Embracing a Material Turn in Software Embedded Design

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Architects are increasingly bundling digital components together with physical assemblies in their pursuit of responsive (or sentient, adaptive, interactive) architecture where hardware and software work together with physical assemblies to mediate the physical environment in real time. Given that 1) architects are responsible for creating built environments capable of enhancing certain values while downplaying or rejecting others and 2) digital components, such as software and data, have direct spatial, social and cultural agency; this practice, labelled here as software-embedded design (SED), calls for a new set of methods for understanding and supporting architects' engagement with their projects' computational elements, their soft materials. This paper advances efforts to build this critical computational literacy for SED designers by introducing and testing an analytical framework which offers a new lens through which to consider the digital components used in SED projects. As soft materials become part of an architect's toolkit, it is imperative that the values and objectives embedded in computational components of a project and the critical practice around their use match those projected and exhibited towards its physical elements.

The paper is organized in two parts to expand the lenses through which designers engage SED by foregrounding the complex interplay between materials, computational elements and real-world outcomes. The first part of the paper elaborates on how a materialist account of digital technology establishes new obligations by recognizing that managing computational elements' roles in shaping projects' (material, spatial, social and ethical) outcomes falls into the domain of the designer. The second part proposes the Project Anatomy analytical framework designed to simultaneously examine a project's soft and hard materials in order to better grasp the relationship between computational components, physical materials and real-world outcomes. A reflection on the tool foregrounds the unique position of SED designers, through their evolving expertise in both soft and hard materials, to find new purchase on materially-oriented, socially-minded engagements with the computational components increasingly proliferating in our built environment.

INTRODUCTION

This paper presents work aimed at expanding the lenses through which designers engage software-embedded design projects in order to foreground the complex interplay between materials, computational elements and real-world outcomes. Architects are increasingly bundling digital components, such as software and data, together with physical assemblies in their pursuit of responsive architecture where hardware and software work together with physical assemblies to mediate the physical environment in real time. These hybrid projects increase the number and extent of links between computational components, material elements and project outcome thereby adding complexity to how we asses project elements' respective roles in supporting, or even counteracting, project values and outcomes. Understanding and managing these entanglements becomes more relevant as we grow to understand embedded digital components as playing a major role in shaping the spatial, social and cultural outcomes in such work.

In addition to elaborating on software-embedded design, the first part of the paper explores how a material-turn in our understanding of digital media points to new obligations for SED designers. Building on materially-oriented writing from scholars in media studies and information science, we reconceptualize embedded computational elements, by resisting their perceived immateriality, as materials in and of themselves. As such, these code/data bundles, or *soft materials*, are not decoupled from a project's physical dimension and instead are seen as constituting key elements of a projects material assembly. We argue that this reconceptualization brings computational elements back into the domain of the designer and that this in turn requires new forms of computational literacy to better situate and manage computational components in their capacity to directly impact project outcomes. In response, the second part of the paper presents the Project Anatomy framework to dissect SED projects in order to better grasp the complex entanglements between participants, actions and material components. By analyzing a collection of SED projects, the framework is tested for its capacity to draw out new understandings of the

Figure 1. Software Embedded Design. [left] Amphipious Architecture [The Living, xClinic, Natalie Jeremijenko, and Chris Woebken]. Image Credit: Chris Woebken. [right] Murmur Wall, San Francisco, CA [FUTUREFORMS, 2015]. Image Credit: FUTUREFORMS.

relationship between a project's material composition and its real-world outcomes.

PART 1: HOW A MATERIAL-TURN IN OUR RELATIONSHIP TO DIGITAL MEDIA POINTS TO NEW OBLIGATIONS FOR SOFTWARE EMBEDDED DESIGN

This paper focuses on a growing praxis, labelled here as software-embedded design (SED), in which architects are increasingly bundling digital components together with physical assemblies in their pursuit of responsive (or sentient, adaptive, interactive) architecture where hardware and software work together with physical assemblies to mediate the physical environment in real time. SED projects are wide-ranging and engage a variety of opportunities found in things like immersive experiences, participatory platforms and responsive architectures.

These works vary in scale, complexity and motivations as exhibited by the following examples (Figure 1): *Amphibious Architecture* by the Living Architectural Lab and collaborators[1] presents a water-based network of sensors and light beacons designed to support collective interests in the environment by celebrating and promoting data-collection by way of an eye-catching dynamic light display installed in New York City's East and Bronx rivers. FUTUREFORMS' *Murmur Wall* visualizes data streams, harvested from online activity, moving through a weave of steel and acrylic tubing in pursuit of an "artificially intelligent, anticipatory architecture that reveals what the city is whispering, thinking and feeling"[2]. A third project, *Latent (e) Scapes*, Christina Leigh Geros, SHO Architects and ULR Studio, is an interactive installation that registers human impact through a garden of synthetic, grass-like, kinetic elements. The project works to draw attention to the symbiotic relationship between the natural and the synthetic.[3]

In each case, physical and virtual worlds are connected and new forms of civic engagement are made possible. The strength of these projects lies in their fostering of a symbiotic relationship between physical and virtual realms where designers explicitly engage stakeholders, situated physical contexts and related sociocultural or sociopolitical conditions to conceive and develop citizen-oriented, context-specific works. Through projects like these, architects actively explore the potential relationships, afforded by new computational capacities, between material, form, data, algorithms and their joint capacity to organize and mediate the built environment[4].

