HOUSE 1 Protostructure: Enhancement of Spatial Imagination and Craftsmanship Between the Digital and the Analogical

Dieter Dietz, Dario Negueruela del Castillo, Agathe Mignon and Julien Lafontaine Carboni

Abstract Conceived around the concept of *protostructure*, HOUSE 1 deploys a strategy to answer a daring but simple question: How could we design a house between almost 300 people? The unique pedagogical framework of ALICE, first year Architectural Design course, proposes the integration of a series of full scale physical wooden constructs, enacting collaborative thinking and drawing on collective spatial knowledge. The *protostructure* constitutes at once both a material and immaterial open source support for the individual and collective interventions by the students. Its material dimension as a physical construction is invested and complemented by the immateriality of the guiding scheme. In this article, we review the steps in the development of the theoretical model and physical implementation of HOUSE 1 and discuss its relevance with regards to the relation between analogical and digital modes of engagement, pedagogical frameworks and spatial cognitive strategies. This implementation of the *protostructure* shows its potential as a tool to approach wood design, through a combination of digital and analogical processes, enhancing the deployment of spatial cognitive strategies with the use of wood as a material through and with which to think about space.

Keywords Protostructure · Collaborative design · Pedagogy · Craftsmanship
Open source · Database · Spatial imagination · Parametric design
Fabrication strategies

1 Introduction

Within contemporary approaches to wood design through digital processes, considerations of how tools foster interaction and remain appropriable constitutes a promising line of research, albeit somewhat secondary. In order to fully incorporate

D. Dietz · D. N. del Castillo (✉) · A. Mignon · J. L. Carboni
ALICE Space Design Workshop, Federal Polytechnic School of Lausanne, Lausanne, Switzerland
e-mail: dario.negueruela@epfl.ch

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and consider how these aspects may contribute significantly to digital wood design and architecture, we must look at educational and participatory design frameworks, where such concepts are most developed. Responding to these potentials and challenges, at ALICE we have developed and implemented, together with students of architecture, the theoretical, material and methodological framework that we introduce in this chapter around the built case-study of HOUSE 1. These experiences explore the full potential of combining a generative design scheme with a strong participatory and engaging dimension.

In convergence with the recent paradigm shift favouring agency and empowerment, students of architecture tend to be increasingly considered as active agents in their learning process. Deep spatial and social engagement are regarded as roots of a collective framework, enacting collaborative thinking and drawing on spatial knowledge. We contend that architecture through the complexity of the design and architectural design, sharpened by globalized problematics and digital mutation should be accounted for as a collective process, place of knowledge-sharing, as well as a support for a personal and collective individuation.[1] Today the natural complexity of design processes is enhanced in view of globalized problematics and digital mutation. In that scope, first-year students in architecture at École Polytechnique Fédérale de Lausanne (EPFL) are asked to engage themselves with space—to act on it and to conceive it, using different tools to project and imagine it. As such space is presented as a source of challenges, and not of theorems. Conceived around the concept of *protostructure,*[2] the pedagogical framework of the Atelier de la Conception de l'Espace (ALICE laboratory), has the objective to foster student skills through individual and collective intervention. It deploys a strategy that seeks to answer a daring but simple question: *How could we design a house between almost 300 people?*

As an answer to this question, the ALICE first year Architectural Design Course proposes the integration of a series of full scale wooden constructs. HOUSE 1, developed as the first of a series, is conceived around the concept of *protostructure*,

[1]For Simondon, individuation is a synonym of ontogenesis. In his article *Fifty Key Terms in the work of Gilbert Simodon*, Jean-Hugues Barthélémy defines the simodonian ontogenesis as such: 'This term is first of all a synonym of **individuation**, because individuation, for Simondon, is genesis. In biology, ontogenesis is also the genesis of the individual; in this case, it is distinguished from 'phylogenesis', which is genesis of the species. However, Simondon also applies this term to philosophical theory itself, because the 'knowledge' of individuation is 'individuation of knowledge' (Simondon 2005; 36). This is the properly Simondonian mode of overcoming the subject/object opposition in view of a non-objectifying philosophical 'knowledge'. […] In the *second* instance, it is the term ontogenesis itself that is enlarged in order to refer to the 'becoming of being' (Simondon 2005; 25) in general, and thus to individuation as the genesis of the individual *and its associated milieu*.' (Barthélémy and Boever 2012). For a discussion of Simondon's theory in relation to the concept of protostructures and protofigurations, see Lafontaine Carboni, 2018, Cité de l'Architecture et du patrimoine.

[2]By protostructure we refer to that which through its use and interaction with, allows for the extension of one's cognitive and agential capacities. It facilitates the mobilization of additional emergent resources, before unnoticed or unexplored. For a more detailed definition, see pages 3 and 4.

developed at the core of the research activities of the lab.[3] The *protostructure* constitutes at once both a material and immaterial support of students' interaction. Its material dimension as a physical construction is invested and complemented by the immateriality of the guiding scheme. Furthermore, the three-dimensional field of the *protostructure* locates every individual proposition or intervention in relation to the ones from the other participants, vertically and horizontally. It embodies each collective situation in a physical medium. At the same time, a temporal framework locates every action into a broader system. Thereby a set of rules is shared by all actors, enabling them to interact within a gravitational system of structural logic and to operate with similar vocabularies (types of response) in order to construct common knowledge.

The concept of *protostructure* has been developed by ALICE over several years in the context of diverse teaching and research formats. At its outset, there are two major intentions. First, as already mentioned, the concept of *protostructure* is operating as a hinge between physical articulation and conceptual idea. Linked to a temporal framework it literally constructs pathways from idea to built form. Second, *protostructures* are able to federate collective action. The idea of structural supports engages the spatio-temporal dimension of people appropriating space in all its dimensions.[4] As such, it opposes the idea of the territory as a *tabula ras*a, where architectures would be placed as objects one next to the other, implying exclusive individual or collective ownership of the planet's surface. In conceiving a project in a 3-dimensional grid space, a project will automatically be, not only next to the other, but also in mutual relationship with every aspect around it, often superimposed with other projects below and above. This relationship will automatically ask for negotiation between all actors involved in the conception process of the overall spatial construct.

Before starting the HOUSE 1 program, ALICE proposed different kinds of structures at model-scale concerning smaller groups of students. Called *Champs*, or *Matrice*,[5] these structures are comparable from one workshop group to the other, but not superimposable. Even though conception challenges did not include full-scale embodiment, the common structural basis allowed for collective appropriation and communication based on a same basis. The definition of the concept of *protostructure* forged by the lab has later concretized this research. Defining simultaneously the physical form of a structure (full-scale wood assembly) and a temporal framework (temporality, program and protocol), the neologism was introduced with the intention to allow for plural experiences and experimentation under a same denomination (Fig. 1).

[3]HOUSE 1 is the final project of the teaching program "Inside Paris", conducted during the school year 2015–16 by the laboratory.

[4]Certain similarities with the radical propositions of Price, Friedman, Constant and others can be seen here.

