the heterogeneity that arises from these sociotechnical assemblages. To this end, it is pertinent to bring in the work of Niklas Luhmann. In his early work, he defined organisation as a social system shaped by the formalization of a particular set of actions and expectations. He also acknowledged that ‘the meaningful connection of actions that constitutes the system (...) lies not in formal structures alone’ (Luhmann 2020: 427), thus distinguishing between two complementary aspects in the study of organisations: formal and informal structures. While, on the one hand, ‘formality’ refers to the extent to which the expectations of a system are formalized (2020: 432), ‘informality’, on the other, ‘transforms the work that is planned as objective performance by the formal organisation into a sociable event’ (2020: 428). In other words, ‘informal structures compensate and balance the formalized social order, counteracting its negative consequences (...) [helping] the organisation to adapt rigidly defined expectations to environmental changes’ (Seidl and Mormann 2014: 131). Then, ‘informality’ rests on two aspects: unpredictability and flexibility, providing uncertainty to processes. As intentions and expectations within projected infrastructures do not necessarily correlate to the ‘real’ outcomes of these sociotechnical assemblages, an approach to the informal dimension acquires analytical value when addressing the instability of infrastructures. For the purposes of this work, an ‘informal infrastructure’ approach has the advantage not only of accessing the ‘site’ (Nicolini 2011) at which materiality, values and bodies converge in the production of an open-ended artifact through activities, structures and conventions, but also of accessing the unplanned. An analytical differentiation between formal and informal practices¹ allows us to address respectively, the homogeneity that enables collaborative practices to reach a global level, as well as the heterogeneity that characterizes the production of prototypes in an open-ended process when coping with failure events. At the intersection of the two, these practices result in a distinctive sociomaterial embedding by which infrastructure of prototyping emerges. 5 10 15 20 25 30 35

From Prototype to Prototyping

 40

In engineering, the prototype² is conceived as a tool developed in the process of designing a system by which possible solutions relating to the

final form are selected and implemented. The prototype thus understood is defined by an inherent teleological characteristic: it is expressed as a state prior to a final form with a specific function. In its most flexible conception, an open prototype allows the designer to test the different possibilities of future use of the final product and to include the intended users in the process. Without intending to make an exhaustive genealogy of the prototype, we consider it necessary to highlight that the appropriation of this concept by the social sciences, and especially by anthropology, has been carried out in a distinctive way. The prototype, from this new perspective, not only characterizes a particular type of artifact but a way of proceeding that results in the current trend of interaction and relationship within the social and cultural spheres when producing knowledge, understood as an experimental process (Corsín 2014). Thus, prototyping as a way of doing acquires the following features:

- 1) *Open-endedness*: the prototype, understood as an artifact always in process, is not a result in itself. If a prototype acquires a conclusive character, it ceases precisely for that reason, to be a prototype.
- 2) *Recursivity*: the prototyping process is a recursive one since it is a sociomaterial entanglement ‘that is constituted by a shared concern for maintaining the means of association through which they come together as [such]’ (Kelty 2008: 28).
- 3) *Relationality*: the very processes of production are viewed by actors as practices of horizontal organisation. Thus, all practices involve both constant consultation and documentation for sharing, thus contributing to the learning of other future members.
- 4) *Political purpose*: All the members who shape community share a common concern in the management of the commons (Olmstrom 1990) and forms of governance by citizenship. This is reflected in a series of ethical-political agreements such as working exclusively with free software and copyleft.

The present proposal focuses on the production processes of three artifacts called *prototypes* which are characterized by interactions in different workshops as well as Internet networks and specific domains such as Meetups. While ITA and Glob@s were designed and developed at a center which is institutionally and financially dependent on the Area of the Arts of the City Council of Madrid, AQE – as a device created by people across the globe – at one stage on its development, passed

through this very center, not only to carry out its construction but also to test its possibilities and limitations. On its website the center is defined as follows:

‘[it] is a citizen laboratory that functions as a meeting place for the production of open cultural projects. Anyone can make proposals or join others and carry them out on a collaborative way. The activity is structured in working groups, open calls for the production projects, collaborative research and learning communities around a wide range of topics’. (Madrid City Council 2021).

It is presented as a laboratory for interdisciplinary experimentation where people from very different backgrounds come together to participate in programmed activities. All of these are carefully designed to be open to being carried out in a collaborative way. One of the practices which this paper focuses on, is the *prototype production workshop*, specifically designed for the development of an artifact through a work team made up of the promoter of the project and interested collaborators.