Importantly, SED differentiates itself from other digital design practices by moving computational elements out of the studio environment and into the real-world by embedding them as active elements in digitally-driven architecture[5]. In essence, SED work transforms computational components from studio instruments (often used in design development phases to refine geometry and optimize fabrication) with limited impacts once the project leaves the studio into persistent and active agents charged with continuous mediation of a project's functioning in time and space.

What does the persistent agency mean for architect's relationship with the embedded computational components in SED work? For one, SED's computational elements function less like design tools, used in project conceptualization and development, but more like materials directly shaping a project's ongoing impacts, experience, performance and other outcomes through their selection, implementation and deployment. As a result, we argue, that the SED elements such as data, algorithms and code implementations, should not be decoupled, through their perceived immateriality, from a project's physical dimension and instead be thought as *soft materials*, materials in and of themselves, and thus explicitly constituting part of the project's material assembly.

MATERIALIST ACCOUNTS

An overview of two recent materially-oriented perspectives of digital media - each accounting for the need to resist dematerialized readings of digital technologies and instead engage them

Figure 2. Pam McConnel Aquatic Centre. MJMA Architects. Image Credit: Shai Gil

in terms of their materialities – reinforces the ideas behind the soft material reconceptualization.

Paul Dourish diversifies the layers used to analyse digital systems in terms of their materialities in his most recent book *Stuff of Bits: An Essay on the Materialities of Information*[6]. He notes that while many accounts of our information society are thought of in terms of their dematerialized nature, the encounters with this underpinning information is always encountered in material form.[7] He focuses on *materialities of information representation* through which he explores how the specific information systems have implications in terms of how/where it is stored/ how it can be moved / who, where, when, how its accessed. For Dourish, "Materialities of information are properties of representation and formats that constrain, enable, limit, and shape the ways in which those representations can be created, transmitted, stored, manipulated and put to use -- properties like robustness, consistency, compressibility, malleability."[8] Using case studies, ranging from how a spreadsheet predetermines the way a problem is approached and solved to the difficulties of basic arithmetic if numbers were represented as roman numerals, the book exposes materialities of information, which are often hidden from clear view. EssentiallyDourish asks us to expand our conception of digital media into assemblages of hardware, software, data representations, project, spatial practices, computer languages and other related elements.

Yanni Alexander Loukissas isolates data as a subject in his recent book, *All Data Are Local: Thinking Critically in a Data-Driven Society*[9]. He leads by reminding us that data are cultural artefacts affected by numerous factors: the people that create them, the time and place they are created, the audience for which they are created and the instruments and machines used to create and consume them. Loukissas foregrounds data's locality, emphasizing the data-setting over data-set and illustrates these relationships by way of thorough case studies. For one, he describes the complex history of the Boston's Arnold Arboretum's practice in maintaining accession data to illustrate that data have complex attachments to place which invariably structure their form and interpretation. Demonstrating that data shapes place and vice-versa, Loukissas offers an account of how two thousand hemlock trees, planted as untracked filler trees in the 1970s inadvertently became part of the arboretum's archive when they became infested, in 1997, by a pest and required treatment. To support treatment the trees were labelled, mapped and assessed and officially added as specimens, seventeen years after they started occupying the grounds. From a data perspective, the arboretum's collection had its largest expansion in its history that year, from a local perspective the arboretum didn't change at all. For Loukissas, placing data in a context is operational (and not neutral) as it engages particular knowledge systems predefined by a combination of practices, processes, concepts and affordances.[10] Loukissas expresses the need for new models for local practice with data as a way to form close relationships with not only data but also to the conditions in which those data are manifest.

These authors reconfirm the need for new types of engagements with soft materials. As producers of the material assemblages constituting their design work, SED designers need to be literate and possess agency with respect to the social, cultural and political effects across the entire assembly – and this includes not only the physical material outside the computer but the digital material inside the machine and the connection between the two.

NEW OBLIGATIONS FOR ARCHITECTS

The proposed reconceptualization of computational elements as materials situates code, data, algorithms in the architect's domain and explicitly managing their effects becomes part of the design solution; the care and consideration around material selection and impacts applies not only to the physical materials but should expand to soft materials as well. In the context of soft materials, this points to a new set of obligations for the architect.

We know that architects are responsible for creating built environments capable of enhancing certain values while downplaying or rejecting others[11]. Accessibility is one such value: while minimum expectations are required to be met in most building codes, designers, both working with SED and not, can make decisions around circulation, materiality and programmatic arrangements that enhance accessibility beyond these minimums through the pursuit of more ambitious benchmarks of inclusion versus simply accommodation.