[5]Called "matrice" or matrix during the years 2010–11, 2011–12 and 2012–13, for the teaching programs Villes Archipels, Ville Entière and Airborne: Non-Site/Earthwork, "champ" or field for the 2013–14' program Where Are We Now?, and finally *protostructure* for the last three years programs, Inside Paris, Inside Zurich and Inside Brussels.

Fig. 1 HOUSE 1 final critics day. © Joanne Nussbaum, ALICE EPFL

Mignon has defined the term as such[6]: ‘The term *protostructure* is constituted by the prefix proto and the substantive structure. The part of the prefix coming from the Ancient Greek doesn’t need hyphens; *protostructure* is so a single word. We equally notice that the prefix is Greek while the substantive is Latin. As such the word is a hybrid (in line with sociology for example).

Structure is coming from the Latin *structura*, itself derived from the supine *struere*, the action of assembling, piling up, but also building, arranging or weaving. The current substantive also indicates the assembly and the resulting form, or even the organisation of elements. It tends to communicate the idea of a set of systems that could be either physical, mental or informational. In the *Dictionnaire d’histoire et de philosophie des Sciences (Dictionary of History and Philosophy of Science)*, Lecourt (2006) uses an architectural metaphor in order to illustrate the hard to define term:

> It is the hinge between plural parts, by means of rigid links often hidden. It is the skeleton or the framework of a building, which provides its stability and cohesion, but not necessarily its meanings. The structure is indifferent to superficial charms of appearance and dressing, it is behind the scenes.

The prefix *proto*, coming from the Greek form πρῶτος, means first. It is composed of the basis *pro*, forward, and the superlative *tatos*. It points at a primary character of the substantive, holding potential of a dynamic row of events. This notion of process is also apparent in *prototype*, the first model of a series. It is also distinguished from

[6]Mignon, Agathe. *Protostructure, archeology and hypothesis of a support structure*. Doctoral thesis (on going), ALICE EPFL.

the *infrastructure* that suggests a static point of view, without meaning of further action or temporal proceeding.

The neologism *protostructure* not only captures a process of creation and construction, but it also aims to establish a transversal view upon a series of realizations and architectural theories. A protostructure designates a system or a building in a primary state. The prefix introduces the temporality placing the structural element as a support and an object of the process, in a state prior to any evolution. A *protostructure* possesses or demonstrates the capacity to adapt; its own nature is subordinated to future uses; it will evolve, change appearance, function, become a trace again or even disappear.

As it constitutes the physically and conceptually necessary base to every process of creation, it institutes a relationship of control in imposing some of its characteristics. We can use the metaphor of the white page to illustrate the concept of *protostructure*: In a primary state, the white page is defined by the format, weight, grain, etc. Once used as a support, its potential forms are infinite. The primary characteristics are nevertheless not erased; they exist through the influence they had on the process: the quality defines the types of technique, the format the limit, etc. Support and uses are bound in a relationship of interdependence; the *protostructure* configured it ahead.

Since 2015 ALICE works with the concept and physical articulations of *protostructure*s. HOUSE 1 was built in summer 2016 and was the first project realized on the basis of this principle. The specific experience of the house as a configuration exercise offered the possibility to explore principles of modelization inherent in digital technologies. These dynamics allow to intuitively establish connections between different conceptions of a given space—analogical, digital and material. The *protostructure* of HOUSE 1, similar to the American balloon-frame system, consists of a construction system based on orthogonal assemblage of discrete and standardized units in three dimensions, revealing space in its Cartesian form. Each assembly is thus a point, each wall a plane, within a grid that defines a primary rhythm. The interaction between the experience of physical space and the reading of a vector-based space is mutual. It is based on the capacity of wood to offer precision both at the level of its drawability—manual or digital—and of its constructability—by hand or with automatized machinery. It is this precision that allows to acknowledge and perceive, the interdependency between details and the whole. The assembly work becomes the key operation in this system through the analogical engagement with each of the smallest components (Fig. 2).

In this article, we review the steps of the development of the theoretical model and physical implementation of HOUSE 1. The first question, '*How could we design a house between almost 300 people?*' has been enacted by the *protostructure*, and experimented through HOUSE 1. In the context of this article we will now ask whether and in what way the materialization of this process follows principles of a digital mode of thinking. How does wood, the only material used during the conception and construction, permit to bound the digital/virtual and the physical dimensions of design?

As part of HOUSE 1, the translation of the operating principles of the digital to wood design will be investigated as a chance to favour agency and empowerment of

Fig. 2 Construction © Aloys Mutzenberg, ALICE EPFL

students in the learning process and architectural conception, giving birth to a shared and collective spatial knowledge. In this respect, the concept of *protostructure* allows us to unveil how this particular engagement with wood design and construction has led to personal empowerment and agency of each of the participants.

To engage with the stated research questions in context of the HOUSE 1 experiment, ALICE gathered the physical and conceptual work of 227 students, studio directors and student-assistants. For HOUSE 1 a particular *protostructure* was designed by members of the ALICE research team: A cubic light structure of 11 by 11 by 11 m. The design of the structure is such that it is able to support its own weight. However, projects need to rigidify the structure in order to be functional, and superimposed designs will become mutually dependant as loads will have to be transferred via neighboring projects. Importantly, the *protostructure* contains the genetic code for the future interventions, allowing it to act at complementary levels. On the one hand, it acts as a collective material support, to be shared, and enabling the physical construction of one project by a large group. On the other, it acts as a research support and as an experiment set-up in respect to the posed research questions. HOUSE 1—conceived, designed, and constructed by 227 people—is the final realization of the *Inside Paris* program, developed in 2015–16 by ALICE and the first-year design studio in architecture, EPFL.

Below we will first discuss the *protostructure*, as a physical support, a virtual space of projection and a social space of interaction. In that sense, the wood construction and assembly system permits to apply a series of digital concepts, as the location system using reference points, or the decomposition of an organisation in the aim to facilitate group cohesion within a shared space. In addition, we discuss the role of the *protostructure* in enhancing spatial cognitive abilities. Secondly, we will focus on the learning and creation process prolonging the extended metaphor between the empirical approach to permit the agencies and the model of data management massively used in the digital fields. Once more, wood will be investigated as a medium enabling us to lead complex spatial research involving a considerable number of actors. The choice of wood fostered an open and collaborative process, enabling a shared language at the origin of a common database of spatial solutions.

2 HOUSE 1, (1) Between Conceptual, Material and Digital Space

Nowadays, the industrial standardization of timber permits to achieve structures with an astonishing precision; a thoroughness of execution in details is obtainable as much as a hyper-regular three-dimensional structure. At the end of the nineteenth century, the *balloon-frame* construction system-or *Chicago construction*-, merged from the industrialization of sawmills and hardware factories (Pizzi 2003; Turan 2009). Massive industrial production of standardized wood pieces of low cross section and steel nails started as a result of the diffusion of the mechanical saw, the invention of multi-bladed saw and the development of a nail-production machine (Fig. 3).

Timber is perfectly parallelepipedic and makes it possible to trust pre-designed assembling. In opposition to a wood-wood notch, nailing facilitates right-angled corners through, for instance, the nailed boards method. Also, the frame method consists in the pre-fabrication of walls, floor and roof using smaller rectilinear cross-section, regularly spaced out. Amongst others, these methods are highly imageable and use a simple Cartesian system of reference (orthonormal). As a trustable material from its virtual to its actual uses, wood permits a quasi-immediate enaction in space —conceptual, material or digital.

