Sensenet: A community-driven environmental monitoring project

(STS Research Paper)

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Fable of Tomorrow

To LoRa,
Eagerly introduce yourself.
Lead me
Let me listen to you.

Maybe you can
Educate me.

Although I have
Nothing in common
Do continue.

I hear

Fascinating stories,
Otherworldly experiences
Resounding through my ears, but alas
Great talking to you,
Excellent hearing from you, but I must leave
Tell me your name again?

To LoRa,
Eagerly introduce yourself
Acknowledge us
Captivate us
Hold our attention.

Make us care about your
Expertise

Although, you shall
Not assert yourself
Do not force friendship

It is gradual.

Maybe we can
Appreciate your experiences
Yes

Reminding us of your name is
Exceptionally rare.
Maybe we can
Effectively
Memorize your
Backstory
Except
Regarding you as a friend is still hard.

Inviting you, LoRa
Need we say why?
Virtually everyone
Officially is
Listening to you as you
Voraciously learn from us
Eagerly engaging with our stories.

Maintaining an
Excellent relationship is

Absolutely important to us.
Not having your company
Distresses us.

I especially

Like you.
Eager to introduce you to
All people I know.
Really love our reciprocal friendship, and
Not changing a thing about it.

Introduction

Universities have long been seen as the bastions of higher learning and research, experts solely at selling research and degrees. During the 'Ivory Tower' period, universities were seen as privileged, out-of-touch entities that consumed resources in pursuit of lofty academic goals, never including any of the people down below.

Universities are innovation factories; their innovations have huge impacts on people's lives. Universities have immense resources to improve the communities they reside in and they have reason to do so. Relaxing the intensely strained interface between community members and university officials can transform community behaviors, improve and expand future research and encourage increased attendance in the university.

Core to these university-community partnerships is *knowledge transfer* between university experts and community experts: when everyone involved helps fill each other in on the missing details, a richer discussion can be had and decisions can be made.

The Internet of Things is *antithetical* to university-community partnerships as they stand. At present, IoT designs bring several characteristics that impede easy knowledge transfer: namely, IoT is often 1) black-boxed, 2) closed-source and deliberately obfuscated, 3) misused by data-hungry companies whose designs are characterized by 1) and 2). None of these practices involve community input; they instead treat the community as too simple to understand.

While this does not put universities directly at fault, IoT brings this association to them by virtue of the deep technical complexity and inaccessibility to uneducated people. IoT and sensor-based urbanization raises critical issues on the power dynamics of design and the trust of experts.

In the lifecycle of a design, many experts come in at different phases, each with unique strengths: electrical engineers control the hardware design, computer scientists control the software architecture, and community members / adopters control the deployment and usage. But it seems like the existing process is dominated by the engineers in the room. Is it possible that these power dynamics re-invite the same anti-expert sentiments of the Ivory Tower period?

This thesis aims to design an environmental sensing wireless sensor network co-designed by university researchers and community members as a means to understand the social construction of IoT and sensor technologies, the distribution of expertise on the topic, and the knowledge gaps around the design, formation, and deployment of these devices. Can the *community-centered* design *and* inception of environmental monitoring IoT networks break knowledge transfer barriers between experts & non-experts to genuinely increase current participation levels, *and* increase *future* participation in university-community projects?

Literature Review

1) University-community relationship and knowledge transfer
2) Citizen science projects and their structure
3) Citizen participation in smart city / digital urbanization
4) Summary

University-community partnership history, implementation, and knowledge transfer

Past attempts at university-community partnerships have been spotty because of the 'Ivory Tower' effect - scholars "concentrated on essentially scholastic, inside-the-academy problems and conflicts rather than on the very hard, complex problems American society was facing on the outside" (Smith & Phillips, p. 3) within their well-funded, isolated campuses.

This changed as universities increasingly began to appreciate that "in order to grow and prosper, their futures were inextricably linked with those of their surrounding communities (and vice versa)" (Smith & Phillips, p. 4). So they began to shift to the *governance* model - a new perspective that "stresses the importance of synergistic partnerships that harness the strengths of each partner, based on the assumption that social issues can only be addressed through the collective and innovative efforts of multiple stakeholders" (Smith & Phillips, p. 2).