While not engaging soft materials directly, the *Pam McConnel Aquatic Centre*[12], designed by MJMA (2012), serves as an excellent example in which the degrees of accessibility and inclusion were greatly enhanced thorough architectural decisions.(Figure 2) The facility is located in the ethnically, culturally, and economically diverse Regent Park neighbourhood in downtown Toronto which is home to many immigrants and new Canadians. MJMA enhanced accessibility and inclusivity by implementing bold moves in the facility's changing rooms and envelope. First, the change rooms throughout are universal – everyone uses a large common space to prepare for swimming relying on small cubicles to supply privacy as needed. Such universality creates a comfortable and welcoming environment for all and works to neutralize issues around gender identity. The changerooms are lined with glass walls, visually connecting them to the aquatics hall, to balance too much and too little privacy thus creating the safest situations for all swimmers – especially children. This notion of an airy pavilion-like space extends to the treatment of the building's envelope which is visually porous on ground level where a continuous window runs along the perimeter. While working well to support the sense of the center as a welcoming space, this level of transparency presents a barrier to an important group in the community – namely Muslim women – who cannot be seen swimming by men. Instead of segregating or marginalizing a small area for these women to use, MJMA chose to support the dynamic conversion of the entire facility to serve their needs through motorized blinds used to veil the aquatics hall and changerooms during women-only programming. The capacity of the architect to enhance notions of accessibility are clear; the values placed on accessibility and inclusion are amplified through numerous design decisions.

Architects are trained to exercise decisions around material performance, structural requirements, spatial and programmatic arrangement and other dimensions of a project's function in order to align them to desired outcomes. This set of concerns has been expanded in recent times to include broader issues on the project site and beyond to include ecological concerns and ethical dimensions[13]. What's less clear, is how prepared architects are to take on this set of concerns in the context of soft materials given that accepting the soft materials paradigm demands new forms of critical computational literacy[14], charged with expanding the lenses through which architects engage their projects' digital components. On one hand, soft materials need to be technically robust, ensuring that they operate safely and reliably once deployed. On the other hand, acknowledging that soft materials have spatial-material agency[15], we need to engage in their social, cultural, political and ethical impacts to the same degree we engage these issues through their physical material counterparts. How does designers' knowledge contribute to the design of a project's soft material assemblies? How do soft materials transform notions of site and stakeholders? How can architects understand their soft material assemblies in the context of overall projects outcomes and values?

PART 2 – PROJECT ANATOMY FRAMEWORK

> "Materiality," as we have shown, explains nothing unless one can show which property, elements, and mechanical aspect of the artefacts and of their making or physical manipulation can be associated with some aspect of the local social practices and imaginary world and why.
>
> —Pierre Lemonnier[16]

Responding to the perspectives of Dourish and Loukissas, and the related expansion of architects' obligations in their use of soft materials, the second part of the paper advances efforts to build critical computational literacy for SED designers by introducing and testing an analytical framework aimed at offering a new lens through which to analyze SED projects. The two stage analytical framework works to: 1) understand a projects anatomy, understood as combination of its stakeholders, operational affordances and material composition and the relationships between them and 2) reflect on the resultant project anatomy to probe project values and outcomes from socially- and ethically-minded perspectives.

PROJECT ANATOMY – PARTICIPANTS, ACTIONS AND MATERIAL MAKE-UP

The project anatomy stage of analysis is centered on a user-oriented perspective; the *Participants & Actions* section of the framework presents a stakeholder-centered view of each SED project by enumerating stakeholders for each project and a corresponding list of actions through which they can engage it. By driving the analysis through this perspective, project participants serve as the critical link between the projects' inner-workings and its broader implications. The complimentary *Material Make-Up* section, which presents a project's internal material assembly as an interrelated hybrid construction of both hard and soft materials, describes how the project's material assembly supports the identified users/stakeholder.

Participants. (Figure 3) Across the study, a varied collection of human and non-human actors have been identified and organized into five primary categories: Citizens, Community Groups, Organizations (corporate, governmental, research groups, project authors/owners), Non-Human Species, and Environment. In addition to these major categories, some stakeholder types are differentiated through a secondary set

