Citizen Informatics: Integrating Urban Data and Design for Future Stakeholders

Abstract

This paper describes a range of existing software tools and prototypes for ICT-supported participatory urban design and planning as a subset of participatory governance, and outlines key features of a future software architecture capable of supporting urban planning and pre-design practices that are both more inclusive and more rigorously evidence-based than the current state of the art. Recognizing that such an architecture can only partly be considered, or developed and tested, from within the domain of electronic governance per se, the authors propose a scenario in which existing tools and practices can be adapted to co-evolve with complementary developments in the realms of data literacy and collaborative design media, towards the evolution of expert public realms, i.e. societies whose lay citizens could be as expert and engaged in matters of design and governance of complex built environments as researchers and professional experts are today. The paper is offered less as a *compte-rendu* of research than as an RFC (Request for Comment) in the spirit of Steve Crocker's RFC 1 of 1967.

Keywords

Citizen Informatics, Digital Literacy, Data Literacy, Collaborative Design, Participatory Design, Participatory Governance

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Introduction

In this paper, we will consider the state of the art of participatory planning and design and its practical potential for development into future use scenarios which meet higher standards both of funcitonality and of inclusiveness, partly by promoting the dissemination of knowledge and expertise into the general population as a subset of use cases.

A general level of data literacy – mature and widespread enough for participatory urban planning processes to be legitimate and competent as a matter of course – might well correspond to Jürgen Habermas's deceptively succinct definition of the public sphere itself: "the critical reflections of a public competent to form its own judgments" (Habermas 1962). At least one of the currently available urban planning simulation tools, UrbanSim, was actually developed with Habermasian orders of legitimacy in mind (Borning 2005):

> "[...] each utterance implicitly raises four validity claims: to the comprehensibility of the utterance, to the truth of its propositional content, to the truthfulness of the expression of the speaker's intent, and to the rightness and appropriateness of the utterance with respect to existing norms and values. UrbanSim is just one voice in public discourse about urban planning."

As things now stand, deployment of fully functional design/planning/governance technologies is – or should be – constrained by local considerations of community capacity, where technically open platforms can actually exacerbate negative equity effects of differences in proficiency levels between contending stakeholder groups (Afzalan 2017). In the starkest terms, the legitimacy of any participatory governance process rests on the expectation that a statement about the impact of a specific proposed change to a specific built environment in its context can be comprehensible and true at the same time, in other words that participating stakeholders are competent to not only read, but critique and develop alternative interpretations of the statistical information on which proposals are based.

Whether they are construed in Habermas' terms simply as "communicative action" (Habermas 1984), or as only one aspect of satisfying "conditions of collaborative rationality" (Innes & Booher, 2010), this paper discusses data, urban planning, and design tools and practices with the understanding that final approved and implemented plans must always be built and recognized as artifacts of negotiation, as much as they are outcomes of investigation.

We will not attempt in this paper to address equally important issues of data collection and curation: open access to relevant raw data by traditional procurement, staff collection/curation, with or without citizen participation in the collection itself, or in the development of the data schema (Garau 2012). What we will address is the potential for a software architecture to support broadly based collaborative participation in the planning and design aspects of local governance in specific modes: data visualization, data analytics, 3D visualization of proposed designs in context, and the synthesis of quantitative and qualitative information and decision support. Within that scope, we will propose a synergistic approach to further research and development in these areas, with a view to developing a "virtuous cycle" of improvement in the functionality and usability of the tools in tandem with ongoing development of the skills and awareness of stakeholders, especially those resident in the most public realm of all, the future.

Are we *smart* yet? If not, do we intend to get smart enough, soon enough?

Background

Future Expectations: Watson, Iron Man, and the AARP

Working technologies can begin to develop their initial specifications (and their raison d'être) as science fiction (Rosen 2013). Dick Tracy's videophone wristwatch and Captain Kirk's Communicator are well recognized and fully exploited as concept prototype variants for smartphones. Indeed, the flip-phone form factor of Kirk's communicator is already quaint. When Minority Report was released in 1992, it caused quite a stir in the digital design world with its holographic 3D gestural interface, operated by fictional expert user John Anderton (Tom Cruise) to dynamically search and correlate identity records, geodata, security camera feeds, and video of crimes yet to be committed. By 2010, when Tony Stark (Robert Downey Jr.) used his personal gear to scan, parse, and filter data embedded in a physical model using a more advanced system, his use of that graphical interface for real-time data filtering and analysis in tandem with a natural language voice AI querying system was impressive, but not radical. In fact, the semantic level of the system's fictional functionality wasn't that different from the text-window natural language AI services provided in the current version of IBM's Watson Analytics.

Fig.6: A fictional billionaire-genius filtering 3D data with a combined GUI/natural language interface. Source: Iron Man 2, 2010 Marvel Studios/Paramount Pictures

In the film, Iron Man/Tony Stark is exceptional: rich, brilliant, and in control– he actually invented and/or owns the technology, from metallurgy to augmented reality to artifical intelligence, with direct access to (among other resources) geodata. In the non-fictional world, Watson Analytics now runs as a consumer-accessible cloud service on some combination of the internet and a portable computer or tablet as a matter of course, for less than the cost of basic cable TV service. Robert Downey Jr. himself was born in 1965, in New York City. At some point during the last three years (Nagourney 2012), he will have started receiving paper and e-mail solicitations from the American Association of Retired Persons (AARP), a non-profit advocacy group whose core constituency is senior citizens, i.e. the demographic tranche least expected to be able to handle complex digital data manipulation tasks online, or elsewhere. Perhaps Mr.

Downey’s experience as a sci-fi action hero helped to prepare him for the AARP’s website, and in particular its Livability Index dashboard, which includes an interactive widget for the customization of rankings of cities as places to retire on the basis of one’s personal weightings of standard quality-of-life parameters. Data sources and analysis are documented, and individual preferences can be expressed, tested, refined, and automatically surveyed. In other words, some of the necessary conditions for a fully functional digital/data democracy are not only met, but taken for granted in at least a few privileged pools and eddies of the info-mainstream. Whether such beachhead implementations occur at the intersection of open data and citizen engagement, public education and data literacy , or industry and entertainment, they will ultimately matter much less than whether a critical mass of citizens develop the right mix of data literacy, access, and engagement.

This is not to say that the supply of public information in its raw form – open data – can be assumed to be complete, authoritatively verified, or timely. While some jurisdictions may have blanket policies or legislation in place, the business of demanding and verifying that such resources be made available in forms that lend themselves to relevant analysis before binding commitments are made by leaders or agencies will in due course become an integral aspect of citizen engagement. A virtual cycle can emerge and develop through the advancement of data literacy on the same terms as reading and writing: if everybody can use the information, a few are bound to be asking for the right information at any given moment, with others standing by to check the answers. Over time, citizen demand can promote the development of more comprehensive, more available, and higher-quality data.