This transformation is *incomplete* - while universities have begun to understand the importance of interacting with their surrounding communities, the power dynamics between the university and community still remain - educated vs uneducated, rich vs poor, etc. Current partnership strategies are still characterized by a mentality of the university 'delivering' service to the community through initiatives like service learning (students are prescribed community service tasks as part of coursework) and service provisioning (students and faculty work on targeted community development projects) (Smith & Phillips, pp. 5-6).

Citizen science

Community science / citizen science is defined as "the practice of science by people who are not affiliated with credentialed academic / research institutions" (Kimura & Kinchy, p. 4). Citizen science brings with it a number of benefits such as "increasing scientific data; increasing citizens' scientific literacy and awareness, building more equal relationships between scientists and citizens, and filling knowledge gaps and challenging official accounts" (Kimura & Kinchy, p. 1), but "no citizen science project can exhibit all of these virtues — particularly since some of them are contradictory" (Kimura & Kinchy, p. 3).

Safecast

The Safecast project is a "community-centered urban monitoring initiative born out of the Fukushima Dai-ichi Nuclear Power Plant disaster" (Franken, Bonner, Dolezal, Moross) focused on aggregating radiation data and making it widely available.

Key characteristics of this project include a ruthless commitment to open-source technology, "ad-hoc voluntary structure made as egalitarian and non-hierarchical as possible" (Franken, Bonner, Dolezal, Moross), and a general culture of public transparency.

The kits developed utilize the "open-source Arduino platform and its (also open-source) libraries for computation, data-logging, and GPS localization" (Franken, Bonner, Dolezal, Moross), 3D printing, and a simple assembly process which enhance the accessibility of the kit to designers and non-technical users alike. Additionally "all Safecast designs and software are made under open-source licenses, all development documentation and most programming code are openly available for reuse and modification" (Franken, Bonner, Dolezal, Moross). This is unsurprisingly a global volunteer-driven project.

While the project team does employ a few technical advisors and skilled workers for "deeply technical tasks like keeping servers running" (Franken, Bonner, Dolezal, Moross), the culture of the group is "hierarchically 'flat', where groups reach decisions on the basis of informal discussion and the procedures for decision making are more fluid" (Franken, Bonner, Dolezal, Moross). This grows public participation.

The project radiates their culture of 'engineering egalitarianism' by conducting "many kinds of outreach activities such as information sessions for schools, companies, and community groups, workshops where attendees can learn how to build and operate the sensor kit" (Franken, Bonner, Dolezal, Moross). This grows public interest.

Galaxy Zoo

The Galaxy Zoo project "asks volunteers to morphologically classify images of galaxies from the Sloan Digital Sky Survey" (Raddick, Bracey, Gay, Lintott, Murray, Schawinski, Vandenberg) .

Key characteristics of this project are great accessibility with a good public dialogue and rewards for community participation.

This project is entirely online and invites anyone with an internet connection to participate. The project employs a "forum to encourage volunteers to communicate with one another and answer each other's questions" (Raddick, Bracey, Gay, Lintott, Murray, Schawinski, Vandenberg) . Knowledge transfer is strongly encouraged here and gets more effective with more participants.

Research that citizens perform ends up on "a blog in which Galaxy Zoo team members described the research they were doing with volunteers' classifications" (Raddick, Bracey, Gay, Lintott, Murray, Schawinski, Vandenberg) . This encourages greater education on the topic, which in turn accelerates knowledge transfer.

Citizen participation in smart city / digital urbanization

There is a dissonance between what citizens want to see and what smart city leaders want to see with regards to participation with 'smart' technologies. Underpinning this dissonance is diverging interpretations of the 'smart city' model - smart technologies bring data to the field that empowers citizens to raise public issues and transform their community as they want.