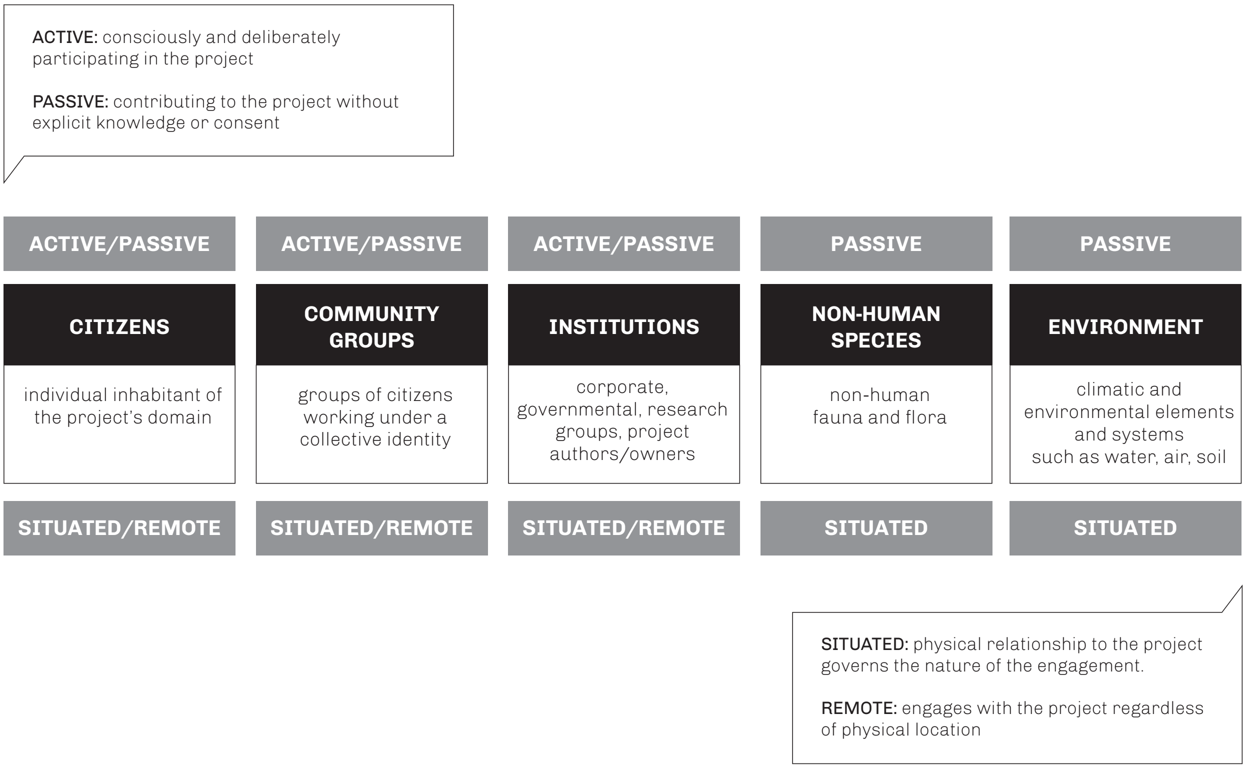

Figure 3. Participant types and attributes. The Project Anatomy Framework organizes participants into five categories and two subcategories.

of attributes: For one, the nature of the type of engagement can vary within a single stakeholder group. One such variation lies in whether the engagement is *active*, where the stakeholder is consciously and deliberately participating in the project, or *passive*, where contributions are made without deliberate engagement. In some instances, stakeholders actively opt-in to the project by registering participation by way of an interface for example. In other cases, the stakeholders are contributing to the project, by their presence being sensed for example, without explicitly making a decision to engage. Additionally, because of the hybrid physical/virtual nature of SED projects, where the opportunity to engage with the project is not limited by physical proximity, some of the user groups are further differentiated in terms of their *situatedness* where users are considered either *situated*, where their physical location/proximity to the project governs the nature of the engagement, or *remote*, where they engage with the project regardless of their physical location, usually by using some type of information communication technology.

Actions. The framework identifies nine action types available to project participants and tracks their presence in each project: Configure, Deploy, Contribute, Be Sensed, Query, Use, Collect, Experience and Learn (Figure 4). These use cases are organized along a *get/set* spectrum in order to characterize the nature of the action: At one end, *get* actions deal with use cases primarily defined by accessing or retrieving project amenities; experiencing a project's atmosphere, retrieving available datasets or, more generally, *reading* signals broadcast by the project are all considered get actions. At the other end of the spectrum, *set* use cases deal with actions where participants assign or manipulate some values or states of the project; rearranging a project's material assembly, providing new data points or information, adapting how a project collects, processes and uses data or generally *writing* to the project in some way are examples of set cases. In between the two poles there are a suite of actions that mix get and set activities in some combination; scenarios where users configure(set) the ways in which they access project data (get) via custom queries can be seen as a hybrid actions.

Material Make-Up. The material anatomy section exposes the material composition of the SED project. Materials are identified and organized into three main categories: 1) Soft Materials are computational elements embedded in the project and include things such as data streams, databases, algorithms, software implementations. 2) SED-ware are physical elements used in the project that are directly supporting the soft materials and often acting as a link between the real and virtual worlds. Examples of SED-ware include sensors, actuators, microcontrollers and conduits. 3) Hard Materials are any additional physical materials used in the project – such as Murmur Wall's steel and acrylic tubes.

Figure 4. Actions. The Project Anatomy Framework identifies 9 types of actions available to participants. Actions are organized along a get/set spectrum in order to characterize the nature of the action: Get actions deal with use cases primarily defined by accessing or retrieving project amenities while set actions see participants assign or manipulate states of the project.

Taking these three elements together, we arrive at a single diagram that captures the project's anatomy. Figure 5 presents the Project Anatomy for FUTUREFORMS' Murmur Wall. Added connections between the three component types articulate the relationships between them: links between Participants and Actions indicate which users have access to which actions, connections between Actions and Materials highlight which materials are engaged in service of particular actions, and lines between materials articulate the interconnections between elements of the projects material composition.