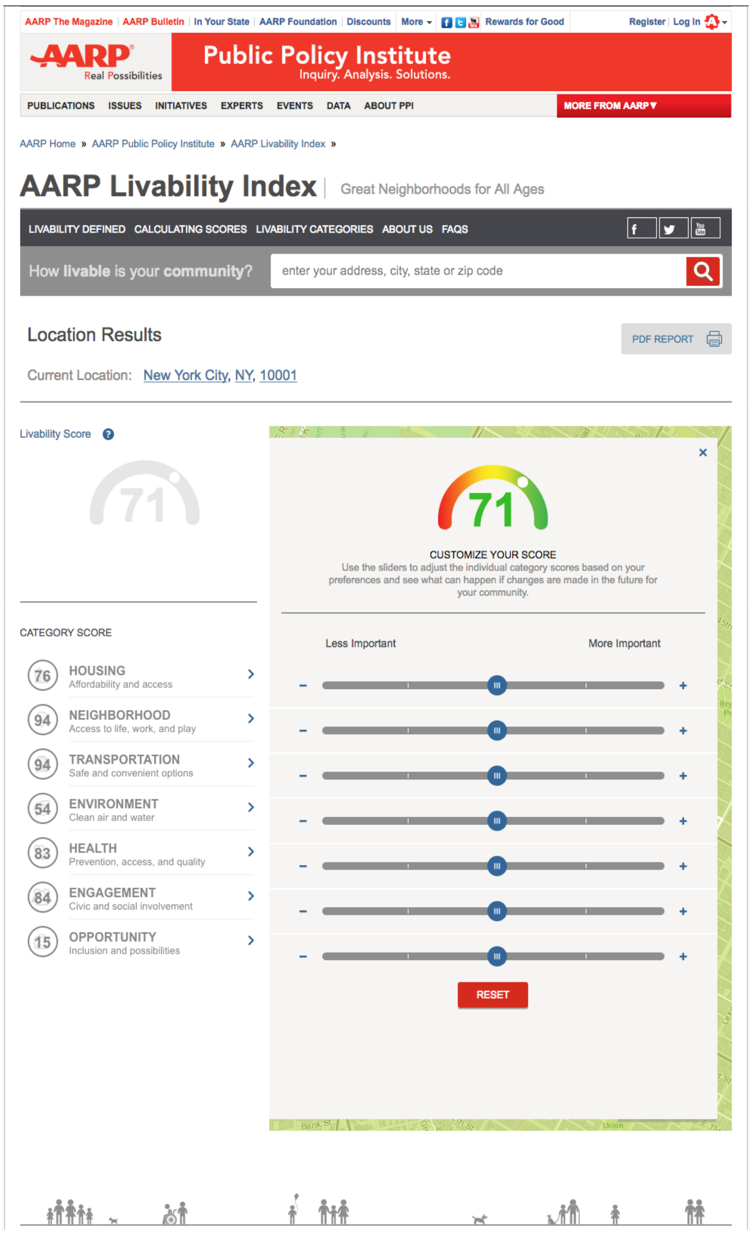

Fig.7: A senior-citizen facing data analytics tool with customizable parameter weightings. Source: aarp.org, accessed December 12, 2017

Complementary Visualization Tools

CityEngine
http://www.esri.com/software/cityengine

CityEngine is a procedural 3D modeling platform for urban development, to supplement the 3D mapping and information display capabilities of Esri's flagship industry-leading geoinformatics platform, ArcGIS Pro. It operates on the basis of customizable rules about land use and built form, interactive visualizations of buildings, compounds, districts, and entire cities to show what they would be like if specific rules were applied to the implementation of changes to an existing landscape or built environment.

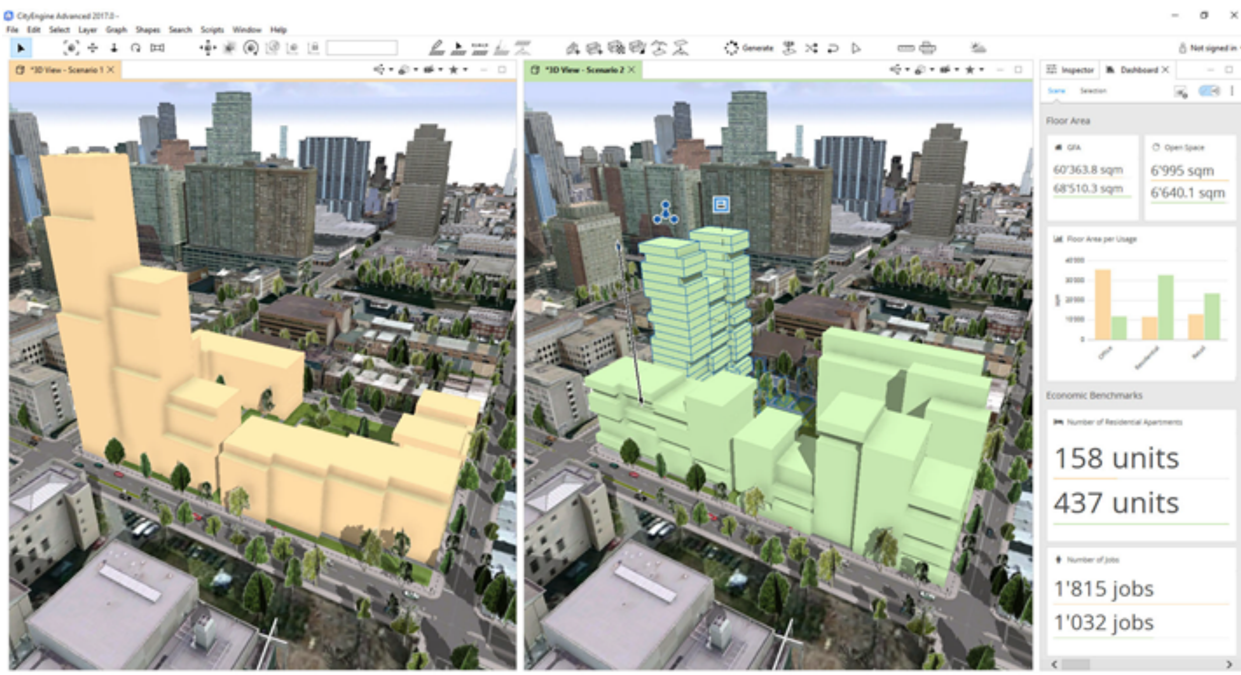

Fig.3: Typical side-by-side presentation of alternative massings for a new urban development (Source: Esri)

A "simulation" environment in two senses of the term:

1. Vernacular: people can see what it would look like, and/or feel like to move around in from "God's Eye View" or pedestrian or fly-through perspectives
2. Technical: as a procedural modeling tool, CityEngine can demonstrate the effects of applying specific regulations/parameters/rules to a design or a place, including the effects of applying different relative priority levels in situations where parameters may conflict or require design trade-offs. As with other procedural design tools for the real world, any number of "candidate" solutions can be automatically generated in a fraction of the time it would take for human designers to work out all the alternatives that would meet requirements.

On its own, a tool like CityEngine offers a new set of requirements and opportunities for public engagement and consultation in design, and deliberation about potential alterations to the built public realm in particular– parametrically built models can be displayed online in "web scenes", with as much information about context, intent, and contingencies as their designers are mandated to share.