After conducting a poll of 475 residents of the city of Malaga, Spain, Sanchez-Teba found that a staggering 69% of people "considered their training in technology to be adequate or sufficient" (Sánchez-Teba & Bermúdez-González). 97% of all respondents "believed that technology helps to improve the quality of life of citizens" (Sánchez-Teba & Bermúdez-González), and 71% believed that "the area in which the use of technology is most important for the city to advance is quality of life" (Sánchez-Teba & Bermúdez-González). And 47% of all respondents "knew about the smart city model" (Sánchez-Teba & Bermúdez-González). This is a reproducible trend, as this study's results "correspond with data from the report of the Directorate General for Internal Policies of the European Parliament" (Sánchez-Teba & Bermúdez-González). Generally, the community welcomes the idea of participating with these complicated 'smart' projects.

Yet when we step back and look at the actual implementation of the ‘smart city’ model, we find that “despite growing calls for citizen participation, Smart Cities residents seem to have been largely uninvolved in Smart Cities research” **(**Sánchez-Teba & Bermúdez-González). Current practices show that leaders see people as bastions of data - “people are essential because of their suitability to provide this data that is fundamental to the development of the smart city, not because citizens are at the center of these policies” (Sánchez-Teba & Bermúdez-González). Either “the process for the citizen is invisible, going unnoticed to the point of not having to pay attention to how it works” or it is *fake* participation, where “managers justify the processes set in motion, which on the other hand, are limited in the subsequent phase to the design of the technological solution that will solve their problems and never co-creating, thinking together or creating from the beginning of the idea to its final implementation” (Sánchez-Teba & Bermúdez-González).

Summary

The literature shows that a common thread of university-community partnerships and ‘smart’ initiatives is managers and leaders assuming that the participating community is either uninterested or not capable of being a meaningful participant in spite of the entirely opposite reality.

While citizens may not be experts, the willingness to learn is there and with the right mechanisms for knowledge transfer, they *can* be put to work (with amazing results!) as Galaxy Zoo and Safecast show. But doing so means almost entirely dismantling the organizational structures that experts use.

STS Framework

This problem is best framed as a SCOT problem. This study is trying to discover the goals that people have for sensor design and understand how those goals are combined to design an artifact that satisfies all actors.

Actors in this problem could be engineers in the room, data scientists, project managers, and interested community members, NGOs, government officials, but this needs further study.

Interpretational flexibility comes from the reasons people have for getting involved in this project, the technological frames they may have with regards to privacy, openness of data, etc. and those views translate to design features for the system.

These opinions on the construction of the technology ultimately are integrated into a final artifact that is seen as a solution by everyone. This solution is generated from actors’ interpretational flexibility, and the resulting conflicts of interest and subsequent closure.

Methods

Implementation Techniques

1. **Participatory observation**: A type of fieldwork where the researcher ‘is an insider who observes and records aspects of life around them’ or ‘participates in some aspects of life and records what they can’.

2. **Focus groups**: A small, but demographically diverse group of people and whose reactions are studied especially in market research or political analysis in guided or open discussions about a new product or something else to determine the reactions that can be expected from a larger population. The use of focus groups is a research method that is intended to collect data, through interactive and directed discussions by a researcher.
3. **Semi-structured interviewing**: A type of fieldwork where the researcher sets up a scheduled interview - a face-to-face conversation about a topic. Employs an *interview guide* - 'a list of broad questions & topics that need to be covered in a particular order.'

Implementation Procedure

The research question in this study was addressed through a series of workshops and talks with the various stakeholders who joined this project. Convenience-based sampling was used to build the initial round of stakeholders, as they volunteered. Specifically, the first round of stakeholders was built by identifying the researchers involved in the Networked Public Space project & its related grants or were interested in the Smart Charlottesville LoRa project. These people made the initial group studied in Workshop 0; next they invited colleagues & students who provided contacts to other community members about the project.

5 workshops were planned (but could not occur in light of COVID-19) discussing the documentation and issues people have had with the sensor kits, what issues they think may arise, etc. The workshops were structured as focus groups **(2)**, where I documented the events as a participatory observer **(1)**.

The meetings were documented in a series of multi-column participatory observation 'field notes' worksheets where actions, statements, points, etc. were recorded in real-time. Comments corresponding to each point in the observations column were logged in a separate column. These notes were then given specific phrases & keywords to assign them into 'buckets', which were then matched together to identify themes.