In the Air: Collaboration for Recursivity

In the Air is a visualization project which aims to make visible the microscopic and invisible agents of Madrid’s air (gases, particles, pollen, diseases, etc.), to see how they perform, react and interact with the rest of the city. (...) The project proposes a platform for individual and collective awareness and decision making, where the interpretation of results can be used for real time navigation through the city, opportunistic selection of locations according to their air conditions and a base for political action. (In The Air 2021)

Over a period of sixteen days, this project and seven others were simultaneously developed in the same open space at the center as part of the workshop on data visualization related to the city. There were two parts to the project: 1) it was proposed that an irrigation circuit be built, which would produce a visual effect by means of sprayed colored water to illustrate the state of the air, and 2) that an on-line visualization tool be developed to display data on particular substances in the air. This project was proposed by an architecture teacher – the promoter – and was joined by nine collaborators: a designer, an artist, a teacher on interaction design, an interaction designer, four architecture students and one of the authors of this paper in the role of anthropologist.

Collaborative participation is an essential part of the *master narrative* (Star 1999: 384–385) of the infrastructure of prototyping. The very

design of the workshop responds to the need for collaboration between participants. It takes on a priority character in the development of the concrete practices through which the forms of production, assembly and learning emerge as a whole. The promoter of ITA was an architect with no previous background in computing or chemistry. Thus, producing the device took a large team of people interacting with one another and others online to develop code; discussing what to implement and how to implement it; setting up a website to host and visualize the data; researching on substances in the atmosphere; setting up the structure of the irrigation system; purchasing various elements (such as Arduinos, colorants, and pipes among others); managing the assignment of data from the Madrid City Council's sensors; and so on. The very idea of collaboration acquires a 'body' in the categorization of participants as 'collaborators':

The figure of the *collaborator* is fundamental in the approach and development of the (...) workshops, as these are conceived as spaces for collaborative work, knowledge exchange and theoretical-practical training, in an environment of horizontal relationships between teacher, developers and collaborators themselves. (Medialab-Matadero 2021).

Prototyping as an open-ended process is the result of the relational dynamics of each particular workshop. All the projects require specialized support for their development. So, they are open to collaboration and therefore to modification. The normative dimension of the workshop is taken for granted from the beginning, since collaborative practices are highly structured. Without collaboration there is no development, without development there is no modification, and without modification there is no prototype. For the prototype to be modified collectively, these practices are broadened through the democratization of both knowledge and tool creation via Internet networks. Participants take from the network – video platforms, programming or data hosting spaces among others – and contribute to the network by sharing everything generated in the workshop through their 'documentation': photos, videos, diagrams, codes and/or explanations. The action of meticulously documenting everything that happens in the workshop and sharing it to different platforms – for example *Vimeo* or *Howstuffworks* – generates a diffuse repository sheltered by Do It Yourself (DIY) ethos, by which, the very concept of society is under experimentation through the changing relationship between individuals, groups, raw materials and devices (Jemielniak and Przegalinska 2020: 120). In this sense, the infrastructure of prototyping emerges not because a user follows a DIY tutorial but 'when' he or she becomes an active part of

sharing networks by collaborating. Sharing results is a condition of membership as this network of the gift (Mauss 1990) is maintained through the localized practices in the workshop by generating a sense of belonging and identification with others that leads agents to speak of ‘community’.

There is a predisposition to build strategies and dynamics built on communication and collaboration (...) because there is complicity. We are all experiencing a transition towards thinking about many things differently and that makes us feel more united (...), for example, the interest in science from this area, I believe, unites the members of this community. (Workshop participant interview excerpt).

In these processes a member has to generate inscriptions (Latour 1987) that feed back into the community’s own values or approaches, thus creating recursivity (Kelty 2008). Infrastructure of prototyping arises as the sociotechnical resources that support the localized production of a particular artifact, enabling and enabled by the maintenance of connections and interactions at global reach via recursivity. It is not just about ‘building’ something: the process of doing so refers to a *community of practices* (Lave and Wenger 1991) that prioritizes the sociality of the event over the material result.

In ITA, a visualization interface of air quality in the city was proposed in the form of a grid showing the distribution of atmospheric agent levels over the whole city, based on interpolation between the city council’s point location data. This gave rise to considerable debate (documented under the heading ‘Interpolating without lying’) involving many people outside the project itself. To generate the code needed for the integration of the data, some of the workshop’s participants (the founders of a well-known new media company) made a mathematical function available (putting it into the public domain with no copyright license), thus emphasising the project’s commitment to community and prioritising moral over commercial concerns (Figure 1).