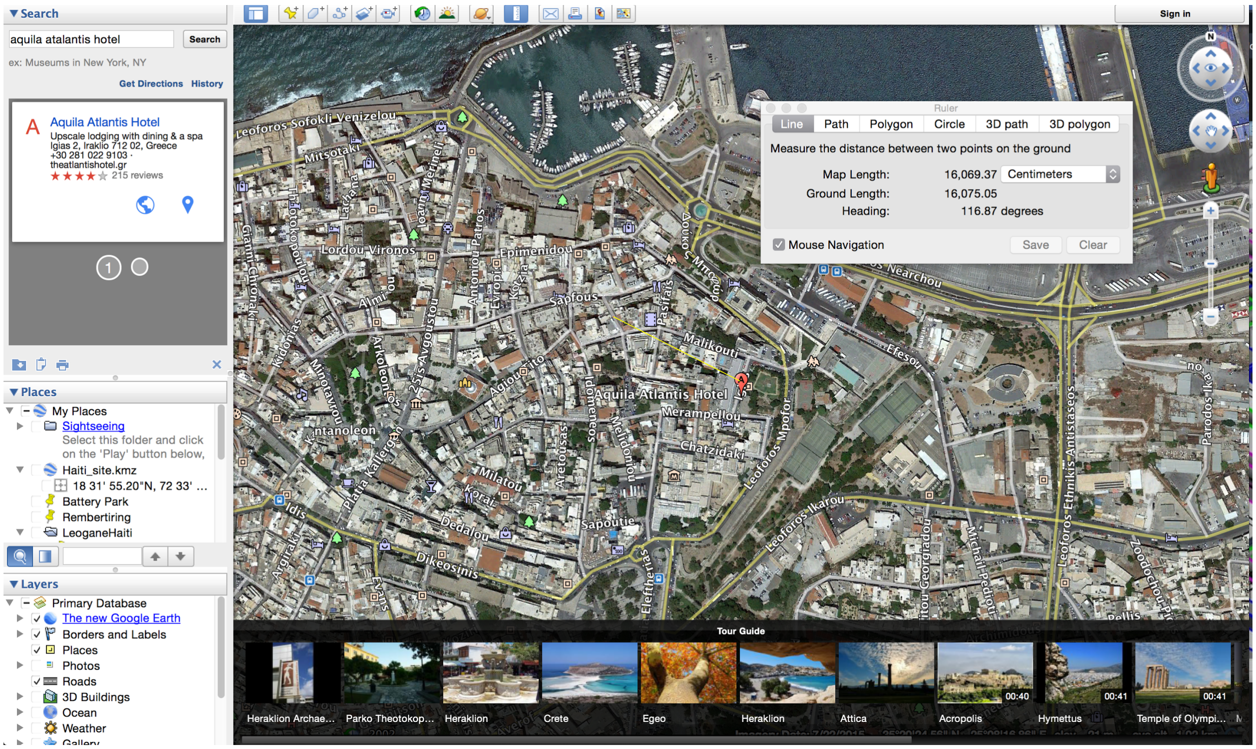

Fig.4: Finding the venue for the Smart Blue City Conference, 2017. Source: Google Earth, accessed September 27 2017

While the web scene does not permit direct experimentation by viewer-stakeholders with the design assumptions or parameters beyond physical context visualization, it does permit and rely on stakeholders' ability and inclination to navigate independently in a 3D representation of a familiar built environment, enriched with proposed physical alterations and indications of their planning rationales & intended effects on their immediate environment. As commercial production software, CityEngine not only proposes, but effectively assumes that a critical mass of proponents and public agencies have or can very shortly develop staff capable of authoring these kinds of simulations, and that what they communicate is already intelligible to politicians, real estate developers, and concerned citizens. For the skeptics among you, Fig. 4 offers a screenshot of the Google Earth interface for consideration, along with the simple question: at the level of the UI's cognitive load and interaction schema, how is this not a geoinformatics dashboard? Is it esoteric, or technologically implausible?

Facebook

At the other end of the spectrum of expectations about public expertise, Igor Nedelovski's approach to his group's People's Smart Sculpture (PS2) Virtual Urban Art project in Bitola (Nedelkovski 2017) requires no more than familiarity with Facebook for submission, presentation, and discussion of designs presented as static images and text, for proposals without complex relationships to quantifiable technical or policy regulations. The great practical advantage of this approach is that it uses an established and familiar platform whose usability issues have been worked out over years with a market-driven emphasis on ease of use for internet "consumers". This provides for a straightforward HCI scenario, in a use case without any actual or potential need for learning curves beyond the matter at hand: which design, if any, do you prefer? What improvements do you suggest? Participants had no more to learn as a pre-requisite for active participation than were already required to do to log on to a computer, and post text to Facebook.

Dr. Nedelkovski took a conservative approach to technology and usability for an ambitious engagement project, a campaign to rehabilitate the landscaping and other design elements of a decrepit Stalin-era central square, and achieved a successful outcome in the built environment (ibid.). Might he have had less participation with a more demanding/complex environment like CityEngine or Betaville? In the absence of two identical Bitolas as comparative study venues, we cannot know for sure, only that the approach taken was effective for the project.

Meanwhile, Esri ArcGIS Pro and CityEngine represent – as a suite – the current standard for commercial GIS software: 2D mapping, geodata management and analytics, procedural 3D modeling for planning and design applications, and a growing array of public-facing online presentation tools. Evolved as they are from cartography and surveying, Geographic Information Systems (GIS) are by tradition and cultural habit part of the toolkit of technical professionals. Fastidious about their role in the editorial process, they scrutinize the quality, completeness, and currency of geodata, and the quality and integrity of public records to be used as basic information resources by highly specialized and variously motivated experts: scientists, engineers, planners, property developers, and litigators, who in turn advise political leaders, journalists, entrepreneurs, and stakeholders.

As Esri sets out to address its next market frontier – the general public – by providing its traditional public service clients with new ways to present complex geodata to constituents online as open data, and thereby public information, new questions of accessibility come to the fore: tools that provide for expert professional use as well as consumer standards and expectations of usability and user-friendliness, trade-offs between power and ease of use, user skill-bootstrapping support and affordances embedded in web client applications rather than formally regimented specialist training courses. There are also legal-ethical questions about "white box" accessibility in the logic and assumptions of underlying models and simulation outputs for projections– for public information to be genuinely "open", the entire chain of schema design, acquisition, abstraction, and any mathematical models applied to projections would have to be user-accessible and editable as well. An even stickier set of accessibility issues arises at the social level: at what proportion of penetration of skills, awareness, and technical access for the most underserved communities within a specific jurisdiction, is it legitimate to speak of the data as effectively open, and the information that data only becomes as fully citizen-accessible in all those dimensions as public? Are we already there, or is there more to do, even in the most developed regions of the most advanced nations, to meet even the standard of "crude literacy" vis-a-vis the information on which public discourse and citizen engagement must be based, in what we are all hoping will not turn out to be the LATE anthropocene era?