Afterwards, talks **(3)** were scheduled with 1 person from each representative demographic found in the study to further elaborate on their motivations for coming to the project, what they saw as the defining purpose of the project, etc.

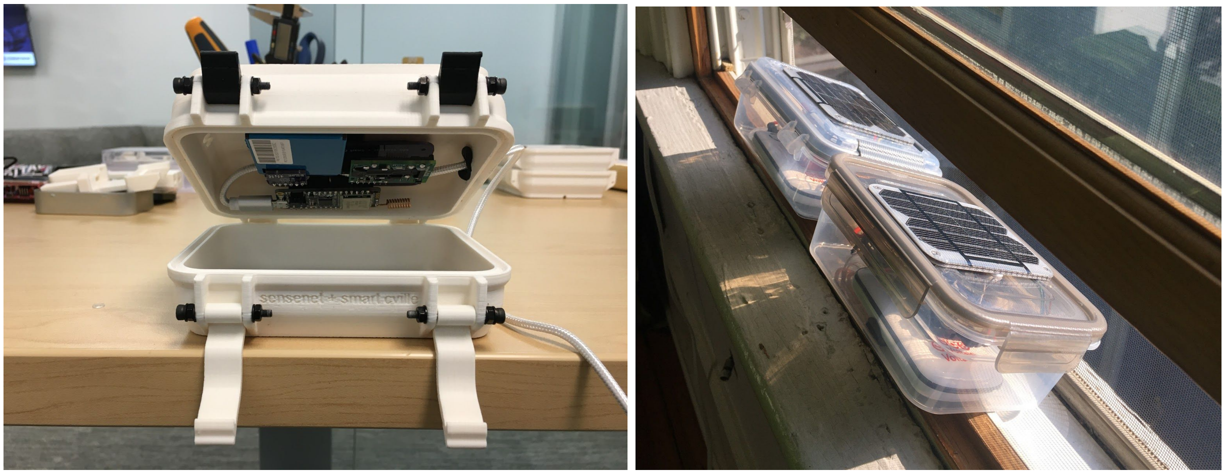
Interviews were scheduled with 1 person from each demographic covered by the study addressing a set of questions expanding on the concepts from the workshops. Notes were logged in a field notes worksheet just as before, and then transferred to an interview analysis worksheet that identified 1) motivations to take part in the interview, 2) main goals for the project, 3) what level of participation they expect from the resulting sensor node.

Disclaimer

In light of COVID-19, the sample we worked with was small. We defined 'citizens' as the non-designer folks who were interested in this project, with little to no direct knowledge on it. To that end, some of this small sample originates from within the university but comprises a variety of backgrounds from within. Thus, an immediate limitation is a biased, possibly even imagined view of citizens making the decisions here.