The *protostructure* of HOUSE 1 is entirely designed in pieces of wood of 10 × 3 cm, 500 cm long, used in one full piece. This scheme originates in a reinterpretation of the balloon-frame. Its departing hypothesis postulated that its design and construction in wood allowed for an intuitive and quasi-immediate interaction with it. Moreover, we hypothesized that these characteristics set up the grounds for the development of a truly collective project built upon genuine collaboration, enabling us also to lead a translation of digital modes of thought into actual space manufacturing (Fig. 4).

Height, width and length are equally of 11 m. Six vertical frames, two delimiting opposite sides and four inside perpendicularly oriented, delineate one-metre-squares, themselves composed of upright members also regularly placed every 70 cm. Two horizontal frames offered intermediary levels at 4 and 6 m off the ground. The general form emerges from the use and assembly of linear wood pieces, which are right-angled and parallelepipedic. The repetition of these constructive elements outlines a

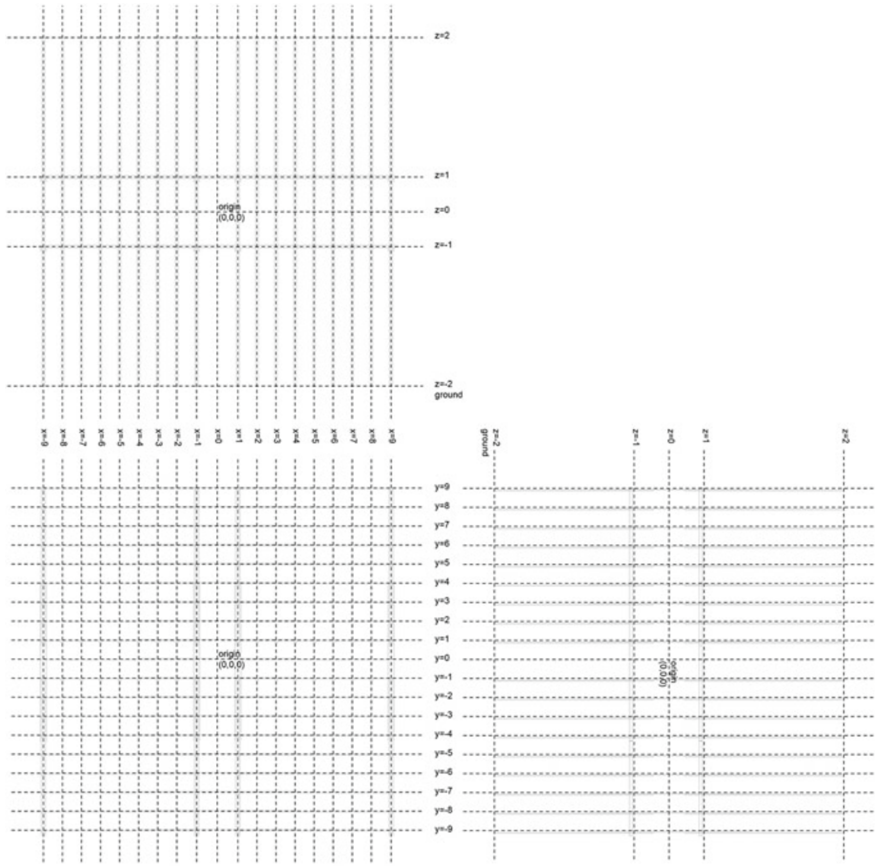

Fig. 3 HOUSE 1, plan and elevation of the protostructure with a numeral reference system (X; Y; Z) CAD drawing. © ALICE EPFL

network of supports in several directions. Assembly nodes locate precise reference points, also composing a self-positioning system in three-dimensional space.

The CNRTL (*Centre National de Ressources Textuelles et Lexicales*) defines Cartesian space as an 'axial system permitting the location of every point in a plane using a pair of two numbers called Cartesian coordinates'. In this sense, the *protostructure* can easily be translated in the Cartesian system: every node is a point, every wood pieces a line, every frame a plane. Each row can be located relatively to the whole, and qualified by its direction. Thereafter, we can notice that most of digital representations of architectural space are using exactly the same system; a point is defined by three reference vectors.

The *protostructure* offers a physical support for intervention but also a system of reference points, which favours comprehension and reading of space. In using similar codes in a full-scale construction, HOUSE 1 provides some landmarks when

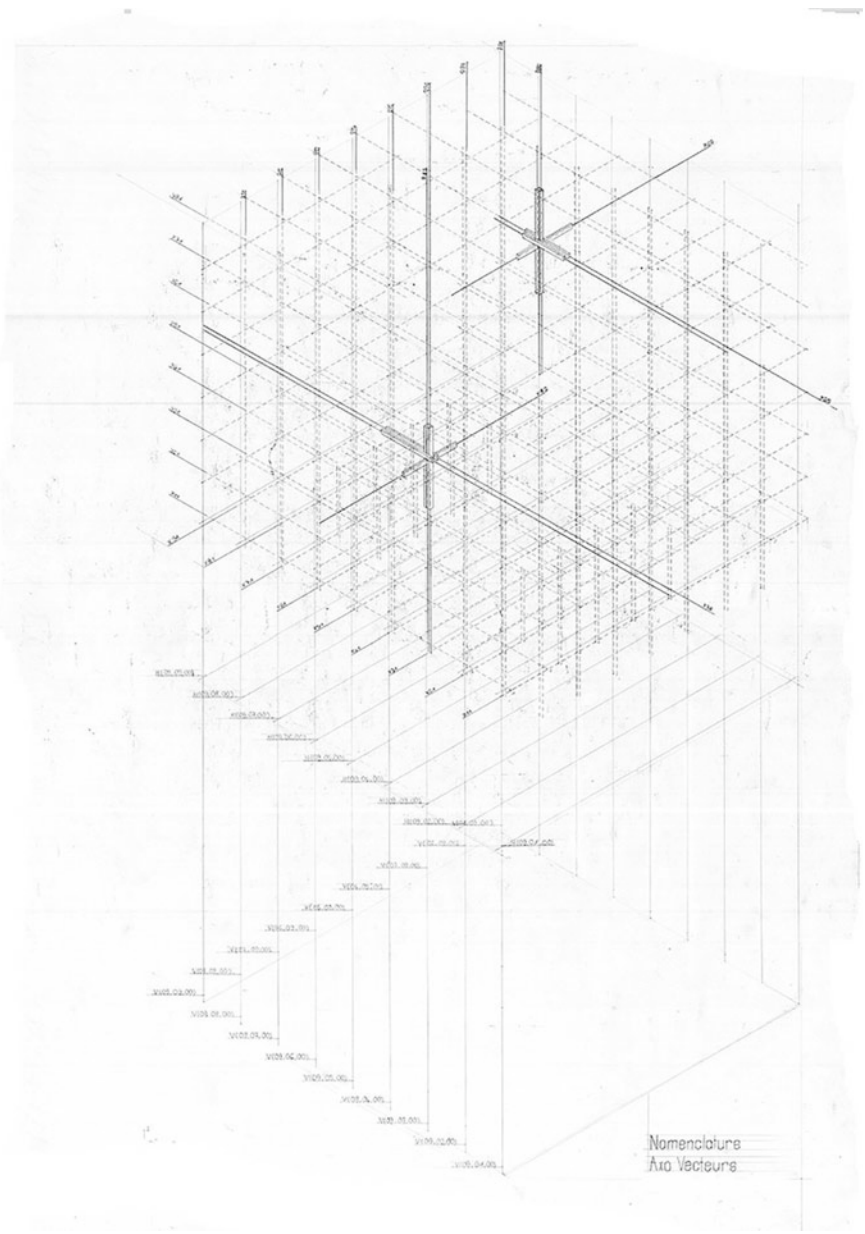

Fig. 4 Axonometric view of the two wood assembly, located using vectors in the tridimensional grid of the protostructure. Pencil drawing on paper. © ALICE EPFL