Though more specific in theory, the sub-question of the potential for broad citizen read-and-write literacy for data per se is not necessarily simpler in practice. Citizen engagement with data as the raw material of public information, and thereby of informed debate, is the basis of which plans for the future can be broadly participatory and evidence-based at the same time. This calls for data structures and analytics tools traditionally associated with large research institutions, corporations, and governments. For the level of analytical understanding thus developed to be of value in turn as the evidence on which to base plans for the future, those tools must in turn integrate with distributed iterative planning and design environments. As more and more local governments make their data repositories freely available online in machine-readable form, and general standards of digital literacy rise to levels now considered professional (the way reading and writing were in medieval Europe), a virtual cycle may emerge: more citizens may be motivated to develop higher skill and awareness levels as more material (data) and tools (software) become available to meet the demand those evolving capacities stimulate. Direct participatory governance infrastructures may yet become mass media, whether crowd-sourcing local futures is construed as political progress, new markets for suppliers, or simply a more effective system architecture.

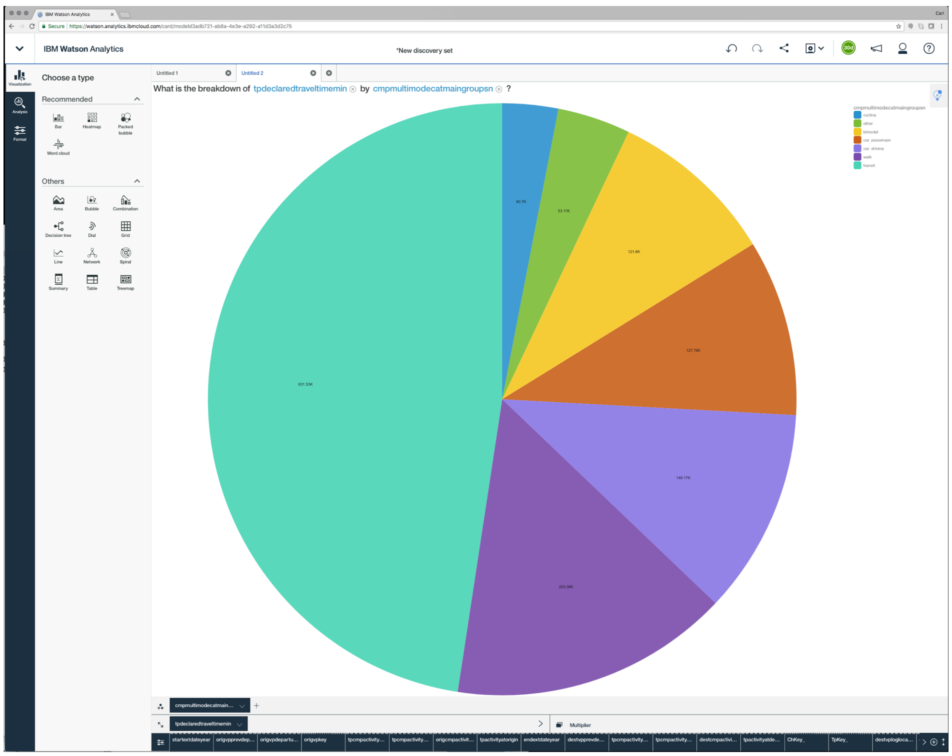

Fig.5: A first pass at visual analysis of data collected through the StudentMoveTO survey, Toronto 2015. Of all reported travel times and modes, more than half were "fully passive", i.e. amenable to study (raising strategy questions for the schools about course support methods and materials, and for the transit authority and city government about the potential educational value of Wifi services throughout the system)

Watson Analytics

IBM's Watson Analytics platform is an encouraging development in this solution space. Watson Analytics is a guided DIY cloud-based data visualization/analytics platform geared to a broader range of user types/skill levels than their more traditional enterprise-oriented Cognos, leveraging IBM machine learning and AI-based natural language support to provide for a convergence of user self-directed skill development and data exploration from the most basic (getting a pie chart out of a spreadsheet) to predictive analytics, i.e. projections and planning applications.

While Watson Analytics does not directly provide for processing of very many of the formats in which open data about transportation are provided by the city of Toronto through its open data portal (only .xls, .xlsx, and .csv, and in particular no support for the 50% of files offered in the .SHP geodata format), the environment does lend itself well to a particular data democratization scenario. A concerned citizen with basic digital skills and a few hours to get self-oriented can upload a file that does fit, explore the data through ad-hoc experimentation with an assortment of standard visualization types, iteratively develop their own understanding/analysis, and in due course "level up" to predictive analytics. These actions represent the crucial steps from reading history to understanding its underlying causal relations, to making informed decisions about how to proceed in the future – in other words, the full complement of functions of literacy, at the level of data.

While there is quite a bit of variety in the forms and norms for provision of data resources by cities with Open Data policies in place, the incompleteness of strategies and practices for actual implementation of data democratization all the way to cultivation of such literacy in the general population is consistent (Nguyen 2016). Data analytics may be emergent as the next frontier of literacy development worldwide or indeed an entirely new liberal art, rather than the esoteric skill of a specialized minority of technical specialists. What mix of in-house service bureaus like the NYC Mayor's Office of Data Analytics, analytics platforms with integrated self-education resources like Watson analytics, and additions to formal curricula at the secondary and post-secondary levels are now appropriate? Data analytics may already be emergent as the next frontier of literacy or indeed an entirely new liberal art, rather than the esoteric skill of a specialized minority of technical specialists.

Betaville: the historical performance specification, current upgrades, and an n-dimensional roadmap for a synthesis of collaborative data visualization and 3D design

When the Betaville Massively Participatory Online Platform was initially conceived as a performance specification in 2008 (Skelton 2014), its design intent already seemed utopian. Betaville offered an online environment in which a dimensionally accurate model of a city or district could provide not just a discussion forum, but an open sketching environment and forum for changes, from the scale of a public sculpture to that of a whole new district.

In the process of working to ensure the platform's reliability and credibility as an accurate representation of spatial relationships (widths of sidewalks and roadways, heights and widths of buildings, etc.) and a 3D model format that could be exported with the full range of authoring tools and open map data, we chose to build out the 3D space as an open geospatial standards-compliant UTM (Universal Transverse Mercator) projection. When cities we worked with subsequently released their geodata in open and OGC (Open Geospatial Consortium) standards-compliant formats, we were ready – at least at a technical level – to integrate GIS data in Betaville to inform open experimentation, debate, and iterative-collaborative design development.

As development of a new WebGL desktop client and server architecture capable of handling mobile, AR, and VR clients proceeds, we have had to ask new questions about usability, and use cases: are we building for the current range of end-users and use cases, or for a future generation of citizens more proficient and engaged than current researchers, expert advisors, and professional advocates, or simply to identify obstacles between present practices and a fully inclusively functional direct digital democracy, for which most of the necessary software tools are available, *now*?