Relationality – through collaboration – is a necessary condition of the process of making such devices that require combined knowledge, materials and skills, and that foster and maintain a particular sense of community based on an ethic of doing, shaping a moral economy (Thompson 1991). In the words of one collaborator:

to enhance the value of this realm (...) and to be able to share and develop and flourish (...) which for me has to do with freedom, which is the most important thing, with the freedom of users, the freedom to be able to

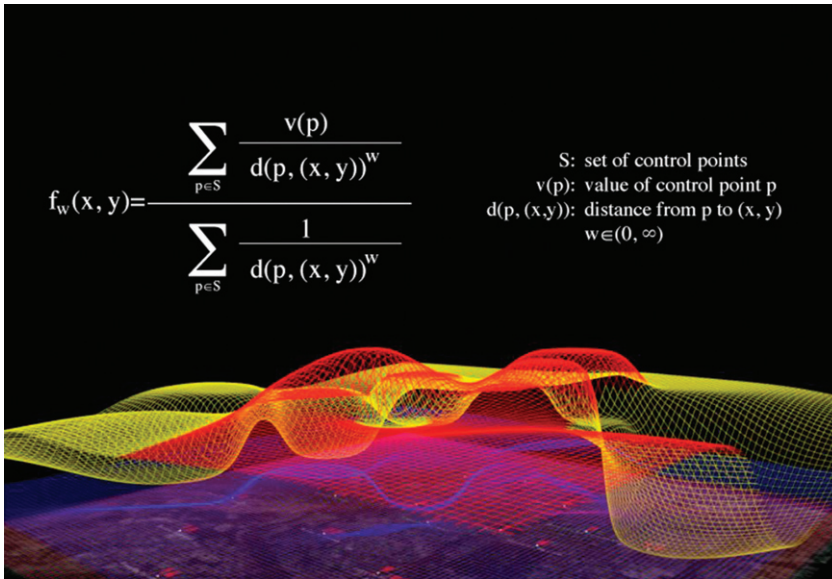


Figure 1. The interpolation and grid. (Source: remixed by Sandra Fernández. CC-BY *Intheair* project)

distribute your knowledge or share interests, so if this space is not preserved, there is a risk of returning to a very narrow view of what exchange between people is, purely mercantilist. (Workshop collaborator, *Fieldwork Diary*, original in Spanish)

So far, we have seen how the formal dimension of the workshop – through the normativity of collaboration – configures a recursive community to address air management in the city by experimenting. However, despite this workshop’s formalized character, the outcomes are always provisional, as they are subject to possible changes. Prototyping incorporates failure as a constitutive part of its own development; that is, as a generative element of the dynamics which characterize the very process. Since the conditions of possibility for such transformation depend on the available capacities and material means, ‘resistance’³ arises as disruptive events which ease the emergence of the informality whereby the infrastructure of prototyping is stabilized.

***Glob@s*: Coping with ‘Resistance’ Through Informality**

The learning process generated from the normative dimension of the workshop refers, according to the actors themselves, to the production

and exchange of 'knowledge'. This is inseparable from the practice developed in the workshop as it emerges at the intersection of members, materials, techniques and shared interests (Nicolini, Gherardi and Yanow 2003). As one participant commented: 'the very process [of producing the object] itself generated knowledge'. In the course of constructing the prototype, each participant learns new skills, acquires new abilities and at the same time teaches something of what he or she knows to others through the routines implemented in the workshop. As we will see below, in the *Glob@s* project, the relational process of learning results in the modification of bodies through the acquisition of new capacities, uses and meanings. This is practice-oriented learning through manipulation. As one programmer commented during a workshop debate on governability models, 'if you learn to build something, you know how it works, and that way no one can think for you'.

When members' expectations on the materialization of techniques, standards and formal routines during the workshop do not correlate to the effects of these sociotechnical assemblages, the stability of the infrastructure is jeopardized. This instability can be coded in terms of 'resistance'. If the process of producing the prototype as an artifact is interrupted, so is recursivity. For this reason, it is essential to promote the course of the prototype by generating alternatives to tackle resistance. As we will show below, addressing infrastructure of prototyping from an informal approach opens up the possibility of understanding resistance not only in the negotiations of expectations by members, but also in the context of materiality.

One of the collaborators of the ITA project (Sue⁴) launched *Glob@s* several months later. 'Air' as a common need to be governed by citizens appears as the thread of both projects. One of the major issues discussed throughout the development of ITA was the lack of confidence in the data provided by the City Council. Suspicions about possible manipulation of the measured air components permeated the discussions on institutional transparency since it would undermine the whole political purpose of the project. The search for alternative solutions regarding reliability of the data produced is the main driver of the new prototype. Thus, this negotiation that constituted a disruption of ITA, was taken as the point of departure for *Glob@s*. This latter project proposed the generation of its own data by creating a toolkit for anyone to measure air contamination and then share this data through the *Pachube* Internet platform.

A flying device, a balloon, which measures the presence of gases and microscopic agents in the air at different heights and sends them to an

Practising Organisation by Performing Materiality

OLPC. The representation of the information obtained is designed to be child-friendly and aims to represent the air pollutants as characters in a screen scenario that appear and act according to the data provided by the device and according to the effects they have on the city's inhabitants (people, animals and plants). (Center wiki website, fieldwork diary)

Every project is assigned a table, where participants introduce themselves. Glob@s initially had just two collaborators, the anthropologist and a Brazilian designer, and we first needed to build a measuring device and a balloon to support it. Neither of us had any prior knowledge about sensors, but learnt that Jay – an artist and eventual third collaborator due to arrive from India, was an expert on them.