building and utilizing it. A particular focus has been made on the notion of assembly; the smallest unit of the *protostructure*'s genetic code enables to understand the whole building, as much as all the merging complex creation. The small cross-section of the American *balloon-frame* capacitates students to manipulate it easily, without any need for particular knowledge or physical ability. In this particular case, only two types of assembling were used: first, surface against surface, realized by pre-drilling and mounting nuts; second, between a surface and the largest side of the timber, realized in situ by using screws (Fig. 5)

Those two simple actions of screwing or tying up do not require particular knowledge or skills. Thus, the manufacturing can be decomposed in terms of time (prefabrication) and workforce (shared between a large number of students).

Every kind of intervention on the *protostructure*, every kind of *appropriation* through individual or collective projection can be translated to the assembly through a value of 0 (Nuts) or 1 (Screws). The coupling of coordinates, length and assembly types, are the kinds of information that allow the construction of the building. Thereafter, it is reasonable to imagine that we can translate the HOUSE 1 project into a series of codes that contain the students' interactions.

The imageability of the *protostructure*, the three-dimensional orienting reference system, the common language of assembling and mounting, its simple manufacture, and the constitution of a database gathered, facilitates the translation from one space to the other. The *protostructure*, as the conceptual, material and digital structure of HOUSE 1, incarnates the interdependence of detail and whole, additionally allowing individuals to identify the means and the function of their action at both individual and collective level.

The first part was angled on the frame offered by the *protostructure* as a support and a mediation device between spaces, to its constructive and qualitative characteristics. As we shortly introduced it, the *protostructure* aims to favour agency and empowerment, for students to be considered as active agents in their learning process. In order to proceed with an analysis of this experience, we will focus on the designing process in the studio throughout the academic year.

3 HOUSE 1 *Protostructure* (2), a Tool for Enhancing Cognition, Imagination and Collaboration

A second relevant aspect of the *protostructure* consists in its role as a cognitive aid. Spatial cognition in humans and other animals is a multimodal process taking advantage of several aspects, among which, how the embodied space of the body mediates in the cognition of its location in relation to an external physical environment (Tversky 2009). Cognitive aids, in particular internal and external representations play a non-trivial role in allowing for good and precise orientation and navigation in space (Portugali 2005), through fixing and offloading cognitive information. The method of working with the concept/tool of *protostructure* for HOUSE 1 was deliberately designed to take advantage and explore the role such a tool could play in enhancing individual and collective spatial cognitive capacities. Cognitive aids are

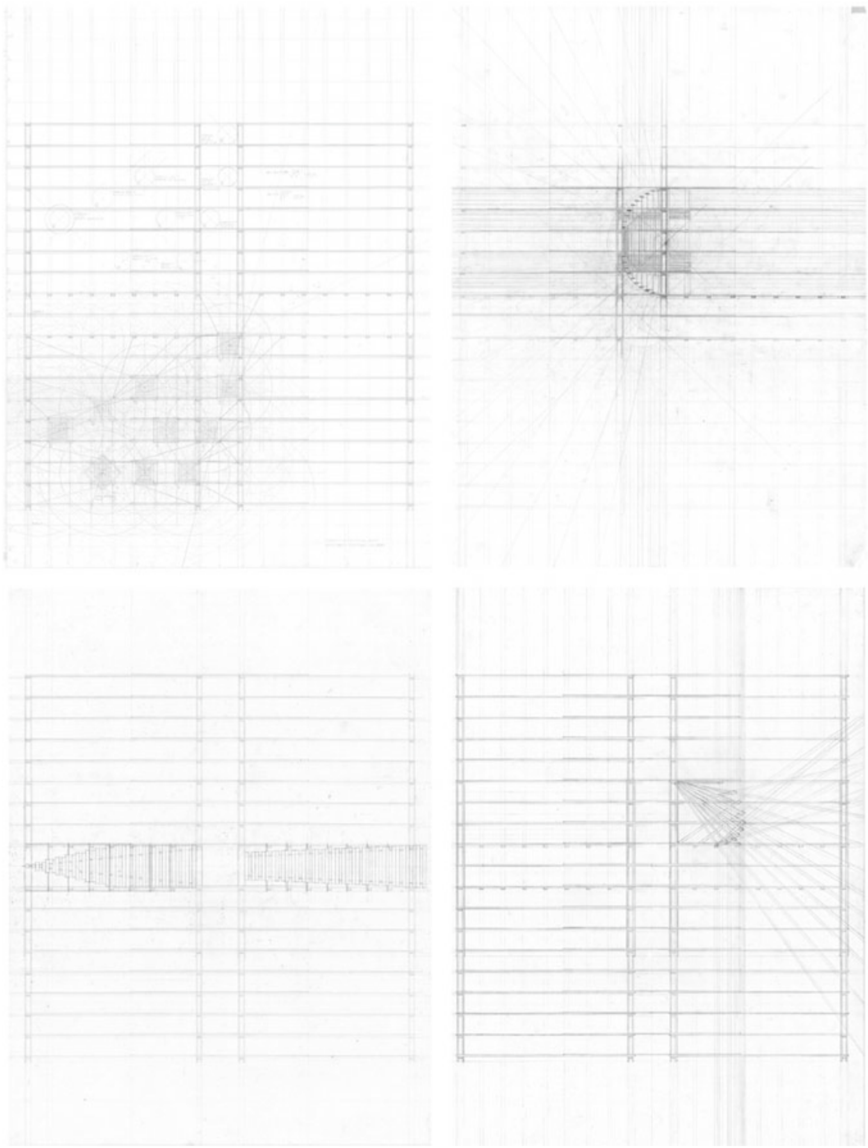

Fig. 5 Four selected student proposals for interventions located in the protostructure. Pencil drawing on paper. © ALICE EPFL