In principle, the enrichment of the original Betaville platform with up-to-the-minute geodata visualization is consistent with a fully-developed positive model of citizen participation in the continuum of awareness, engagement, planning, design, and governance. In a single software environment, an urban space can be considered from a pedestrian's perspective, or a planner's aerial view wide enough to consider impacts on local-to-regional issues. Betaville scenes can include features underground, whether to account for geotechnical considerations or a full understanding of transport and other infrastructure below grade. Adding a further level of information to the "smartness" of the model to provide historical, current, and projected statistical information overlays could support even "smarter" iterative developments of alternative solutions. In practical terms, recent developments in the Betaville ecosystem support the plausibility and possibility of a future in which broad participation in urban-level governance can be supported and informed at a level beyond what researchers and professionals are working with now, within a model of governance that includes distributed collaborative design of alternatives to present public realms. This can actually become a world in which data analytics and infrastructure planning effectively become as universal as reading, writing, and arithmetic are now... but only if the full spectrum of users, from planners and engineers to citizen stakeholders, can reasonably be presumed to be able to handle the information, and its digital representations.

Fig.1 : Proposal for a "flying bike lane" to connect the Brooklyn Bridge to the downtown area, while minimizing conflicts between cyclists and drivers, as part of the "Downtown Brooklyn Commons" initiative co-sponsored by the Downtown Brooklyn Partnership and Brooklyn Borough Hall, 2011, the only bicycle lane concept on which the borough president and city commissioner of transport ever agreed for the record. Source: Gotham Innovation Greenhouse

The original performance specification for Betaville was based on an end-user "persona" with well-developed skills, either through a combination of informal engagements with consumer-oriented geo-mapping services like OpenStreetMaps, Google Earth, and Waze, in combination with entertainment vehicles like Second Life and Final Fantasy, or formally facilitated orientations in educational and civic settings, in schools, libraries, and city-sponsored workshops. The key process design principle was to provide a low-cost, highly accessible platform for consultative and community-driven ideation and development of consensus for genuine improvements to the built environment which could allow for richer and more creative community participation in advance of conventional development practices, which tend to defer community engagement until *after* large investments in design development.

In the context of those optimistic assumptions, and with a mature participatory design-governance use case in mind, it seemed reasonable to build a full-featured platform. This consists of interactive 3D models accessible online; navigation from regional aerial view down to street-level walkthrough; objects (buildings) linked to external urls; full display of proposal and associated chat histories; sun/shadow placement according to local real time or user-selected time/date; location-based audio sources; performance stats display; in-world object editing; Github repository to provide for independent implementation of Betaville servers by third parties; and infographic overlays of user-imported geodata…

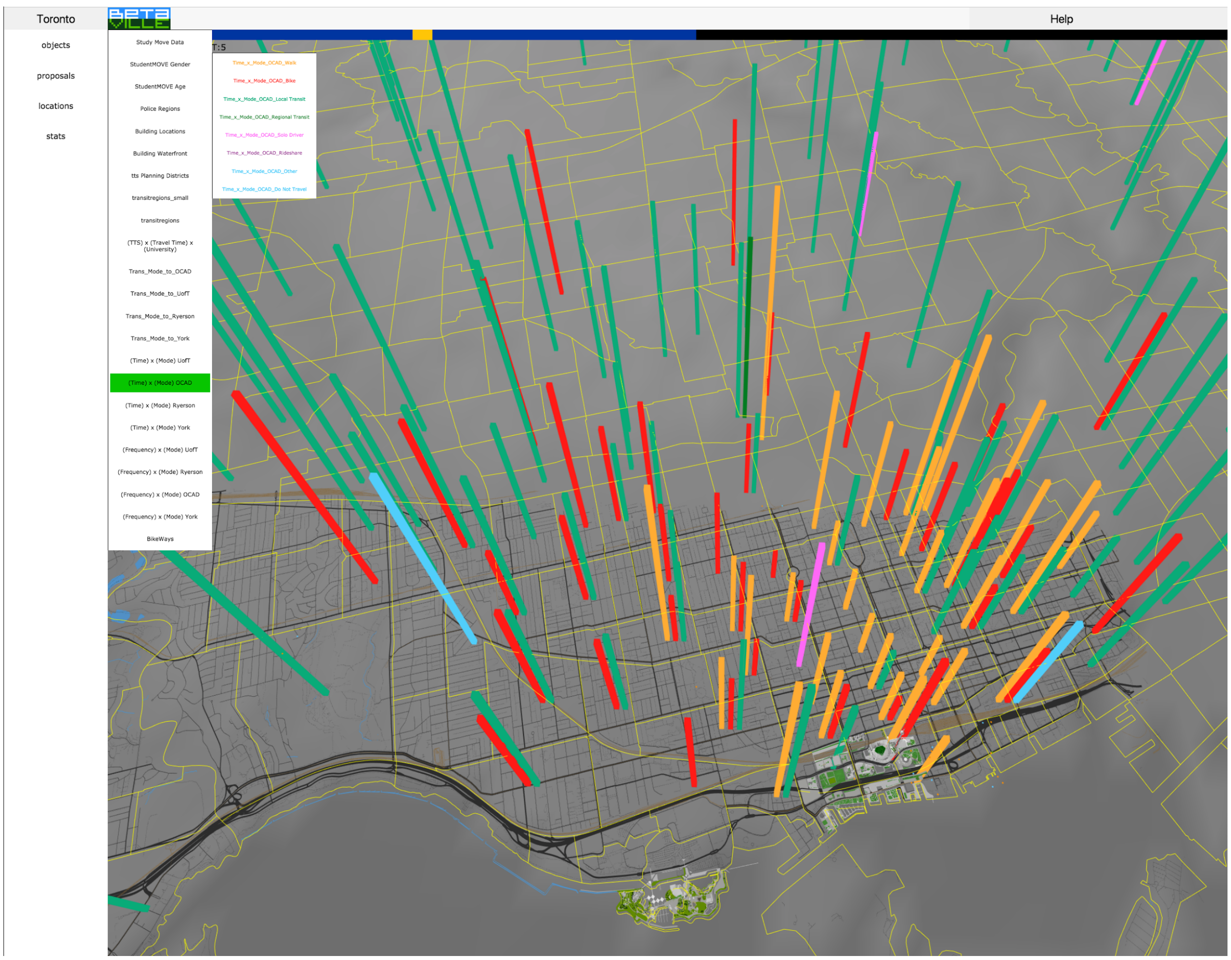

Fig.2 : Distribution of origins of students traveling to OCADU by mode and trip duration- this image made it immediately obvious to institutional stakeholders that active transport planning had limited potential scope for OCADU: people walked only from within a radius of 3km, mostly very high-cost districts of the city. Source: Gotham Innovation Greenhouse/OCAD U

At present, technical development is proceeding on two distinct tracks: at the City University of Applied Sciences in Bremen, a team under Dr. Thorsten Teschke is working to develop a flexible back-end architecture to provide for selective implementation of components of the system's functionality, interoperating with a broader variety of client (AR, VR, web/desktop, and mobile platforms) and data types; and in New York (Gotham Innovation Greenhouse), we are working to provide for better usability and self-teaching resources embedded in the UI, to facilitate at least the long-form facilitated curricular, enrichment, and citizen workshop formats that have been most successful to date in New York, Toronto, Los Angeles, and Montreal.