After initial Internet searches and following a tutorial on *solar-balloons.com*, we decided to construct a balloon based on an approximate estimate of the still unknown weight of the device. A paper pattern was used to measure and cut thirty refuse bags to make the balloon's panels. These were black to absorb heat from the sun and create lift from the thus expanded internal air. However, as it was a cloudy day, a hairdryer was used to test the balloon in what was previously the men's bathroom and had been resignified a 'wet lab' by means of a poster (Figure 2). The planned work was therefore reconfigured through the unplanned modification of an informal space in the environment, thus making the procedure more flexible in order to achieve its defined objectives.

The attempt to inflate the larger than expected balloon was photo-documented by two centre managers. The first failure was that the balloon was bigger than the 'wet-lab' and an attempt was made to inflate it outside, passing the dryer cable through a window.

Despite having scrupulously followed the tutorial instructions, the result was not what was expected. The second failure was that heat from the hairdryer was insufficient to lift the balloon. It also resulted being too large to be considered a 'homemade device'. Perhaps this was the DIY rationale cut-off point, referred to by one collaborator at the start, when 'others can do it by themselves, but you can't.'

It was a non-viable option that, despite its pragmatic failure, was documented and included in the center's wiki. Finally, the rubbish bag solar balloon was replaced by a one-meter diameter plastic balloon filled with helium, (Figure 3).

It's a very intensive process because you're always looking for solutions. If one doesn't work then you have to think again, and then look, and there are things that you don't know how to do and you have to look for something else (Collaborator interview excerpt)



Figure 2. Wet lab poster. (Source: Sandra Fernández)



Figure 3. Balloon. (Source: Sandra Fernández)

In this vein, the informal infrastructure of prototyping emerges inseparably with the formal order. In turn, the *informal infrastructure* is a response to these failure events by means of what Henke and Sims (2020) call ‘repair as maintenance’ work. Such work is performed as

long as the current sociomaterial order ensures recursive practices at global reach. The search for alternatives is part of the repair work of informal infrastructures of prototyping as it is not only necessary to gather information but also to check it hands-on, to ensure its pragmatic application during the workshop in order to achieve the desired results.

The same kind of dynamics described for the construction of the balloon were present in other stages of prototyping, such as the building of the measuring device and the design and development of the software, as well as the integration of all these processes. Sue had to select information from the tutorials as not everything on the pages was suitable for the prototype as it was proposed. She knew some electronics, and about some assembly components and could do some soldering but she needed to combine these skills and knowledge with others from different sources – and Jay’s help – in a process of laboratory experimentation. Trial and error was the model that worked best because it allowed her to bring together information and materials by understanding how it worked in practice. In this process, she acquired practical knowledge which, through the body, allowed her to take ownership of what she knew and apply it in another time, place or dimension⁵. Thus, the informal infrastructure approach allows us to focus on the unforeseen elements embedded in formal practices and to foreground their relevance as practices of making *things* through learning processes which transform bodies and environment. In other words, when practicing organisation, analytical attention to the ‘resistance’ of *things*, reveals the transformative role of these sociomaterial configurations in the constitution of environmental relations. In our specific case, the ‘resistance’ of things manifests itself in the form of limitations produced by prior knowledge on air properties as well as the material and human resources for the construction of a hot air balloon. Thus, sociomaterial configurations become the search for flexible solutions through debates and manipulations at the intersection of human and non-human agents in order to achieve expected results by mobilising values at local and global level for future actions to take place (Figure 4).

ITA and Glob@s participants not only learnt to build a device for measuring and/or visualising air quality but precisely by this process, they produced a specific and shared meaning of ‘air’ which, as an ontological category, is an ‘air in relation’. The artifact thus encapsulates both a definition of air marked by its relations with the urban subject and governance models, as well as precise instructions on how to continue working on the same topic. Both prototypes aim to inform citizens about the state of air, making them participants.