OUTCOMES ASSESSMENT

The second stage of the framework leverages the information from the Project Anatomy phase, into an analysis of the wide-ranging values and outcomes, both planned and unplanned, of an SED project. Responding to results from the Project Anatomy phase we have defined three interrelated dimensions through which to reflect on the implications of the resultant project anatomy visualization:

> *Equity & Access:* considers the opportunities and limits around accessing the project. Is access to the project fairly distributed given its context? Do barriers (to information, mobility, amenity,

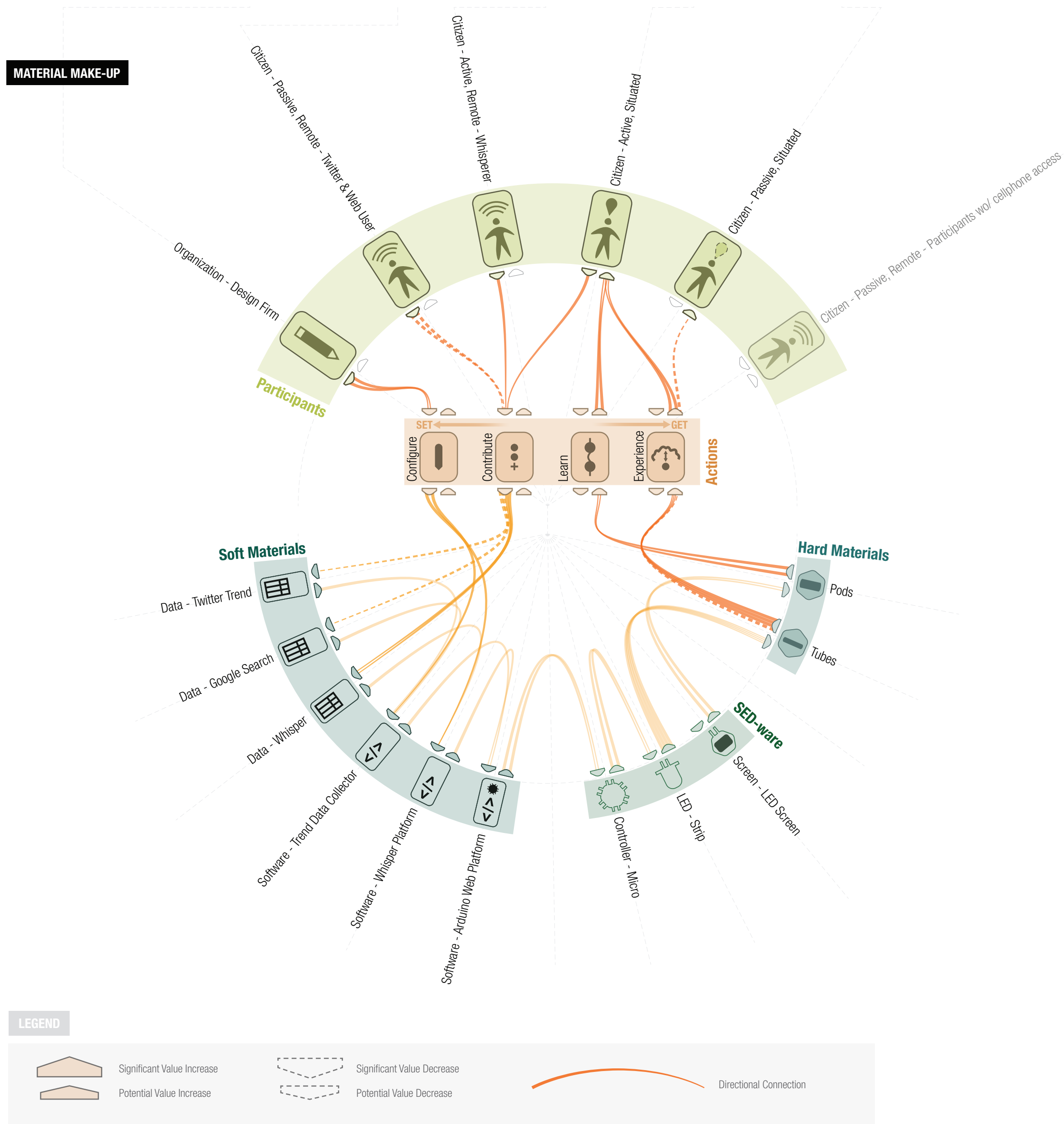

Figure 5. Project Anatomy of Murmur Wall [FUTUREFORMS]. By looking at the participants and actions sections, both the situated and remote users' ability to contribute to the project by adding data actively through whispers or passively through tweets and google searches show up. Thus, readers can understand the different abilities situated and remote participants have to contribute to, learn from, and experience the project. It should be noted that "whispers" are fed into the algorithm separately and are not collected by the design firm, maintaining the privacy of the situated and remote active participants.

financial opportunity) exist to accessing the project's services and benefits the project?. What is accessible through the project? what becomes less accessible? by whom?

> *Participation & Experience:* deals with the degree to which the project empowers users to participate in decisions which affect their lives and shape their experience of the built world. What modes of engagement and participation does the project support? physical/virtual participation? What are the benefits or drawbacks of participation?