In the years since the Betaville project first got underway in 2008, the mainstream of software development for more conventional use cases has evolved significantly: not only in terms of the availability of open data at the municipal level, but also in terms of the availability and accessibility of geodata, general-purpose data analytics, and distributed visualization and design tools and practices at the intersection of big data, design, and public information/engagement. As our research, development, and deployments move forward, we look forward to the dissemination of new third-party open-source and commercial tools that we don't need to re-invent at the artisanal scale of research prototypes, and to the broader evolution of socio-technical readiness among citizens, within the broadest possible understanding of citizenship.

Future Directions: General Requirements for Massively Distributed Evidence-based Urban Governance

Requirement 1: Universal Data Literacy

The very idea of literacy has been evolving, even maturing. In 1975, the Persepolis Literacy Symposium (UNESCO 1975) had already moved well beyond the "three R's" (readin', writin', 'rithmetic):

> "The International Symposium for Literacy, meeting in Persepolis from 3-8 September, in unanimously adopting this Declaration, considered literacy to be not just the process of learning the skills of reading, writing and arithmetic, but a contribution to the liberation of man and to his full development. Thus conceived, literacy creates the conditions for the acquisition of a critical consciousness of the contradictions of society in which man lives and of its aims; it also stimulates initiative and his participation in the creation of projects capable of acting upon the world, of transforming it, and of defining the aims of an authentic human development. It should open the way to a mastery of techniques and human relations. Literacy is not an end in itself. It is a fundamental human right."

by 2016, the same modalities of comprehension, analysis, critical reflection, and authorship had been fully re-imagined to include their digital data variants, sometimes under the aegis of exactly the kinds fo organizations one might expect to be able to address the issues as a matter of public education, like the Open University in the United Kingdom (Wolff 2016):

> "Data literacy is the ability to ask and answer real-world questions from large and small data sets through an inquiry process, with consideration of ethical use of data. It is based on core practical and creative skills, with the ability to extend knowledge of specialist data handling skills according to goals. These include the abilities to select, clean, analyse, visualise, critique and interpret data, as well as to communicate stories from data and to use data as part of a design process".

We propose an understanding of a standard or norm of data literacy well beyond the equivalent of conventional crude literacy, the ability to decode and comprehend written language at a rudimentary level" (Kaestle 1988), as a general education mandate because it is a practical requirement for public governance– practical in the sense of feasibility, as well as practical in the sense of necessity.

Requirement 2: Massively Collaborative Design

In his critique of Stanford University's d.school, and of "design thinking" as a quasi-liberal art, Peter Miller actually advocates for a variant of design that might derive more value from historical knowledge and understanding. He states, "Design thinking that took the past more seriously could provide a framework in which humanists and scientists could work together on problems that need to be understood and even solved, such as climate, food, poverty, health, transportation, or built environments." (Miller 2017). The most prosaic level of this prescription might well correspond to what we have been calling evidence-based debate and design up to this point: discussions and designs (solutions) at the very least informed by reliable quantitative information about the status quo, data trends that have led to it, and patterns on the basis of which to predict likely effects of action.

We have discussed elsewhere (Skelton 2014) the discontents of conventional workflows for public consultation about major infrastructure and commercial development initiatives, and the disadvantages of over-committing resources to a design process that's essentially complete, late, and over-budget before the first "town hall" public meeting starts.

We have demonstrated (ibid.) that the technical requirements for direct citizen engagement in effective pre-design and concept sketch development in context could be met with consumer-level computers using standard internet connections using operating-system agnostic client software from about 2010. We have witnessed dramatic improvements in the availability of geodata since then. We might expect to be treated as optimists rather than Utopians when we propose more ambitious goals and expectations for future habits of collaboration between proponents, communities, and public agencies.

While many environments designed to support real-time design collaboration at or beyond the scale of individual buildings as online consumer – ergo, citizen – entertainment are considered passé, the professional practice of real-time AEC (architecture-engineering-construction) is still very young, even experimental (Adamu 2015). The generation(s) already long bored with Second Life (usage peaked 2009) and Sims Online (shut down 2008) may be better prepared to handle real-time distributed design and discussion processes embedded directly in data-rich design tools than professional specialists conditioned to expect and require *private authoring* in "heavy" distributed BIM (Building Information Modeling) design environments like Autodesk Revit, Dassault Systèmes Catia, and Gehry Technologies Digital Project. As a typical benchmark for this, consider the 2016-2020 UK BIM strategy (UK Infrastructure and Projects Authority 2016): They intend by 2020 to be ready to begin to handle real-time collaboration under the flag of "level 3 BIM" (ibid.), thus bringing a key industrial sector to parity in 2025 or so with the Massively Multiplayer Role-Playing Games (MMORPG's) of 1989-2001. The challenge may sometimes be less a matter of helping lay citizens catch up to specialized digital professionals, than the reverse.

Requirement 3: Evidence-Based Planning

The ultimate form and expression of data literacy might well correspond to, or at least support, Jürgen Habermas's deceptively succinct definition of the public sphere itself: "the critical reflections of a public competent to form its own judgments" (Habermas 1968).

For broadly participatory governance to be effective and competent, citizens would have to have not only access to the quantitative information on which such planning is - at least officially - based, but also the skills and means to perform their own independent data analysis and scenario projection, that is a level of data literacy well beyond current standards outside the realms of academic research and professional consulting. Even and especially at the district scale, relationships must be expressed between traditionally qualitative neighborhood/community concerns and the perspective/mandates of municipal-to-metropolitan-to regional institutions of governance: land use planning transportation infrastructure planning/design/operations, etc. Without direct stakeholder participation, quality of life – which should be the ultimate measure of any governance practice – will always be abstracted out. For that reason alone, the neighbors must be at both tables: the negotiating table *and* the drawing board. For that reason literacy must now include full data literacy, and collaborative planning-to-design skills.