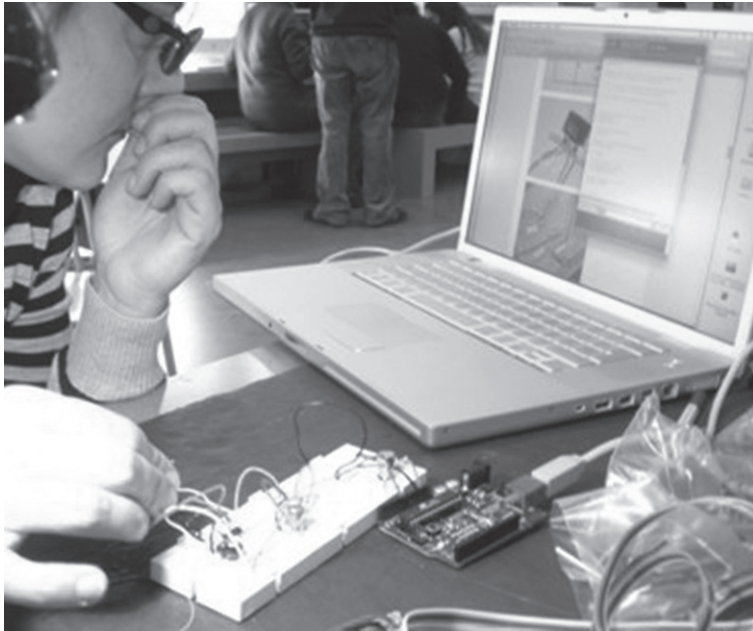


Figure 4. Protoboard test. (Source: Sandra Fernández)

Air Quality EGG: ‘What Make Things how they are’

The ontological construction of air does not emerge independently of this entanglement, but rather it does so as a result of the assemblage of bodily-material-epistemological conditions of the prototyping. From this view, the possibilities for what it means to be the ‘air’ emerge from infrastructure. ‘Air’ as a category of being, is related to human breathing and the idea of health, connoting concerns for citizenship awareness and responsibility, education of the next generation, and users’ technology engagement. Prototypes encapsulate this relationality – the organising order under which they have been produced – in its materiality. As Bowker (2015) has claimed ‘the objects we see making up the world (...) are themselves infrastructurally determined’. Therefore, ‘air’ refers not only to a mixture of particles with concrete effects in terms of health or pollution – and not as, for example, a habitat for viruses or a medium for the propagation of waves – but also to distinctive forms of interaction namely, collaborative, open and public.

The normative dimension to both engage people to act morally and politically in relation to environmental issues (Marres 2013)

Practising Organisation by Performing Materiality

and also to promote shared learning dynamics, permeated a third prototype: AQE. 1

The Egg is a WiFi-enabled device that uses sensors to record changes in the levels of specified air contaminants. Each Egg can detect at least one air contaminant – NO₂, CO₂, CO, O₃, SO₂, particulates, and volatile organic compounds (VOC). It tracks any changes and automatically uploads the data to the cloud where it can be accessed through our web portal, mobile app (...). (Air Quality Egg 2021) 5

As in the previous cases, using open licenses – for example Creative Commons – is mandatory in order to allow other people to access the device’s functioning and assembly instructions, making it possible for everyone to work on the work of others. 10

The development of the prototypes was almost always carried out jointly, with a few core developers coordinating (and developing) the areas of hardware design, programming and physical design. These people who carried out a large part of the development obtained feedback from the rest of the group regarding usability, various tests, scientific research depth, and so on. (Collaborator interview excerpt) 15

The first version of AQE was published on the Internet under an open license. Then two meetings were held in New York and Amsterdam from which the so-called ‘sensemakers’ – closely related to ‘Internet of Things’ groups – emerged. Continuity between the three prototypes shows that informal infrastructure of prototyping is clearly embedded into and inside of other sociomaterial arrangements since: 1) the development of the prototype as an open-ended process is sunk into different networks – Meetups, Internet of things, Google Groups and so on – and informational flows, and 2) a set of negotiated compromises on the citizen management of air through the ‘egg’ permeates to other communities and fields of expertise. One of the developments of AQE is aimed at the institutionalized education community. 20

Students of all ages can benefit from using the Egg. Topics such as air pollution and the effects of carbon dioxide can easily be introduced to students at all levels using the Air Quality Egg learning system. Older students can use the Egg’s data to create labs and test various hypotheses. This makes Air Quality Egg a strong addition to any school, with multiple applications at all levels. (Air Quality Egg 2021) 35

So education, technology and the air converge when it comes to ‘understand[ing] the importance of making decisions backed 40

Somatechnics

by data’ (Air Quality Egg 2021). This data-driven learning allows users to interact with one another. Though the accuracy of data generated and the calibration of the device were a concern during the prototyping workshops, the value of the device lies, following Jennifer Gabrys (2019), in enabling citizen sensing of air quality for creating further calls to action on environmental concerns. In her own words:

Data gathered through electronic sensing is seen to be the force that propels perceived possibilities for activism, but here the force of data depends less on the accuracy of data and more on the process of making a device that can draw attention to data practices as materialized and potentially political engagements (Gabrys 2019: 190).