of accrued importance in dealing with particularly complex and detailed cognitive and sensorimotor tasks, and especially so in collective settings where there is a need to develop precise and concise sets of signs and codes to mediate such interaction. Moreover, it has been noted that, in human cognition, spatial relations are typically qualitative, approximate, categorical, or topological rather than metric or analogue (Tversky 1993). Usually, this results in imprecisely held conceptions of space, which are non-reconcilable with physical three-dimensional space.[7] The *protostructure*, as proposed in the HOUSE 1 project, attempts to facilitate an incremental and iterative development of spatial cognitive capacities in students and participants through its direct appeal to what is, at once, a conceptual and material three-dimensional grid of reference. Moreover, the chosen scale and material—wood—have an impact on the capacity to interact with this emergent and iterative *protostructure* as an external spatial representation, by involving the body and its senses into the venture. "The space around the body, that is, the space immediately surrounding us, the space that functions for direct perception and potential action, is conceptualized in three dimensions constructed out of the axes of the body or the world" (Tversky and Hard 2009). By developing the *protostructure* as an immersive interface, a particular feature is attempted: the embodied dimension of spatial cognition extends from the body into its immediate surroundings, which is graspable and apprehendable thanks to its simple yet generative orthogonal coordinate system, and through the use of discretized structural wooden members. An additional relevant feature of HOUSE 1, is its materialization of both a three-dimensional orienting reference system and of students' projects, which behave as salient features, allowing for a very precise spatial orientation that profits from both features.[8]

This role of the *protostructure* as a cognitive aid through its role of external representation is well captured by the concept of scaffolding,[9] which proposes that human cognitive capacities both depend on and have been transformed by environmental resources.

The interaction between the material and conceptual dimensions of the *protostructure*, moreover, speaks of our capacity to imagine and manipulate spatial organizational structure as a particular 'cognitive interface' that mediates between abstract or non-perceptual knowledge and the 'real world' (Freksa 1991). In the case of HOUSE 1, students showed the ability to "use" and practice space as grounds for the translation of different sets of concepts, relations and assemblages. In this way, students learnt to grasp certain more abstract and complex concepts and categories by understanding them in terms of spatiality.[10]

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[7]Like the cases where individuals' mental maps of locations wrongly capture distance and arrangement of objects due to biases, preferences or relative importance.

[8]This complementarity poises HOUSE 1 as a rich laboratory where to test postulates from both cognitive maps theories (originating in the work of Tolman from 1948) and shape-parameter theories of spatial navigation (ref). The discussion about these revolve around the question of whether an "initial sense of place and direction arises from the overall geometry of the framework or from the perception of distinctive landmarks within that framework" (Gallistel 2017).

[9]This idea, originally present in the work of Vygotsky on the Zone of Proximal Development, has been later further developed by Clark (1997) and Sterelny (2013, 2010). These theories clearly imply a non-internalist and non-nativist view on human cognition and agency.

[10]The thesis of Freksa (1991) states that "rather than generalizing by forming a common abstraction for various domains we generalize by forming suitable analogies to a well-understood concrete domain". This presupposes this ability as the more common capacity of human cognition, against

4 Digital Analogies: (1) Database Approach of Education in Architectural Design

Before any full-scale construction, the *protostructure* is introduced to students as a problematic space to interact with, through the use of a set of tools. From the first exercise to the HOUSE 1 manufacturing, the conscious limitation in terms of materials, in correlation with the plethora of students' experimentation, lead us to consider the amount of individual solutions, inventions, and interventions as a *database*. We consider the term database in its broader sense: a set of related data and the way it is organized. Through this analogy, we are able to afford the complexity of a project involved with 300 designers (classification method, queries, entry, hypertexts…).

In order to conceive their projects, students were invited to use two different cross-sections; the first is the 10 × 3 cm section of the *protostructure*, the other is 2 × 5 cm width and length. In a first phase, students are asked to intervene separately—without any need to locate their project in comparison to others, they just had to locate themselves in the *protostructure*. This exercise resulted in more than 100 different proposals of similar scales, with the same material and in the same context (Figs. 6 and 7).

Students are also asked to produce a set of drawings and a model of the *protostructure* in order to include it in their projects. A plan, an elevation per student, and one 1/10 model per studio constitute the standard basis fostering critical capacities and spatial analysis skills. Therefore, students rapidly become experts in extracting information from those drawings, as well as dexterous in re-constructing and enacting conceptually, digitally or materially to proposition or intervention.

Architectural design exercises have neither right nor false answers, as proposals that followed the protocol constitute in themselves a coherent entity, and provide many possible answers to the same input. Since the *protostructure* is designed by the repetition of a common detail, we can thereafter classify and analyse locations in the reference system as reactions to the basic assembling and behaviours in the *protostructure*. In this manner, a homogenous breadth of *dispositifs* stems from the narrow range of the cross-sections. First, the standardization of the modality of drawing the project; secondly, the defined set of tools facilitates the concretization of an index of possibilities; and thirdly, the sharing and access to all this data. As a result, not only are projects easily identifiable and readable as the nature of intervention is the same—by nature, we mean method and goals—but also students become well aware of the languages they used.

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the commonly held belief among design professionals that this transformation or translation of complex abstract thoughts into space is one of the key abilities in design and architecture, acquired through practice and education.