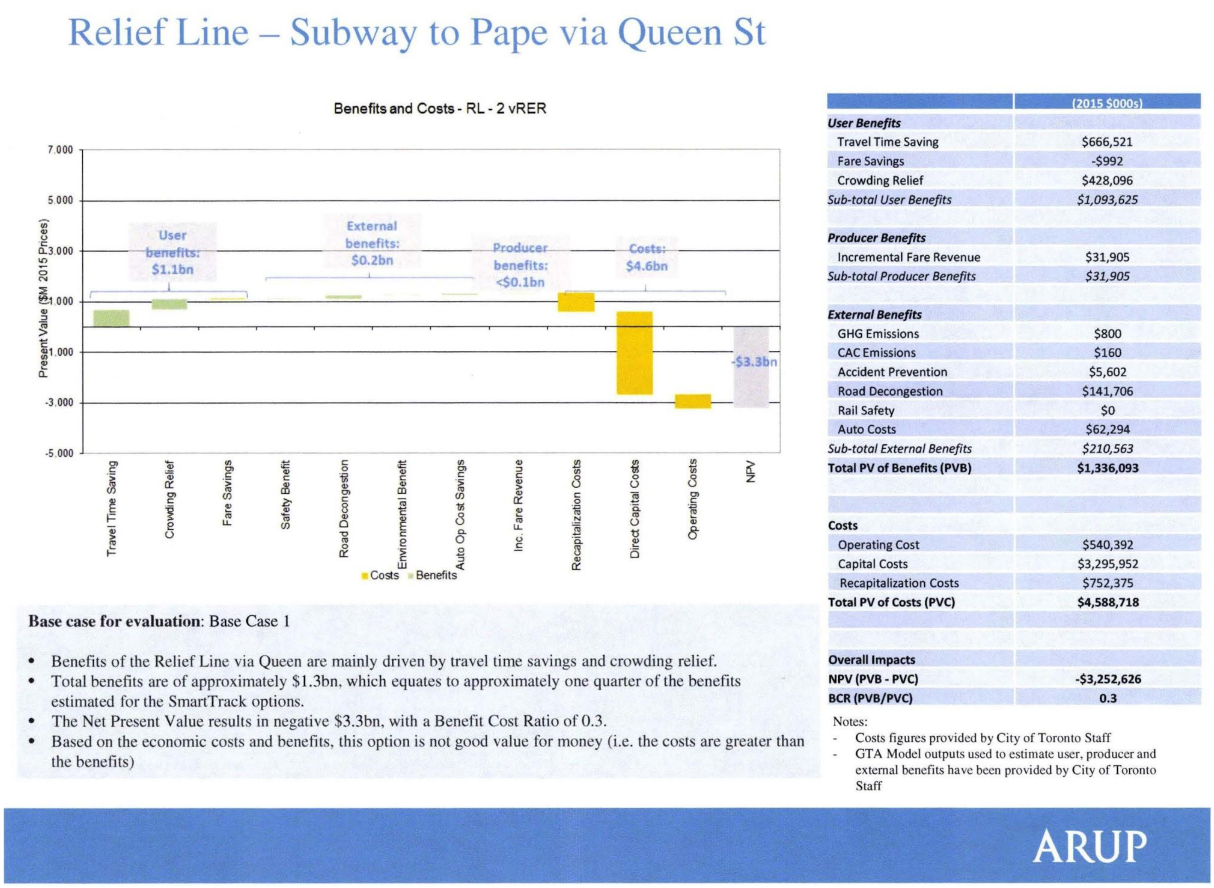

Fig.8: excerpted from a consultant's report to the Planning Department of the City of Toronto, obtained through Freedom Of Information process by a citizen, released 2017 as a raster .pdf, i.e. NOT machine-readable. Source: City of Toronto/FOI

While there may be semantic distinctions to draw between a public that is competent, and one that is equipped, and one that is informed, we know from experience that all three qualifications for participation in governance are mutually indispensable, if the end in view is long-term viability of the system. Claims for direct public participation in governance must ultimately derive their legitimacy from the credibility of the premise of the full complement of competence, engagement, and probity among the citizenry, or at least the promise that their engagement will improve the general levels of qulaity, equity, and effectiveness of governance. At most, as long-term stakeholders, citizens have the best reasons to govern conscientiously for the long term, and therefore represent the best investment as students of robust methods and practices. On this basis, it makes sense to cultivate new levels of knowledge, skill, and access beyond current standards of literacy among the broadest possible cross-section of any constituency, just as it makes sense to raise the ethical bar for that socio-cultural investment beyond the "fundamental human right" of 1975 (UNESCO ibid.) to the level of a fundamental human *responsibility*, the first side-effect of successful *empowerment*.

While it may be technically possible to build a single software environment – and the panoply of documentation to support it – that provides for full integration of design, public debate, data display, and "white box" analytics, the deeper methodological requirement may be for a timely stock-taking about how much of collaborative digital design-to-governance development belongs more properly in the allied domain of general education, where the skills and knowledge required for full excercise of citizen rights and responsibilities are imparted and developed.

For collaborative participatory planning to mature as a model for local governance in a world characterised by an abundance of raw evidence (data) and readily available digital tools, the general population should be better prepared than many professionals are now. How much of that can be addressed by bringing electronic governance experience into the undergraduate and secondary curricula, and how much must yet develop there independently on the understanding that data analytics, 3D visualization, and mathematical modeling are becoming *de facto* liberal arts?

As the Betaville prototype platform's function set has already evolved well beyond user skillsets we can find or foresee beyond our research peers and post-graduate students, its research and development horizons are diverging: research will focus more on direct use cases for participatory urban planning and design, and indirect use cases in which the deployment's primary purpose is skill and expectation development at the level of collaborative participation in the public realm. Development will be oriented less to proving the build-ability of core functions and more to broad-spectrum usability and system architecture deployability under varied conditions, to support as many experimental direct and indirect use cases as possible.

It's not just Captain Kirk's Communicator that's already in hand. Vannevar Bush's Memex (Bush 1945) has been in our laps in the form of notebook computers for a generation; Douglas Engelbart's Framework for the Augmentation of Human Intelligence (Engelbart 1962) has been implemented, and supplanted; Tony Stark's Jarvis, with its combined graphical/language interface and AI inference engine, will probably be available online for a modest monthly subscription within a year or two. Real-time massively collaborative design of real worlds, rather than just "second lives", is in the info-pipe. It should and can be as available as Facebook, and as accessible as we collectively choose to make it.

Conclusion (RFC)

We have described a range of interactive-to-collaborative-to-participatory visualization, design, and planning software tools in realtion to the specific field of particpatory urban planning and design, as a special case of the general issue of necessary skills for effective planning and governance built on direct citizen participation; we have identified the need, and the possibility, of universalization of new kinds of (digital/data) literacy to support meeting that need, at the intersection of participaptory design and planning tools & practices with education. Our own work on and with the Betaville platform has demonstrated the practicality of developing software environments to support this kind of work with hybrid teaching-research initiatives at the modest scale of a small distributed academic consortium.

We hope that the paper's conclusion is actually a beginning, somewhere between a challenge and an invitation to colleagues and collaborators. As a Request for Comment, it is addressed to the Future Stakeholders mentioned in the article's title:

> 1: stakeholders yet to come (your descendants, and/or the descendants of people you care about)
>
> 2: people with a stake in the future (their ancestors).

When Steve Crocker wrote and circulated RFC (Request For Comment) 1 in 1967, essentially proposing the Internet, he wasn't just looking for comments on the idea itself, he was looking for creative collaborators to help both develop the idea and make it happen. If you might be one of those, from data literacy programs to massively collaborative design and governance tools and deployments, please let us know.