The process of prototyping has resulted in an egg whereby enabling citizen sensing of air quality lies in the users’ technology engagement. By mobilising a set of negotiated compromises and technics, communities and bodies, artifacts and materials, the egg is built on an installed base that inherits both limitations in terms of lack of accuracy – resistance –, and also strengths as it allows the permeation of other structures – as in the case of institutional education – as well as scaling up sociomaterial collaborative organisation. According to the AQE website, a 4th grade student at an elementary school says the following: ‘I just like learning about our world and what makes things how they are... I want to learn how I can make air quality better’ (Air Quality Egg 2021). The egg, as a determined set of infrastructure practices, potentially determining political engagements, acquires ontological and practical value through matter since ‘it generates consequences for how we experience and act in our world’ (Carlile *et al.* 2013: 3).

Conclusions


From a practice-based approach and with the aim of setting aside dualistic views of the object-subject relationship, this article has addressed the complex organisation of multilayered practices that make up prototyping processes through the concept of ‘informal infrastructure’. Focused on the ‘air’, this analytical tool has allowed us to understand these processes not only as practices of material production but as a dynamic entanglement of ‘things’. Infrastructure of prototype integrates a set of heterogeneous elements – rubbish bags, Arduinos, laptops, bodies, pollutants, open licenses, moral concerns, flows of information and so on – which participate in the generation of

distinctive relations between them according to, and shaping in turn, specific environments. 1

Prototyping sets a specific ‘ecology of visible and invisible work’ (Star and Strauss 1999). The normative dimension of organising is displayed through collaboration as a key part of the master narrative of the infrastructure of prototyping. Collaboration, which is highly normalized, is pervasive in these practices, thereby concealing the complex ‘choreography’ of things on which it rests and is ensured by. It makes this ‘choreography’ invisible, specifically when it comes to coping with limitations. The unplanned or unforeseen element, which distinctively characterizes the infrastructure of prototyping, acquires a crucial value in addressing social change through material-semiotic reconfigurations (Jensen and Morita 2017). In order to address the mismatch between intended expectations and ‘real’ effects in practice, the unforeseen that emerges as ‘resistance’ challenges the very subject-object distinction by de-centering ontological issues and prioritising relational ones. As shown above, the prototypes not only result from an entanglement of *things* – as a distinctive way of performing organisation – but also transform the very notion of citizenship – as a political process of performing materiality. Adopting the analytical tool of ‘informal infrastructure’ sheds light on how systems of organising are maintained in an ongoing ‘choreography’ of things by stepping into the informal dimension of the unplanned. Thus, in order to provide stability to the infrastructure, maintenance work is required: alternatives have to be negotiated and put into play by reconfiguring the relationships between things. 5 10 15 20 25

By prioritising effects over functions (Leach 2014), prototyping acquires value as a mobilizer of ethical and political commitments which shapes ‘community’. Thus, the infrastructure of prototyping emerges as property of action embedded in an installed base through which it is bonded to other forms of organisation such as institutional education. Some of the prototyping processes has resulted – so far – in an egg, whereby citizens’ involvement in the monitoring of air quality resides in user technology engagement. They are involved in environmental issues by using the egg. As a ‘ready-to-hand object’, it makes maintenance work invisible for the user but invisibility, as a condition of ethical-political engagement, is relational. Thus, imaginaries of the future are not shaped *rationally*, but relationally. 30 35

ORCID 40

Francisco Sánchez Valle  <https://orcid.org/0000-0001-6144-3962>

Notes

1. While formal and informal dimensions are differentiated in the article for analytical purposes in order to emphasize those interactions that are often taken for granted within the workshops, actually both are closely intertwined becoming constitutive of the practices described below.
2. In what follows we will use 'prototype' to refer to the artifact and 'prototyping' for the process, though this analytical differentiation does not work in practice.
3. Material resistance refers here to the limitations produced by the object as a permeable membrane for human practices in the constitution of environmental relations (Anusas and Ingold 2013: 69).
4. The anonymity of those who participate in the research has been respected by using pseudonyms.
5. Actually Sue began here a long period of technological experimentation in various workshops and courses both in laboratories and universities all around the world.