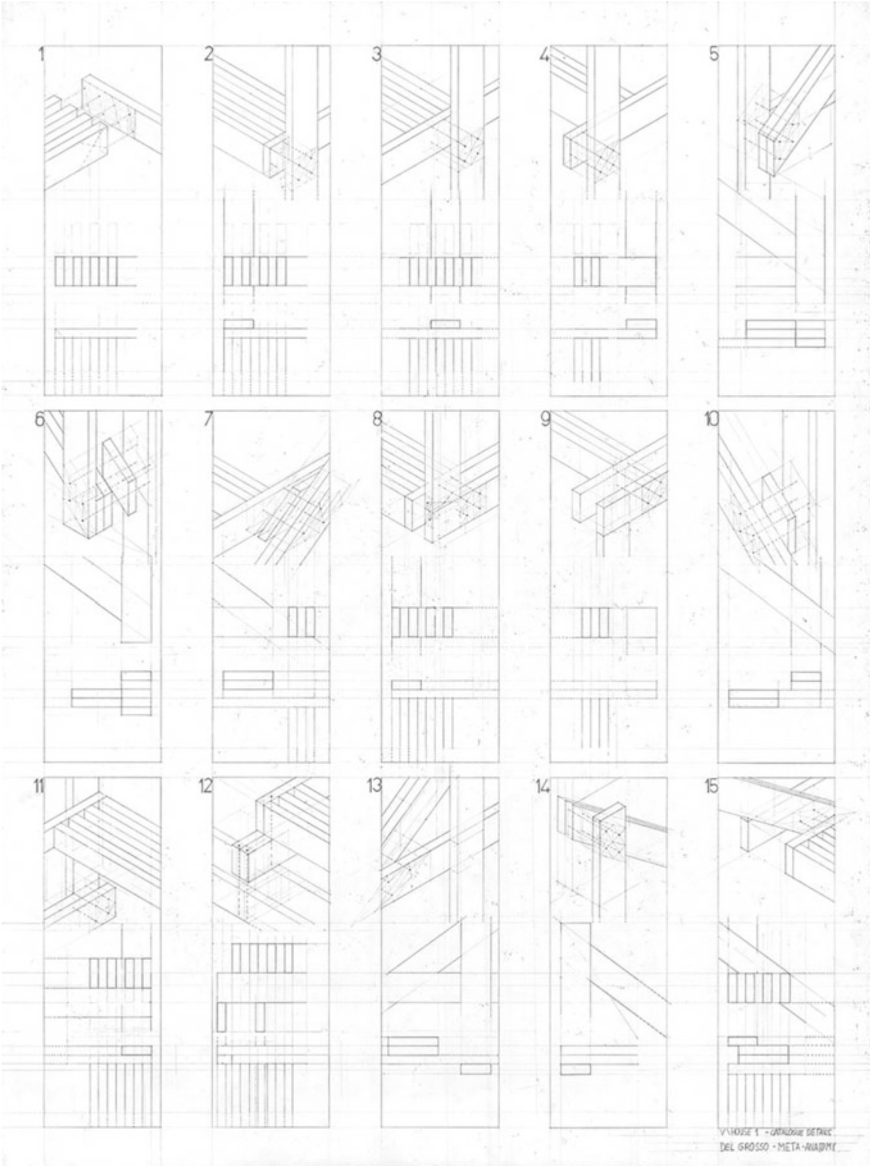

Fig. 6 Series of 15 variations with the wood pieces assembled with screws. Pencil drawing on paper. © ALICE EPFL

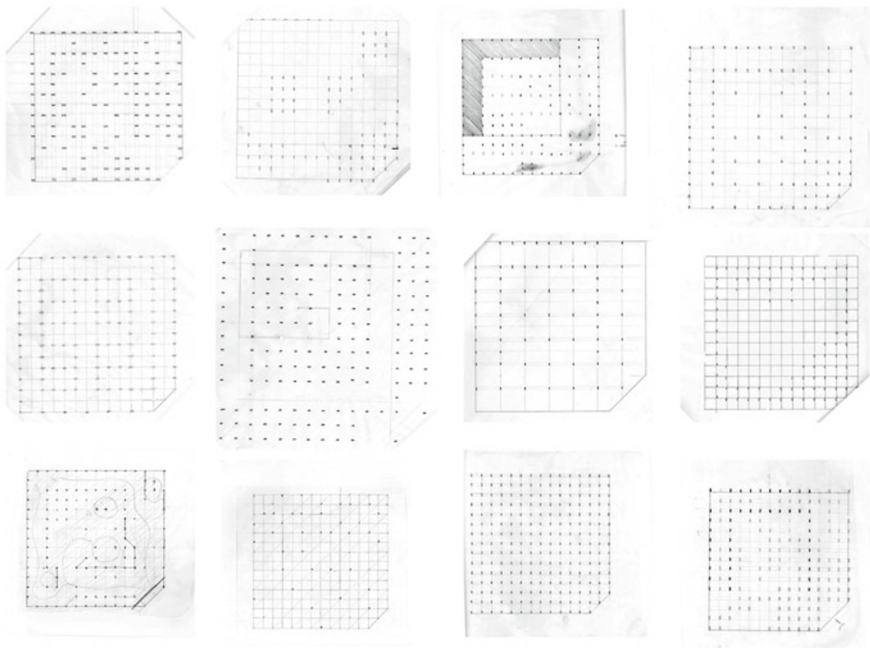

Fig. 7 12 Composition research drawings. Pencil drawing on paper. © ALICE EPFL

5 Digital Analogies: (2) an Open Source Architectural Design

Subsequently, 12 projects are selected from the database in order to be developed, designed and constructed by each studio in the full scale house. The graspability of wood and the design codes enable the database, to be employed as a common language favouring dialogue and exchange. This is, in fact, the basis of an Open Source (OS) system (Open knowledge International n.d.). The implications of such an approach are non-trivial, for it lays the grounds for the perfectibility of the project, allowing for its projection into an active future life. Such accessibility and perfectibility do constitute a radically different status of the project with regards to what traditionally in the world of architecture have constituted fixed and immobile built works. Thanks to the versatility and malleability of wood as a construction material, the project acquires a different status between the mental model, graspable through a quick induction of its structuring rules, and the built yet dynamic dimension. The implications for participation and inclusivity are difficult to over-emphasize, as following the principles of OS systems, any user can then become a participant. In fact, this approach to architectural and urban OS systems have seen a fertile scene of proposals, debate and experimentation in the last years (see for instance Ratti and Claudel 2015). From the privileged position of a hybrid setting combining the

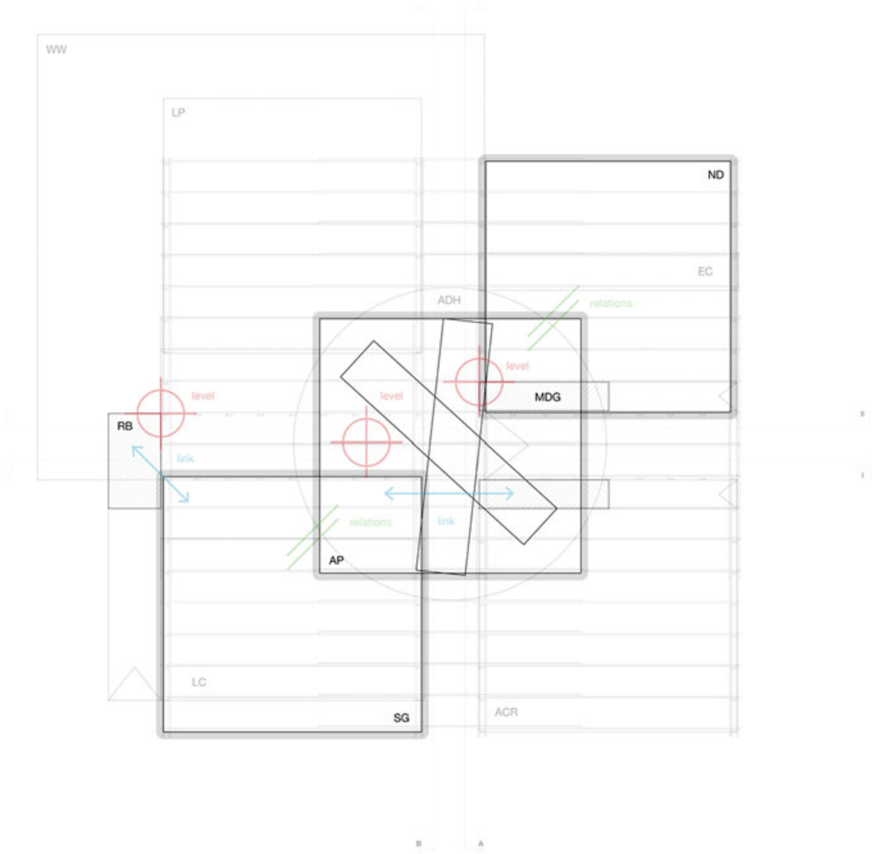

Fig. 8 Plan of the location of the 12 interventions within the protostructure of HOUSE 1, identifying «zones of tension». CAD drawing. © ALICE EPFL

academic framework and individual agency, it is interesting to note how this specific pedagogical and projective experience combines exposure to the reality of the physical dimension of its construction and location, with the social aspect of participation, empowerment and negotiation (Figs. 8 and 9).