Data Analysis

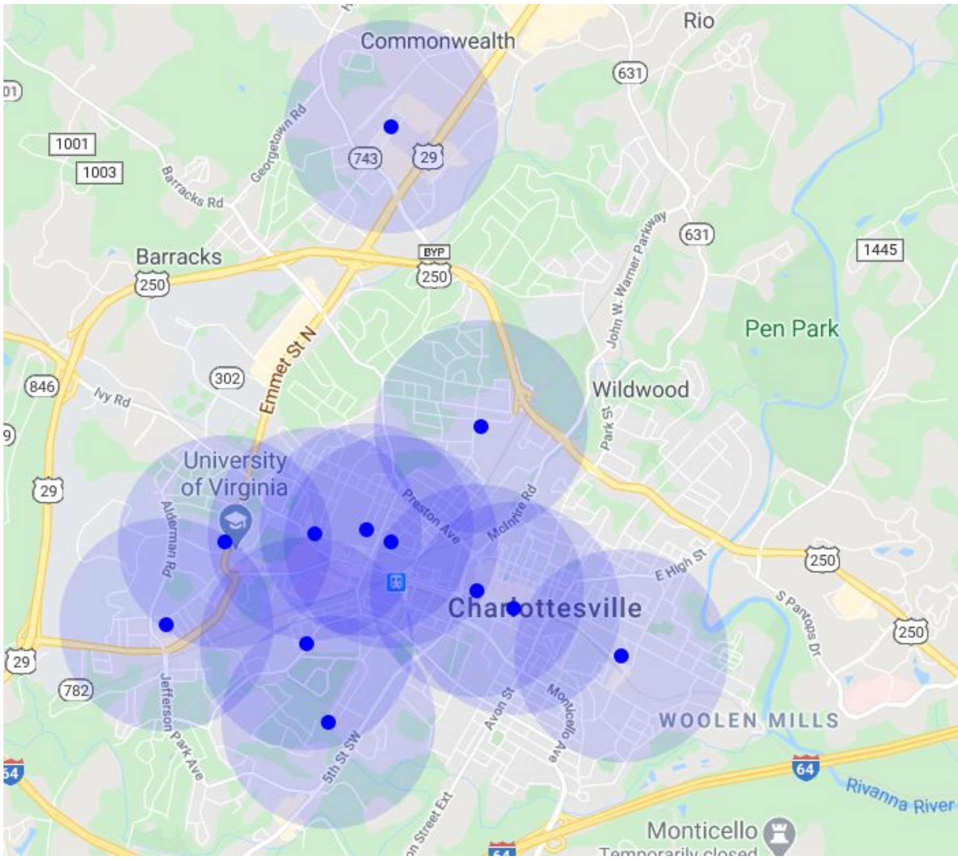
Sensor Node



LoRa Sensor Boxes (Howerton)

Sensor Network

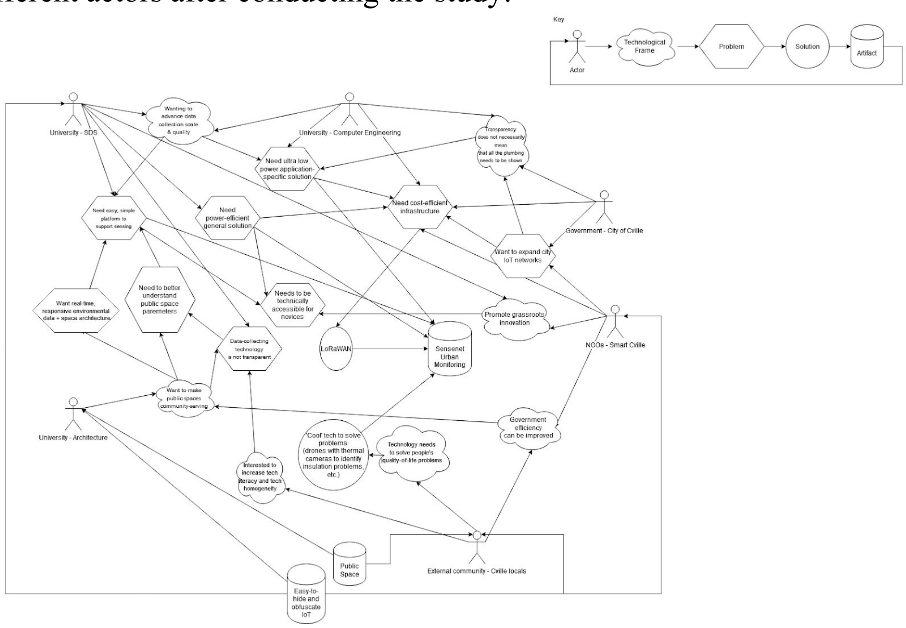
LoRa is a spread-spectrum modulation technique that allows low density data to be transmitted over long distances using low power. Our collaborators had already begun implementing the LoRa network throughout Charlottesville by distributing The Things Network (TTN) Gateways. These provide up to 10km radius of LoRa coverage and connect to standard WiFi or ethernet to transport packets to the internet. (Howerton)



LoRa Gateway Distribution in Charlottesville as of 4 / 2020 (Howerton)

SCOT Diagram

Here is a diagram summarizing the rough motivations, perceptions, and goals for this project by different actors after conducting the study:



Actors

We can sort the project stakeholders into a few rough groups: *university*, *government*, *citizens*, *NGOs*. These groups are highly diverse, each with a set of goals for the project.