References

Adamu, Z., S. Emmitt, R. Soetanto (2015). SOCIAL BIM: CO-CREATION WITH SHARED SITUATIONAL AWARENESS In: Journal of Information Technology in Construction 2015/16 http://www.itcon.org/papers/2015_16.content.07536.pdf

Afzalan, N., T.W. Sanchez, J. Evans-Cowley (2017). Creating smarter cities: Considerations for selecting online participatory tools In: Cities 67 21–30

Borning, A., B. Friedman, J. Davis, P. Lin (2005). Informing Public Deliberation: Value Sensitive Design of Indicators for a Large-Scale Urban Simulation. In: H. Gellersen et al. (eds.), ECSCW 2005: Proceedings of the Ninth European Conference on Computer-Supported Cooperative Work pp. 449–468. Springer

Bush, V. (1945). As We May Think. The Atlantic, July 1945 https://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/303881/

Dewey, J. (1916). Democracy and Education Simon & Brown 2012 https://www.gutenberg.org/files/852/852-h/852-h.htm

Dunne C., Skelton C., Diamond S., Meirelles I., Martino M. (2016) Quantitative, Qualitative, and Historical Urban Data Visualization Tools for Professionals and Stakeholders. In: Streitz N., Markopoulos P. (eds) Distributed, Ambient and Pervasive Interactions. DAPI 2016. Lecture Notes in Computer Science, vol 9749. Springer, Cham

Engelbart, D. (1962). Augmenting Human Intellect: A Conceptual Framework. SRI Summary Report AFOSR-3223 • Prepared for: Director of Information Sciences, Air Force Office of Scientific Research, Washington DC, Contract AF 49(638)-1024 • SRI Project No. 3578 (AUGMENT,3906,).
https://www.dougengelbart.org/pubs/augment-3906.html

Garau, C. (2012). Focus on Citizens: Public Engagement with Online and Face-to-Face Participation—A Case Study. Future Internet, 4(2), 592-606.

Habermas, J. (1962). The Structural Transformation of the Public Sphere: An Inquiry into a Category of Bourgeois Society (Strukturwandel der Öffentlichkeit. Untersuchungen zu einer Kategorie der bürgerlichen Gesellschaft) Trans. Burger, T. MIT Press 1991
https://pdfs.semanticscholar.org/359a/4f9e78f2efe441dce955c609db17b8295e12.pdf

Habermas, J. (1968). Toward a Rational Society / Student Protest, Science, and Politics. Trans. J. Shapiro Boston: Beacon Press 1970
https://books.google.com/books/about/Toward_a_Rational_Society.html?id=cW7PmVj7kzQC

Habermas, J. (1984). The Theory of Communicative Action vol.1: Reason and the Rationalization of Society Trans. McCarthy, T. Boston: Beacon Press

Heer, J., F. Van Ham, S. Carpendale, C. Weaver, and Petra Isenberg (2008). Creation and Collaboration: Engaging new audiences for information visualization. In: *Information Visualization* pp. 92–133, Springer 2008
http://www.cs.ou.edu/~weaver/academic/publications/heer-2008a/materials/heer-2008a.pdf

Innes, J., D. Booher (2010). Planning with Complexity: An Introduction to Collaborative Rationality for Public Policy. New York: Routledge

Kaestle, C. (1988). The HISTORY OF LITERACY AND THE HISTORY OF READERS In: Perspectives on Literacy Eugene R. Kintgen, Barry M. Kroll, Mike Rose eds. p. 96 SIU Press, 1988

Miller, P. (2017). Is Design Thinking the New Liberal Arts? In: The Evolution of the Liberal Arts in the Digital Age pp.167-173 Taylor & Francis 2017

Nagourney, E. (2012) Who Told AARP About My Birthday?. In: New York Times Booming Section, Question Mark Column, Nov. 9, 2012
https://www.nytimes.com/2012/11/09/booming/how-aarp-learns-peoples-birthdays.html

Nedelkovski, I. (2017). The Smart City as Shared Design Space. In: Smart Cities in the Mediterranean - Coping with Sustainability Objectives in Small and Medium-sized Cities and Island Communities (pp.153-174) Springer

Nguyen, M. T., E Boundy (2016). Big Data and Smart (Equitable) Cities. In: Seeing Cities Through Big Data: Research, Methods and Applications in Urban Informatics. Piyushimita (Vonu) Thakuriah Nebiyou Tilahun Moira Zellner, eds. Springer 2016
https://play.google.com/store/books/author?id=Piyushimita+(Vonu)+Thakuriah

Perry, D., B. Howe, A. M. F. Key, C. Aragon (2013). VizDeck: Streamlining exploratory visual analytics of scientific data. In: *iConference 2013 Proceedings* pp. 338-350.
https://www.ideals.illinois.edu/bitstream/handle/2142/36044/206.pdf

Plaisant, C. (2005). Information Visualization and the Challenge of Universal Usability. In: J. Dykes, A.M. MacEachren, M.-J. Kraak (Eds.), *Exploring Geovisualization* Elsevier 2005 http://hcil2.cs.umd.edu/trs/2004-36/2004-36.pdf

Prodromou, T., T. Dunne (2017). Data Visualisation and Statistics Education in the Future. In: *Data Visualization and Statistical Literacy for Open and Big Data.* IGI Global pp. 1-28 https://www.safaribooksonline.com/library/view/data-visualization-and/9781522525127/

Rosen, R. (2013). Why Today's Inventors Need to Read More Science Fiction. In: The Atlantic Sept. 20, 2013.

Qu, Z., J. Hullman (2016). Evaluating Visualization Sets: Trade-offs Between Local Effectiveness and Global Consistency http://faculty.washington.edu/jhullman/BELIV_16_CR.pdf

Satyanarayan, A., R. Russell, J. Hoffswell, J. Heer (2016). Reactive Vega: A Streaming Dataflow Architecture for Declarative Interactive Visualization. In: *Proceedings*, InfoVis 2016. https://idl.cs.washington.edu/files/2015-ReactiveVega-InfoVis.pdf

Seo, J., B. Shneiderman (2005). A rank-by-feature framework for interactive exploration of multidimensional data. In: *Information Visualization* v. 4, n. 2 pp. 96–113. https://pdfs.semanticscholar.org/3102/2f1999dd7b48b6d755732d0a7411764f3476.pdf

Smith, A., K.L. Schlozman, S. Verba, H. Brady (2009). Will Political Engagement on Blogs and Social Networking Sites Change Everything? http://www.pewinternet.org/2009/09/01/will-political-engagement-on-blogs-and-social-networking-sites-change-everything/ Accessed 9/21/2017

UK Infrastructure and Projects Authority (2016). Government Construction Strategy 2016-20

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/510354/Government_Construction_Strategy_2016-20.pdf

Wolff, A.; D. Gooch, J. Cavero, U. Rashid, G. Kortuem (2016). Creating an understanding of data literacy for a data-driven society. In: *Journal of Community Informatics* v. 12 n. 3 http://ci-journal.net/index.php/ciej/article/view/1286/1225

Wongsuphasawat, K , Z. Qu, D. Moritz, R. Chang, F. Ouk, A. Anand , J. Mackinlay , W. Howe, J. Heer (2017). Voyager 2: Augmenting Visual Analysis with Partial View Specifications. In: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* pp. 2648-2659 https://dl.acm.org/purchase.cfm?id=3025768&CFID=1009868292&CFTOKEN=69981534

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