The OS model of knowledge-sharing favours a horizontal hierarchy even in the case of a considerable amount of people. Likewise, the multilayered human organization encourage a re-appropriation of the conceptual material provided through different level of proximity. Indeed, the studio director is the referee of the official academic program that introduces fixed output and tools, but requires individual interpretation of the path. Student assistants (year four and five) lend levels of meaning of the tasks to students, as well as airbornes (year two), encouraging student-to-student learning. The same conceptual aids and program are described and handled through several lenses, which encourage an active position facing the exercise; an

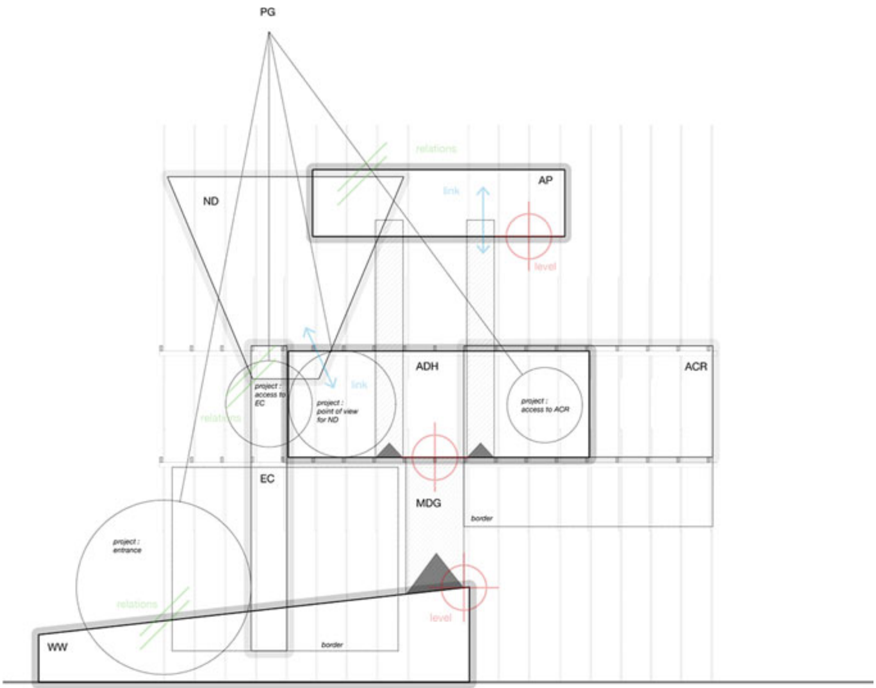

Fig. 9 Diagrammatic section of the location of the 12 interventions within the protostructure of HOUSE 1, identifying «zones of tension». CAD drawing. © ALICE EPFL

intentional gradient of vagueness or ambiguity puts the objectives into perspective. For instance, the concept of *protostructure* is a strong input by ALICE researchers. After having been theorized by the lab, each agent transcribed the notion according to her/his role; students addressed the input by producing their own definition, contributing to a plurivocal theoretical production. Looking at their publication ALICE Blog, we noticed a strong appropriation of the terms. Resources—conceptual and material—become available thanks to the concourse of plural actors, both in terms of individuals and meanings.

The database is composed of a set of individual and collective answers to the exercise, as well as of conceptual and material inputs which are thus shared as an OS system, but tries to encourage an individualized navigation system. The data is either graspable or re-organizable, always in the process of transformation; this *in-between* data and navigation system aims to set up a space for the inscribing on the self into a collective experience, as a system of footnotes or reading notes in the global experimentation. Through these uses, we claim that a database can be said to be OS only if the navigation system enables individuals to appropriate the whole, by inventing new meanings, and by mounting and dismounting new boards, leading to a perception of the self.

6 Analogic Digitals: Towards Empowerment in Open Source Systems

> Knowledge is open if anyone is free to access, use, modify, and share it — subject, at most, to measures that preserve provenance and openness. (Openknowledge)

In open movements, open is equivalent to free; open source software (OSS), free software… With reference to the definition of the OS, which it is derived from, the formulation 'makes precise the meaning of 'open' with respect to knowledge, promoting a robust *commons* in which anyone may participate, and interoperability is maximized' (Open knowledge International n.d.). Kelty sustains that the values of OSS 'reach directly into the heart of the legitimacy, certainty, reliability and especially the finality and temporality of the knowledge and infrastructures we collectively create' (Kelty 2008: 6–7). New overlooks on the relationships between data, empowerment and agency, raised from social analysis of such movements (Couldry and Powell 2014; Baack 2015). This organization model can be applied in other domains (Demil and Lecocq 2006; Matei and Irimia 2014; Weber 2005) and tend to favour empowerment. Nevertheless, apart from the potential criticism of reticular forms of control (Stiegler 2008) derived from Foucauldian methods of analysis that can be associated with Big Data, OSS projects unveil empowerment problematics through the lens of usability (Rajanen and Iivari 2015). Thanks to the physical experimentation of OS organization in collective architectural design, we can propose a new insight on the potential shortcoming articulated on the notion of participatory and egalitarian settings through open code, enhanced by graspability of the tools. An inverted analogy from HOUSE 1 to digital mode of thought allows us to investigate where personalization ends and empowerment starts.

As we briefly introduced, we argue that opening the code may not be sufficient; the conflict between the free software movement and the open source can shed light on specific aspects. Stallman stated that 'The two terms describe almost the same category of software, but they stand for views based on fundamentally different values. Open source is a development methodology; free software is a social movement. For the free software movement, free software is an ethical imperative, essential respect for the users' freedom' (Stallman 2007).

To summarize, the different settings to favour empowerment of the *protostructure* are the following:

- High usability of the reference system through a Cartesian model with high imageability and interdependent framework through repetitive operations.
- Simple manufacturing of the wooden structure, demanding no particular knowledge or physical capacities providing high agency of participants, and narrow range of assembling, easing the reading of the whole.
- Common representation tools—plan, elevation, model—at the same scale, enabling a comparable data input and graspability of conceptual input through multiple proximities of levels of interlocutors, and clear outputs; Individualized reading/navigation system into the database of previous experimentations.

– Tool to enhance cognition, imagination and collaboration, through the appeal to both embodied and extended dimensions. This facilitates a direct and fluid feedback between internalized and external spatial representations, where collaboration is key to accomplish shared knowledge.

Not all of these allow to draw an analogy with OSS or FreeS. Nevertheless, both need social interaction—birth of an ethical group—and openness of the code, plus high agencies are central in the HOUSE 1 project. We contend that the *protostructure* is a development methodology, but above all an operating system for learning processes through student-to-student and social interactions.