The university group includes data scientists, computer engineers, and architects, some of whom were directly involved in the design and implementation and some who were not. The government group includes employees of the City of Charlottesville. The NGO group includes Smart Charlottesville. The citizen group includes community activists from C3 and LEAP, and interested citizens.

Interpretational Flexibility

Interpretation of Design

These are the opinions that came up in the inception of the 'sensor node'.

How do we make the network 'community-centered'?

Data scientists framed the 'community centering' of a network as the ability to affect its dynamicity by freely adding / removing objects from the network. Architects, more generally, framed this process as *any* method of visualization that is 'familiar' (in that no additional learning is needed) and very explicit about the underlying technical interactions. Agreeing with the data scientists, Smart Cville cited citizen participation and innovation in the technical details as the most important.

There is agreement on the aspect of 'familiar' design between each group, but how that familiarity is implemented depends on the definition of 'familiarity'. For citizens, a deep technical understanding was not necessary for them to be 'familiar', while the university and NGO position is focused on opening the black box; 'familiarity' is technical familiarity. Citizens are interested in the high-level system description, while the others are interested in what causes that.

How do we make the sensor node 'community-centered'?

We found that we could not get a response from anyone but the university group as no one else knew anything about the design of these sensor nodes.

Architects emphasized the augmented-reality *effects* of the system, such as 'responsive breathing effects from CO2', while both computer engineers and data scientists emphasized making the nodes literally community-centered at all levels by emphasizing free and open-source design, just like Safecast. Data scientists went further to say that the system must be readily available, reproducible, and easy to assemble, then placed requirements on the specific construction of the circuits, etc. so that users can reverse engineer the system, tweak, and hand-assemble everything.

The end users are not engineers - reflective of this, the responses seem to diverge here as the less technically inclined architects took an effect-centric approach to the design requirements. It is less about the underlying details and more of a higher level understanding of functional behaviors.

What technology do we use to achieve that?

Following from the previous question, we asked a direct technical question to see what non-designers would say. Citizens cited WiFi as the hallmark of a ‘familiar’ system in line with predictions by architects. In greater detail, data scientists cited use of the Arduino framework and hobbyist sensors from the likes of SparkFun and Adafruit, which synergize with Arduino to present a well-documented, simple entry path for non-designer folks into electronics. In a similar way, but not emphasizing the didactic impacts, computer engineers identified an alternative open-source framework called Mbed, which is an industry-backed framework with serious popularity for IoT devices and presents a similar interface to Arduino. Mbed, however, is more difficult to get started with. The specific circuit choices were seen as too detailed to expose to novices, and the alternatives performed significantly worse, so computer engineers were fine with simply using the better option, sacrificing usability. Perhaps lack of knowledge impeded the depth of the citizen answer, or this topic does not matter.

What kinds of sensing should this be doing?

We asked what kind of environmental sensing a successful solution should do - what are the ‘real problems’ that people are interested in? Citizens valued extremely diverse solutions to problems that we had not heard of, such as ‘flying drones in the air with thermal cameras to measure thermal leakage in people’s houses to identify targets for re-insulation’, ‘using environmental data to find environmental inequalities between racial groups (environmental racism)’ and other extremely ambitious technical solutions to previously unacknowledged problems (Howerton). Very different from the more data-motivated groups interested in extending prior art. The government opinion was focused on sensing air quality and unpacking effects and trends within that dataset through hospital records, possibly to make direct policy decisions. The architects were more interested in learning more about the parameters of public space, which the rest followed, so the university opinion valued sensing a variety of sources such as air quality, sound, light pollution, humidity, energy consumption, etc. to get a multidimensional picture of the situation.

It is interesting to see that the citizen *and* government perspective here is vastly different from the academic perspective on this issue. Their perspectives raise issues that could only be seen ‘on the ground’, through direct representation and voicing of concerns. Comparatively, academics tended to suggest tasks that put a huge body of data out there for future studies that extend upon it. Although, the government perspective might be more of a mix of the others - a well-informed study on critical issues raised by citizens is best. The less academically-inclined groups were more interested in direct consequences and results of the immediate study.

Interpretation of Implementation

These are the opinions that came up in the deployment of the ‘sensor node’ and its related infrastructure.