> *Rights & Security:* engages the issue of individual rights with respect to access to information about the circumstances and decisions affecting them while maintaining the ability to appeal decisions people feel are unfair. In addition this category foregrounds the issue of fairness in treatment of security, privacy, property.

This second stage, even in its nascent form, foregrounds a set of questions designers could use to explore the relationship between intended and authored project values, actual

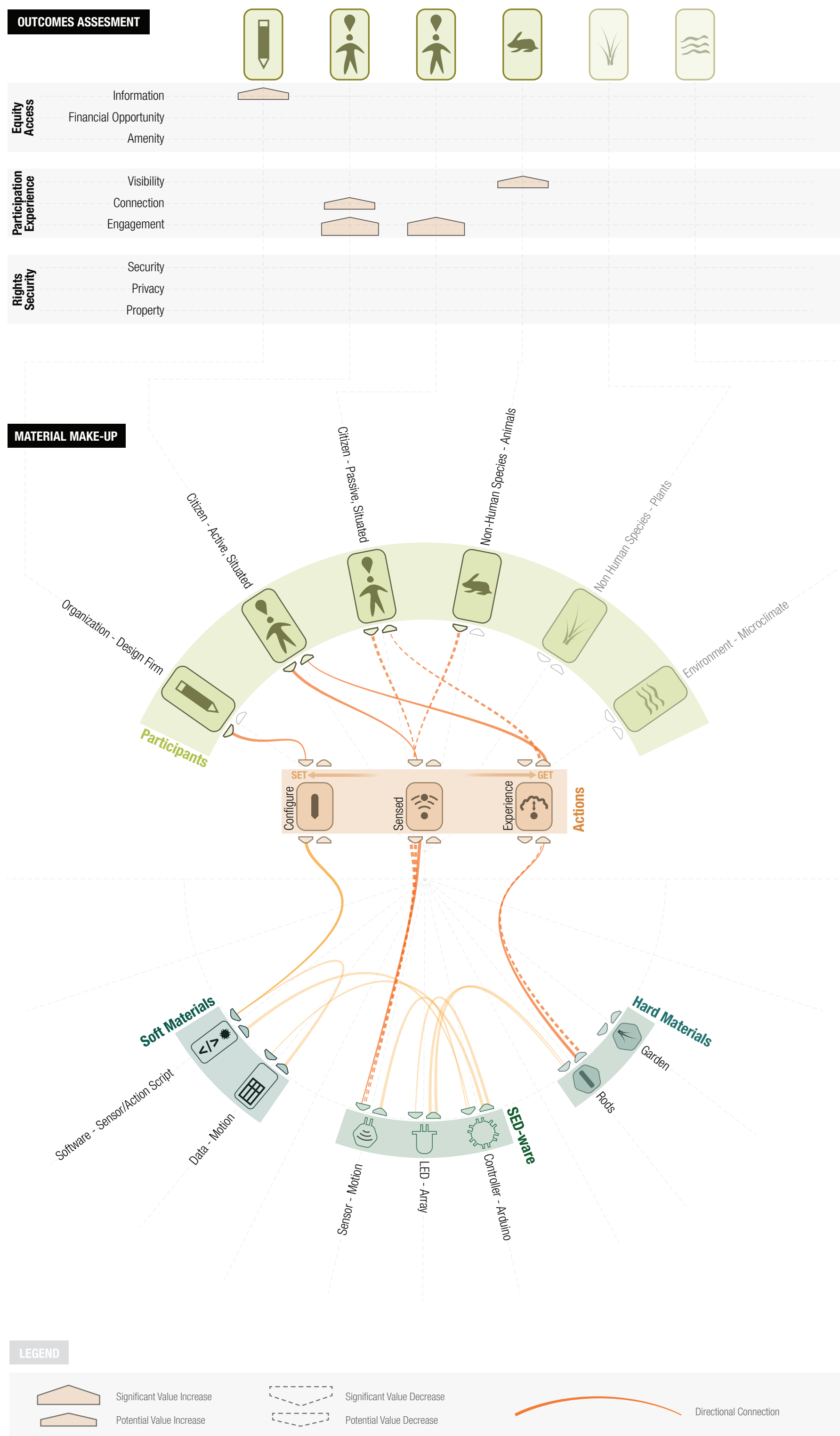

Figure 6. Project Anatomy and Outcomes Assessment of Latent (e)Scapes [Christina Leigh Geros, SHO Architects and ULR Studio]. The participants section of the framework makes it clear that the project engages only situated participants and is thus very focused on the local. Lines connecting the citizens to the actions show that there is a singular interaction scenario for this project (being sensed and then experiencing the colour and intensity of the rods in response). This means that active and passive participants have same amount of engagement, however there are no barriers to participation since cellphones are not required to engage the project. While the project brief engages the ecology of the garden, the SED-ware and soft material bundle is not equipped to sense or engage the garden's microclimate or plant species. Thus, the connection to the garden is made primarily through the quality of the hard materials.