Rajanen and Iivari (2015) pointed out the lack of research addressing the 'important issues as regards power and politics in OSS'. At the opposite of empowerment resides Alienation. In the book "On the mode of existence of the technical object", the French philosopher Gilbert Simondon is giving an interesting definition of 'Alienation'. He proposes a system of analysis consisting of three concepts, 'Element/Individual/Set', to understand genesis, evolution and transformation of technical objects. In the words of Jean-Hugues Barthélémy, 'the levels of analysis in MEOT are classic, as the element composes the individual, and the individuals compose the set' (Barthélémy and Boever 2012: 210). Elements exist in two types, the tool and the instrument. Both participate in the problem resolution of the individual/technical individual and compose it. By using this system, Simondon is able to formulate the ground of an industrial 'psycho-physiological alienation'. At the level of technical individuals, beings are able to perceive through instruments and to act through tools. According to Simondon an important shift happens when uses of technical individuals become industrial. He suggests that the industrial use of the machine is destroying the system of 'coupling between the inventive and organizing capacity of plural subjects' (Simondon 1958: 342). Indeed, the role of the worker changed: tool holders became an auxiliary of the machine, descending from the level of the individual to that of the element. It is the contention of Simondon that replacing humans with machines at the rank of the individual, is the cause of a psycho-physiological alienation as much as the Marxist socio-economical one. Yet, 'today, technicity has a tendency to reside in sets' (Simondon 1958: 16). OS and FS movements are perfectly illustrating this shift into modes of invention in technical culture; empowerment is now processing at the level of sets.

Students are thus provided with tools to act first on the element level through wood construction, thereafter on an individual level with architectural and spatial invention, and finally on the set using diagonal and individualized reading of the conceived database. With this, we aimed to go further with an open code of the *protostructure* in order to engage students in concretizing invention at each level of the 'technical object'. With the objective of setting up a collaborative project, H1 does not simply provide material support in the form of a wooden structure, but frames the capacities of the material within a specific and overall logic of an open system. Thus, a set of rigorous rules constitutes, beyond simple constraints to the project, a generative playing field for the emergence of a community of participants and actors around the enactment of a common objective and the resulting shared knowledge. The very provision of these sets of generative rules and their materialization into a physical support provide for the spatial conditions of a network. This, in turn, allows for a number of possible combinations already contained in potential. This "virtuality" is, thanks to the simplicity of the setup, the versatility and ease of transformation of the material, which permits students to re-act at each level of the technical object, inventing and imagining new solutions.

Finally, *protostructure* as both a concept and an operational setting between the virtual and the actualized, the digital and the physically built, articulates space as a radically different category. Beyond hegemonic stances that tend to consider space as an extant object, *protostructure* poses an agential turn, proposing to consider space as a capacity (Jiménez 2003; Negueruela Del Castillo 2015) (Fig. 10).

7 Epilogue: HOUSE 1 in Versailles (500–1000 Words)

At the same time as the HOUSE 1 project was launched at EPFL, first meetings took place between ALICE EPFL and the Ecole Nationale Supérieure d'architecture of Versailles in late 2015. A collaboration was launched between the schools with Edouard Cabey, studio director with ALICE EPFL, and Cédric Libert, professor at Versailles School of Architecture. The idea was to expand the experience of collaborative work across schools and to observe how what we described above as a genetic code would lead to further projects and configurations in terms of project-outcome, and on spatial and social levels. The project was scheduled to take place in parallel in terms of phases of first encounters between students and exchange during critiques, and in sequence in terms of construction, in order to allow for HOUSE 1 to be disassembled on the EPFL-campus site and the *protostructure* to be relocated and reassembled in Versailles. Also, certain elements of some projects were incorporated in the following process leading to the HOUSE 1–12 CITIES project that occupied one of the courtyards of the Versailles School of Architecture between September 2016 and January 2019. The collaboration dispensed a course about the 12 imaginary cities by Superstudio.[11] During the summer, a collaboration between Versailles and the HOUSE 1's students took place, with the aim to propose 12 more interventions in the same *protostructure*, following the course "Twelve Cautionary Tales…". The new *protostructure* design consisted of a reconfiguration of the HOUSE 1 *protostructure* elements from a cubic disposition to a more linear arrangement, with two halves of the square plan folded up. Thus, the rhythm of the elements and vertical proportions were similar to HOUSE 1 at EFPL, while the overall spatial articulation changed. In a first step, a limited number of EPFL students came to mount the *protostructure* and explained the coding system (reference, assembling, conceptual approach, etc.); thereafter, the 12 interventions were conceived. Participants from Versailles visited the former *protostructure*, but did not assist to the elaboration and

[11] Twelve Cautionary Tales for Christmas, (12 Ideal Cities), (Superstudio, 1971).

Fig. 10 HOUSE 1–12 cities, second phase of HOUSE 1 experimentation, at the Ecole Nationale Supérieure de Versailles. © Agathe Mignon, ALICE EPFL

construction; EPFL's students were relied upon as carriers of knowledge from their past experience, and were key in bounding both instances.

Beyond the creative support that the *protostructure* has provided twice, HOUSE 1–12 CITIES at Versailles enhanced students' capacity to use a genetic code; as ideally is the case in an Open Source System. They took over the hardware and rearranged the cartesian reference system in order to foster new interactions. In fact, the empowerment process we tried to put in place went further than we expected. Not only did students co-design a database and a navigation system of high-usability, they were also able to directly conceive and manufacture spaces of the *protostructure* at each of Simondon's levels, from the element, throughout the individual space, to the global set. Handling structural balloon-frame elements, they (h)ac(k)ted the learning process, sharing a collective spatial knowledge through agencies of wood design. In this sense, the choice of wood for designing and as a construction material, allowed participants to intuitively understand the role of details in a complex construction, as well as to emphasize the importance of a common language in realizing a collaborative project.

In the context of this article, we would like to stress the aspect that the concept of *protostructure*, including its conceptual and physical dimensions, and its accompanying spatio-temporal timeline making it operational, bear further implications in terms of access to tools and integration of synthetic processes. As in any discipline, architecture employs a long series of tools. Many of those pertain to the realm of simulation (Cross 2001). We have seen that the *protostructure* federated a smooth integration of nearly any tool involved in the process. From sketch to hand drawing, from construction drawings to models at any scales to mock-ups in 1:1, from pencil to Japanese saw to computer aided design. Importantly, diverse 3d-software became an integrated part of the process, naturally adopted by students in learning from one another without any frontal teaching involved. In the final HOUSE 1 configuration, room-projects entirely developed by hand-crafts were realized next to projects scripted via parametric design software. The integration was particularly smooth as all actors would refer to the tools at hands and most appropriate for a given process, almost always combining an array of them to get to the projected aims. The same can be said of the blog, which was, as mentioned, an important element in providing access to information in this Open Source system. The blog would contain any information from text to scanned drawings, to vectorized data-files, to photos, all arranged in chronological order and edited by the students themselves. In fact, through the rigorous structure of the concept of *protostructure* both in time and in space, the strengths of computational thinking and iterative processes can be observed as a natural behaviour and outcome in the context of complex design processes involving many actors.

Finally, this framework for collaborative design and construction bears consequences for the development of shared spatial knowledge, further reaching into questions of identity formation. Through interaction with the haptic and conceptual dimension of the *protostructure,* students develop their own nuanced and intentional stance with regards to what it means to deploy and invest space. This transformative *mise-en-espace* partakes of a genuine collaborative effort, forging this dimension into the very definition of what new digital wooden design and architecture are capable of.

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