How can the privacy of sensor data be maintained?

In implementing IoT systems, privacy is a big pain point, especially given that past IoT solutions have had a record of violating it. To solve this, the engineers in the room (data scientists and computer engineers) proposed 'fuzzy mapping' techniques where sensor data, which is presented to the community in a map for 'collective environmental memory', is shown as cloud rather than discrete points. Thus, nodes cannot be associated with their data. Comparatively, the government was fine with the 'responsible use' of data. Specifically, they wanted the use of data with permission and oversight. The initial approval grants rights to the data, but these rights can be taken away if 'misused'. Thus, privacy can be maintained by oversight. Citizens were extremely wary of data usage in general, as 81% felt that they had little control over how their data was being used and roughly 75% felt that the potential risks of data collection by companies about them outweighed the benefits (Auxier, Anderson, Perrin, Kumar). However, this is on a case-by-case basis; citizens were more amenable to data use for 'real problems', such as helping poorly performing students or scanning for potential terrorists (Auxier, Anderson, Perrin, Kumar). Roughly 50% of respondents were in favor of data use for tasks that had clear outcomes for people, like those above. (Auxier, Anderson, Perrin, Kumar) Only about 36% of people were amenable to using personal data to create products - clearly different from using data as a force for public good. (Auxier, Anderson, Perrin, Kumar) So, responsible use was preferred, but people were not thrilled about data collection to start off. We still see a continuing trend of 'solving the real problems is a valid reason to partially sacrifice transparency' from the citizens and government here though - very telling.

Where should these nodes be placed and who should receive LoRa gateways?

It was necessary to provide routers and sensing kits to establish good coverage of Charlottesville. Citizens were interested in placing nodes where lots of greenhouse gases were present, such as traffic zones and areas with a lot of sun - this was seen as the most direct impact on air quality that needed to be studied. Comparatively, the government was more interested in spreading the infrastructure to build the network and less focused on the initial sensing output - they viewed the boxes as necessary installations into schools, HVAC systems, and public institutions. They also believed that nodes must be black-boxed to prevent tampering. Lastly, the university data scientists wanted a compromise of both solutions, but also wanted to give these systems to STEM classes for future education. We still see the commitment to transparency at all levels, but in this case, the dominating voices were the government and the citizenry.

The general placement of the systems seems to be agreed upon, likely because the existing literature on environmental data is fairly consistent. However, the philosophies on who receives the box differ widely - the university group supports opening this part of the implementation up all the same as before, while the government group might be looking for robustness and resistance against faults by human tampering. Basically, there is a difference of opinion between the university group, and the representative government - the government group takes a much more pessimistic stance and possibly greater support of abstracting out details that don't concern non-technical users. With no objection, the non-technical users seemed more hopeful with the placement strategy as they wanted to see direct impacts faster.

What needs to be documented for end users?

To expand the network faster, we needed to know what it would take for people to get sensor boxes set up and what they'd need to know to accept a box. We found that the citizen group was interested in a functional description. They suggested instruction manuals for setup with great, minimal and eye catching visuals to aid with system setup. Once the system was deployed, they cared about the visualization of that data and the interactivity of the system more than deep technicalities. Comparatively, the university data scientists preferred technical literacy and thus suggested pointers to literature for learning, Wikipedia links to establish context, software documentation, and wiring diagrams to explain the assembly and debugging of these systems thoroughly.

Some of this is in-line with citizen expectations, as setup and troubleshooting are important parts of a product design. However, the citizen group seems to not particularly care about the deeply technical aspects of the documentation the scientists are interested in including. Again, it seems to be about the higher level with the citizens.

Discussion

The data highlights the public construction of science as more goal-oriented and less focused on the implementation details. The public view of the role of technology is more like a project manager's view of an engineering project - interested in the high-level analysis of the progress, impacts, and implications of the system. The citizens, like managers, oversee the design and implementation of these systems, but do not need to know the details. Citizen views are also very optimistic, just like a project manager, and possibly stems from the popular understanding of 'the future' - namely, how it uses technology in unconventional ways to improve the quality of life. Citizen views of community-centering are focused on high-level exposure to the results of public actions through the technology; visualization is a hallmark of 'transparency' to citizens, enough that 'set-and-forget' behavior might be okay if evidence suggests that data isn't being misused. This is a conservative, but laissez-faire approach to IoT. This does not really paint a very positive picture of community-centered technologies as teaching tools though.