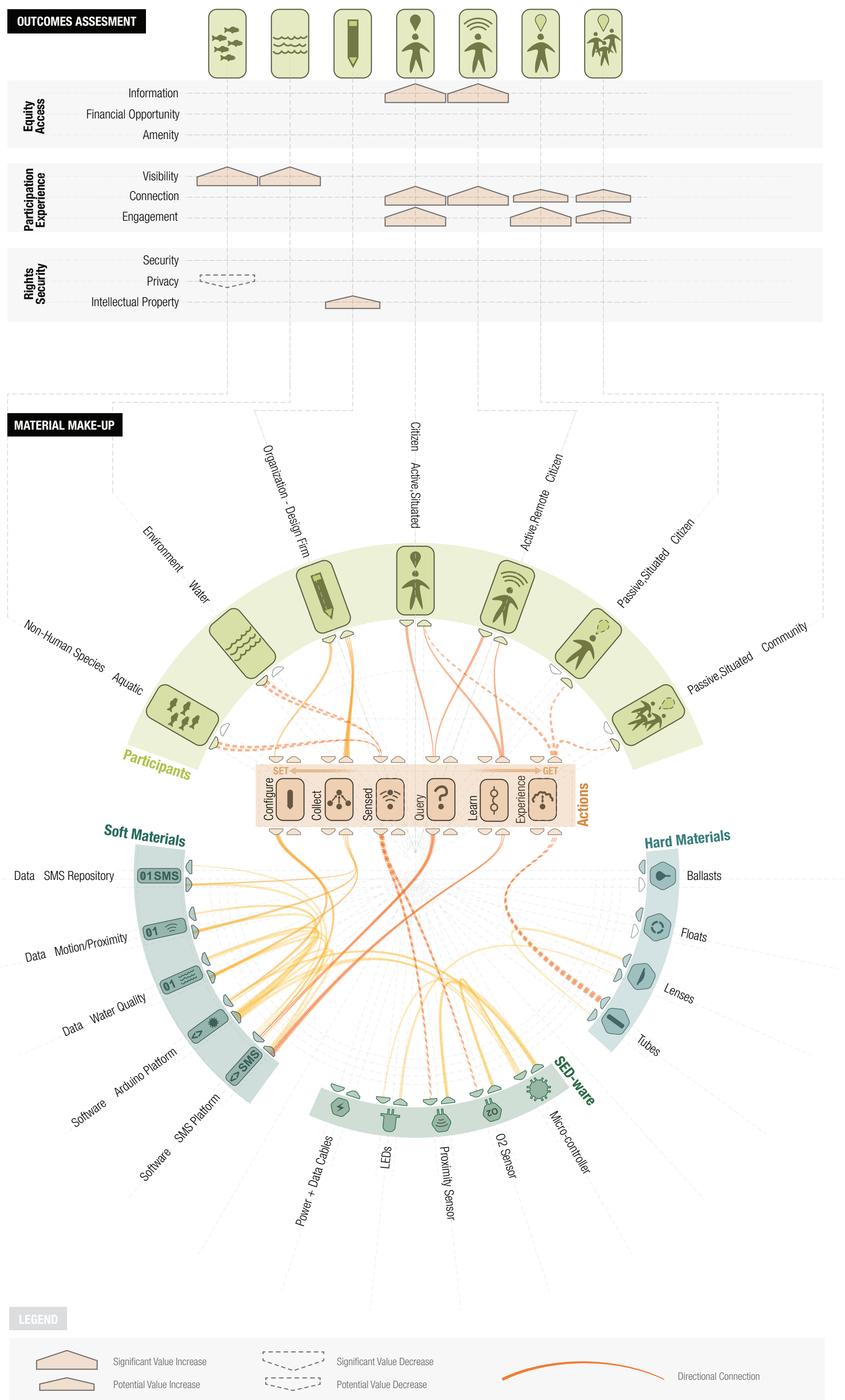

Figure 7. Project Anatomy and Outcomes Assessment of Amphibious Architecture [The Living, xClinic, Natalie Jeremijenko, and Chris Woebken] In this analysis, a variety of participants engage the project in multiple scenarios. This includes a more passive experience of the LEDs alerting any passersby to the hidden aquatic ecosystem, as well as the ability for situated and remote active human participants to query the project and gain environmental information from the sensors, allowing further engagement, learning, and visibility. While these additional layers of engagement add to the project, they present a barrier for individuals who do not have cellular devices. Through its SED-ware and soft materials, this project activity engages the environmental and non-human participants in the project by sensing fish proximity and oxygen levels of the water. It also presents the ability to inform human understandings of this ecosystem through potential analysis of the data collected.

outcomes and, central to the frameworks goal, how materials, especially soft materials, support or impede achieving them.

Figures 6 and 7 show both stages of the framework in action on the Latent (e)Scapes and Amphibious Architecture projects respectively. In addition to the Project Anatomy section, we incorporate the Project Outcomes analysis in which we begin to reflect on where the project's agency lies in terms of the outcome dimesons described above. We can see that both projects address human relationships to non-human species and urban-ecological systems, but vary in the locality of the participants, barriers to participation, agency the participants have when engaging with the system, and amount of feedback and information the participants receive. Now that these readings are available through the framework, we can take further steps to test these outcomes against the project goals to evaluate the use of soft materials in these SED projects.