References

- Air Quality Egg (2021), 'Main Page'. Available at: <https://airqualityegg.com/egg> [Accessed: 15 September 2021].
- Anusas, Mike and T. Ingold (2013), 'Designing Environmental Relations: From Opacity to Textility', *Design Issues*, 29: 4, pp. 58–69. https://doi.org/10.1162/DESI_a_00230
- Barad, Karen (2003), 'Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter', *Signs*, 28:3, pp. 801–831. <https://doi.org/10.1086/345321>
- Beyes, Timon, R. Holt and C. Pias (2020), 'By Means of Which: Media, Technology, Organization', in *The Oxford Handbook of Media, Technology, and Organization Studies*, Oxford: Oxford University Press, pp. 498–513. <https://doi.org/10.1093/oxfordhb/9780198809913.013.44>
- Bowker, Geoffrey (2015), 'Temporality. Theorizing the Contemporary', *Fieldsights*, September 24. Available at: <https://culanth.org/fieldsights/temporality> [Accessed: 10 October 2021].
- Carlile, Paul, D. Nicolini, A. Langley and H. Tsoukas (2013), 'How Matter Matters: Objects, Artifacts, and Materiality in Organization Studies', in *How Matter Matters: Objects, Artifacts, and Materiality in Organization Studies*, Oxford: Oxford University Press, pp. 1–15. <https://doi.org/10.1093/acprof:oso/9780199671533.001.0001>
- Clarke, Alison (ed.) (2017), *Design Anthropology. Object Cultures in Transition*, London: Bloomsbury. <https://doi.org/10.5040/9781474259071>
- Corsín, Alberto (2014), 'The Prototype: More than Many and Less than One', *Journal of Cultural Economy*, 7:4, pp. 381–398. <https://doi.org/10.1080/17530350.2013.858059>
- Gabrys, Jennifer (2019), 'Sensing the Air and Experimenting with Environmental Citizenship', in R. Glas, S. Lammes, M. de Lange, J. Raessens, and I. de Vries (eds), *The Playful Citizen. Civic Engagement in a Mediatized Culture*, Amsterdam: Amsterdam University Press, pp. 175–194. <https://doi.org/10.1515/9789048535200-011>
- Gatt, Caroline and T. Ingold (2013), 'From Description to Correspondence: Anthropology in Real Time', in W. Gunn, T. Otto, and R. C. Smith (eds), *Design Anthropology. Theory and Practice*, London: Bloomsbury, pp. 139–158. <https://doi.org/10.5040/9781474214698.ch-008>
- Haraway, Donna (1985), 'Manifesto for Cyborgs: Science, Technology and Socialist Feminism in the 1980s', *Socialist Review*, 80, pp. 65–108.

Practising Organisation by Performing Materiality

- Harvey, Penny and H. Knox (2014), 'Objects and Materials: An Introduction', in P. Harvey, E. Casella, G. Evans, H. Knox, C. Mclean, E. Silva, N. Thoburn, and K. Woodward (eds), *Objects and Materials: A Routledge Companion*, London: Routledge, pp. 1–17. <https://doi.org/10.4324/9780203093610> 1
- Harvey, Penny and H. Knox (2015), *Roads. An Anthropology of Infrastructure and Expertise*, Ithaca: Cornell University Press. <https://doi.org/10.7591/9780801456466> 5
- Henare, Amiria, M. Holbraad and S. Wastell (eds) (2007), *Thinking Through Things: Theorising Artefacts Ethnographically*, London: Routledge.
- Henke, Christopher, and B. Sims (2020), *Repairing Infrastructures. The Maintenance of Materiality and Power*, Cambridge, MA: The MIT Press.
- Ingold, Tim (2007), 'Materials against Materiality', *Archaeological Dialogues*, 14, pp. 1–16. <https://doi.org/10.1017/S1380203807002127> 10
- Ingold, Tim (2010), 'Bringing Things to Life: Creative Entanglements in a World of Materials', *ESRC National Centre for Research Methods. Working Paper Series*. Available at: <https://eprints.ncrm.ac.uk/id/eprint/1306/> [Accessed 21 November 2021].
- In the Air (2021), 'Main Page'. Available at: <http://www.intheair.es/> [Accessed: 24 October 2021]. 15
- Jemielniak, Dariusz and A. Przegalinska (2020), *Collaborative Society*, Cambridge, MA: The MIT Press.
- Jensen, Casper B., and A. Morita (2017), 'Introduction: Infrastructures as Ontological Experiments', *Ethnos*, 82:4, pp. 615–626. <https://doi.org/10.1080/00141844.2015.1107607>
- Kelty, Christopher (2008), *Two bits: The Cultural Significance of Free Software*, Durham: Duke University Press. <https://doi.org/10.1215/9780822389002> 20
- Latour, Bruno (1987), *Science in Action: How to Follow Scientists and Engineers through Society*, Cambridge, MA: Harvard University Press.
- Latour, Bruno (1999), *Pandora's Hope: Essays on the Reality of Science Studies*, Cambridge, MA: Harvard University Press.
- Lave, Jean and E. Wenger (1991), *Situated Learning: Legitimate Peripheral Participation*, Cambridge: Cambridge University Press. 25
- Leach, James (2014), 'Choreographic Objects. Contemporary Dance, Digital Creations and Prototyping Social Visibility', *Journal of Cultural Economy*, 7:4, pp. 458–475. <https://doi.org/10.1080/17530350.2013.858058>
- Leonardi, Paul (2012), 'Materiality, Sociomateriality, and Socio-technical Systems: What do these terms mean? How are they different? Do we need them?', in P. M. Leonardi, B. A. Nardi and J. Kallinikos (eds), *Materiality and Organizing: Social Interaction in a Technological World*, Oxford: Oxford University Press, pp. 25–48. <https://doi.org/10.1093/acprof:oso/9780199664054.003.0002> 30
- Luhmann, Niklas [1964] (2020), 'Organization, Membership and the Formalization of Behavioural Expectations', *Systems Research and Behavioral Science*, 37:3, pp. 425–449. <https://doi.org/10.1002/sres.2689> 35
- Madrid City Council (2021), 'Medialab en Matadero'. Available at: <https://www.madridcultura.es/entidad/150/medialab-en-matadero-matadero-madrid#:~:text=Medialab%20en%20Matadero%20es%20un,a%20cabo%20de%20manera%20colaborativa> [Accessed: 20 November 2021].
- Marcus, George (1995), 'Ethnography in/of the World System: the Emergence of Multi-sited Ethnography', *Annual Review of Anthropology*, 24:1, pp. 95–117. <https://doi.org/10.1146/annurev.an.24.100195.000523> 40