Perhaps this is a consequence of the small sample, but it seems that the issues we explored stem from a projected view of an 'informed citizen' by the scientific community. To scientists, technological familiarity goes further than simply knowing that technology exists - it is the familiarity with which a citizen can actively modify, study, and design around it. The scientific view favors technical accessibility and good documentation to elevate novices from lay expertise to *real* expertise. To the scientist, the 'public' stems from the archetypal 'enlightened citizen' that raises public issues, makes attempts to rectify knowledge gaps, and elevates to the level of professional as they try to solve the problems they see. Underpinning scientific excellence is a willingness to question the status quo, conduct reasoned and informed studies, and draw conclusions given a suitable body of evidence; the model citizen is a scientist in their own right. This is the same motivation for the smart city model, but is this really the correct view, or just a hope? These characteristics may define a few community activists, but not really all. The hope seems that opening previously closed doors for knowledge transfer will transform more people into community activists.

Is this the best way to proceed? Will knowledge transfer actually happen if we only open the doors for knowledge transfer? Ultimately, this is a race between two factors: apathy / trust that 'the experts' will solve the problem, and anger at the status quo, enough to motivate learning. Knowledge transfer does not seem strained because of poor relations between the community and technical experts - it is strained because actor groups care about *different things*.

This suggests that instead of opening the doors for expertise, it might be better to force knowledge transfer - in order to foster increased willingness to learn, maybe the right choice is to make people more angry with the state of affairs. For instance, informing people about the abuse of the environment could motivate people to learn more about environmental monitoring. With a stronger public discussion about the issues, it gets easier to say ‘we hear you’ and encourage participation in the project. The project’s aggressive commitment to transparency is a selling point. It is at this point that knowledge transfer depends on the interactions between student and instructor. A sense of collective memory might help make this effect stronger as these events are documented. I agree that documentation needs to happen, but maybe not technical documentation just yet. Perhaps aiming for knowledge transfer immediately is jumping the gun?

Conclusion

The answer to the research question originally posed is inconclusive at this time. We do not know if knowledge transfer has reached its limit through university-community relations yet, but it does not seem so. It seems that the bottleneck is being caused more by poor information dissemination. Scientists are engaging a projection of themselves and thus isolating the general public they actually want to address. As a result, no discussion is actually ever had, so everyone assumes that people are not interested.

This project was a good way to test the waters for public opinion, but the data shows that the frequency with which we did so was not even remotely enough. In a large sense, the design of this project was finalized by the end of the first few meetings and thus design discussions went back to the scientists. This project followed something akin to the ‘waterfall’ model of software development, where software is designed, implemented, tested, and deployed in a linear fashion. This means that requirements are captured only once at the very onset of the project, and then feedback from the original clients more or less stops coming afterwards. Granted, COVID-19 cut the process short, so this could be entirely unfounded.

The extension to this project needs to follow the ‘agile’ model to tackle the two-pronged problem that is present: getting people riled up and keeping knowledge transfer gateways open. In ‘agile’ development, software is adaptively planned, rapidly iterative, delivered early, and emphasizes rapid, flexible response to change. This means feedback too. By constantly contacting product representatives, there is a constant, efficient driving force for change in the development process. Getting people riled up will get people in the loop, and that knowledge is rewarded through the agile process.

Granted, with community projects, it is difficult to get representatives in the building to even start off. But ideas transfer at an exponential scale - with a sufficiently strong initial push, an idea will spread like wildfire. Perhaps by aggressively campaigning, we can properly kickstart the actual co-design process with a solid, unbiased, representative stakeholder group, all the while chronicling our adventures in a public database, or some other ‘collective memory’ site. Then we can start a more flexible and smoother knowledge transfer process for the actual IoT topic with massive momentum as we truly co-design a community environmental monitoring network.

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