RESULTS & REFLECTION

The Project Anatomy stage sheds light on a variety of aspects of a given SED project. The lists of participants and actions offer both explicit and implicit information with respect to the terms by which the projects are considered via the framework. On the one hand, the stakeholders listed in each project signal the explicit opportunities and scenarios that the project addresses. On the other hand, understanding which user groups are absent and which actions are available to which users shed additional light on issues around access, equity and participation. The Project Anatomy exercise also exposes the blend of material types at work in a given project and the degrees to which they are interconnected. By linking the materialities back to actions and then linking action back to stakeholders we build an understanding of the dependencies and exclusions between project materials, actions and participants.

As SED projects move from test-beds to real-world deployments, articulating the entanglements between project elements can be used to support a reflection on a project's real-world outcomes. We can learn, for example, that in order to participate in a configuration action you need a data-enabled smartphone. We can also learn that certain participants are excluded from set actions and hence have limited abilities to truly participate[17]. Lastly we can see, by having a closer look at the nature of exchanges between participants, soft materials and SED-ware, if and how access to security and rights are maintained. For example, does a participant have access to or benefit from their contribution – be it physical or data- or process-based?

Two aspects of the framework will be tackled in future work: 1) The ambition is to reflect on alignments between project intentions and actual outcomes. To get to this level of analysis, a shift from a black-box understanding of the project to a white-box understanding, informed by the project authors, will be necessary to accurately characterize the project's goals and delve further into the inner-workings of the data and software involved in the project. 2) Analysis of actions and participants will expanded beyond post-deployment scenarios to include actions during earlier phases of the project, such as conceptualization, specification and design.

Another important next step is to transition the framework from being a tool applied to SED projects *post facto* into one that can support designers in conceptualizing and evaluating SED work while still in design and development phases.

CONCLUSION

The paper argues that a materialist account of embedded computational components can serve as a way to complement performance-oriented engagements with SED by exposing alternative, harder to measure, perspectives centred on social and ethical impacts and outcomes. The Project Anatomy framework finds new purchase on materially-oriented, socially-minded engagements with the computational components increasingly proliferating in our built environment; it offers an alternative lens through which to consider SED projects by presenting the entanglements between participants, operational affordances and material composition and the relationships between them. By engaging a project's technically-oriented material make-up alongside its socially-oriented aspects around modes of participation and forms of access, we offer alternatives to simplistic technologically-situated views of SED work and, instead, support complementary engagements that maintain a connection to the complex urban condition in which these SED projects operate.

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ENDNOTES

1. Project Credits: The Living, xClinic, Natalie Jeremijenko, and Chris Woebken.

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6. Paul Dourish, *Stuff of Bits: An Essay on the Materialities of Information* (Cambridge, MA: MIT Press, 2017).

7. Dourish, 3.

8. Dourish, 26.

9. Yanni Alexander Loukissas, *All Data Are Local: Thinking Critically in a Data-Driven Society* (Cambridge, MA: MIT Press, 2019).

10. Loukissas, 155.

11. William M. Taylor and Michael P. Levine, *Prospects for an Ethics of Architecture* (Abingdon, UK: Routledge, 2012.

12. The project was renamed from the "Regent Park Aquatic Centre," MacLennan Jaunkalns Miller Architects, accessed September 27, 2019, http://www.mjma.ca/Portfolio/Featured-Projects/Regent-Park-Aquatic-Centre.

13. The 106th ACSA Annual Meeting (March 2018) organized around the theme of "Ethical Imperative" foregrounded discussions around ethical challenges of architecture.

14. Maya Przybylski, "Critical Computational Literacy: A Call for the Development of Socially Aware, Ethically Minded Research within ACADIA," in *Proceedings of the 38th Annual Conference of the Association for Computer Aided Design in Architecture* (ACADIA) Mexico City, 2018: 30-35.

15. This argument is articulated in key offerings from the field of software studies, which position software—its actual lines of code, not just its effects—as a material practice with both social and spatial outcomes. For titles, see, e.g., Matthew Fuller, *Behind the Blip: Essays on the Culture of Software* JSTOR. 2003; Shannon Mattern, "Interfacing Urban Intelligence" in *Code and the City*, ed. Rob Kitchin and Sung-Yueh Perng (Abingdon, UK: Routledge, 2016: 49–60; and Matthew Fuller, ed., *Software Studies: A Lexicon* (Cambridge, MA: MIT Press, 2008).

16. P. Lemonnier, *Mundane Objects: Materiality and Non-Verbal Communication* (Walnut Creek, CA: Left Coast Press, 2012), 128.

   This quote also appears in Dourish, *Stuff of Bits*, 58.

17. Sherry R. Arnstein, "A Ladder of Citizen Participation," *JAIP* 35, no. 4 (July 1969): 216–224, described various levels of engagement, ranging from empty rituals of participation through to having the real power and the corresponding ability to affect the outcomes of the process.