- Marres, Noortje (2013), 'Why Political Ontology Must Be Experimentalized: On Eco-show Homes as Devices of Participation', *Social Studies of Science* 43:3, pp. 417–443. <https://doi.org/10.1177/0306312712475255> 1
- Mauss, Marcel [1925] (1990), *The Gift: the Form and Reason for Exchange in Archaic Societies*, London: Routledge.
- Medialab-Matadero (2021), 'Convocatorias'. Available at: <https://www.medialab-matadero.es/convocatorias/desvisualizar-convocatoria-para-colaboradores> [Accessed: 2 November 2021]. 5
- Mol, Annemarie (2002), *The Body Multiple. Ontology in Medical Practice*, Durham: Duke University Press. <https://doi.org/10.1215/9780822384151>
- Nicolini, Davide (2011), 'Practice as the Site of Knowing: Insights from the Field of Telemedicine', *Organization Science*, 22:3, pp. 602–620. 10
- Nicolini, Davide, S. Gherardi and D. Yanow (2003), 'Introduction: toward a Practice-based View of Knowing and Learning in Organizations', in *Knowing in Organizations: A Practice-based Approach*, New York: M.E. Sharpe, pp: 3–31. <https://doi.org/10.4324/9781315290973>
- Olmstrom, Ellinor (1990), *Governing the Commons. The Evolution of Institutions for Collective Action*, Cambridge: Cambridge University Press. <https://doi.org/10.1017/CBO9780511807763> 15
- Orlikowski, Wanda (2007), 'Sociomaterial Practices: Exploring Technology at Work', *Organization Studies*, 28, pp. 1435–1448. <https://doi.org/10.1177/0170840607081138>
- Otto, Ton, and R. C. Smith (2013), 'Design Anthropology: A Distinct Style of Knowing', in W. Gunn, T. Otto, and R. C. Smith (eds), *Design Anthropology. Theory and Practice*, London: Bloomsbury, pp. 1–29. <https://doi.org/10.5040/9781474214698.ch-001> 20
- Radomska, Marietta (2018), 'Promises of Non/Living Monsters and Uncontainable Life', *Somatechnics*, 8:2, pp. 215–231. <https://doi.org/10.3366/soma.2018.0252>
- Seidl, David and H. Mormann (2014), 'Niklas Luhmann as Organization Theorist', in P. Adler, P. du Gay, G. Morgan and M. Reed (eds), *The Oxford Handbook of Sociology, Social Theory, and Organization Studies*, Oxford: Oxford University Press, pp. 125–157. <https://doi.org/10.1093/oxfordhb/9780199671083.013.0007> 25
- Star, Susan Leigh (1999), 'The Ethnography of Infrastructure', *American Behavioral Scientist*, 43:3, pp. 377–391. <https://doi.org/10.1177/00027649921955326>
- Star, Susan Leigh and A. Strauss (1999), 'Layers of Silence, Arenas of Voice: The Ecology of Visible and Invisible Work', *Computer Supported Cooperative Work*, 8:1–2, pp. 9–30. <https://doi.org/10.1023/A:1008651105359> 30
- Star, Susan Leigh, and K. Ruhleder (1996), 'Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces', *Information Systems Research* 7:1, pp. 111–134. <https://doi.org/10.1287/isre.7.1.111>
- Thompson, Edward P. (1991), 'The Moral Economy Reviewed', in *Customs in Common: Studies in Traditional Popular Culture*, London: Merlin, pp. 259–351.
- Tilley, Christopher (2007), 'Ethnography and Material Culture', in P. Atkinson, A. Coffey, S. Delamont, J. Lofland and L. Lofland (eds), *Handbook of Ethnography*, London: SAGE Publications, pp. 258–272. <https://dx.doi.org/10.4135/9781848608337.n18> 35
- Trist, Eric and J. Bamforth (1951), 'Some Social and Psychological Consequences of Longwall Method of Coal-getting', *Human Relations*, 4:1, pp. 3–38. <https://doi.org/10.1177/001872675100400101>