Interview med Lukas Mocek fra Sensor Community

Interviewet er foretaget fredag d. 15 oktober 2021

Lukas: Hello

Maria: Hello! Is it okay if we record this meeting?

Lukas: Yes, of course

Maria: Yeah, okay. So we wanted to ask you a few questions about your community.

Lukas: Is there someone else with you?

Maria: Yeah, this is Luna and Julie

Lukas: I only see you, but that's okay!

Luna: So our first questions is "what provoked or kickstarted your idea to start Sensor Community?

Lukas: Okay, so in the beginning there were news articles in the newspapers, that the official measurement stations had detected very high values and very quickly such values are compared to global level. And then our city, that has around 600.000 inhabitants, was compared to cities like Beijing and Shanghai that has over 30 million.

The point is, that two years prior to this article, I was living in both cities for a year each. That was kind of crazy, because I experienced how the stations were there and I was very… how to say? sporty and I could run a lot, but there I could not run after 15 minutes because my breath was taken away from me.

Having such values in Stuttgart was frightening and we citizens had the idea that how easy it would be if you could just go to a website and you open it open and have a visualization – a map – that detects the values of how the situation is now. We asked the official institutions and requested the data. The first responses was "no, we could not have it" but after telling them that there is a European law so you should give it, then they give you a PDF, which is not in a shareable format with values how the situation was 6 months ago.

Through a lot of pingpong you see the frustation is increasing but you see that you will not get an IPR with fresh results from today or now that you can display on a website. Then we had several different technical groups here in hackerspaces, libraries, that are meeting and setting up networks for communication. They kept it together and explored what was possible, so we bought sensors that were available to citizens and low cost. Then we created this core kit, that you still see on the website. We had a campaign that was that we wanted 300 sensors just for our city. In the beginning it was a very local approach just to cover our city and it was very German. Everything was communicated in German. What was great was that, through a crowdfunding campaign money came together and then it was rolled out and a network was established with the 300 sensors.

Everything was from the beginning being done in a very transparent way. The code that was used was immediately open source so people could follow up how it works and the data that was provided was immediately 'open data', so everything ever measured, you can download.

Then there was the third pillar, that is the visualization – the map – that you can see the values with how it is now, and this is refreshed every 2 ½ minutes automatically.

Maria: And you are an NGO, right?

Lukas: We are currently nothing, we are just 4 people that know eachother.

Maria: But what is your background then? Are you educated within sensors or with air pollution?

Lukas: No, no specific sensor or air pollution background. We had from the beginning team members that are from the field, for example Ewald, that is now retired. He is a meteorologist, and he was one of the people setting up the official measurement station network, so he brought in the knowledge about what to care about and the contacts with the material testing institutes where we gave them some of our devices and they ran this 3-step process of measuring in their facility which is like a closed chamber where they can change all the aspects of the air, temperature, and humidity.

This is the same process they also do with the super expensive equipment. Then they have mobile version of their measurement devices which is placed into the field. Side by

side with our sensors. Then an official person comes and goes through the checkbox and sees if anything doesn't have to be done it measures for weeks.

Then in the third and final step they, an institution, create a document which says how good or how bad the sensors behave. In this you should see a graph of how quickly or great this very local sensor of only 17 euros and the size of a hand behaves. That means if the curve goes up, how quickly it will follow the values and how close it will follow the official values. Both is really good, actually crazy good. Of course it is not exactly the same, but that is due to the process of how it is measuring because it is using a laser. It sucks in the air through pipe into the chamber and the laser sensors the light and then the detector detect what is reflected by the particles. This process is being repeated every 2 ½ minutes. It sends out the data through our server and what we do, is we pay the cost for the server from our pockets and then we maintain the server, the software and website. We aggregate the data through the sensor network and we make it available publicly.

In the beginning it was only a German project and now we have switched into a global platform, operating in 24 languages. So Germany is only one of many.
We see it as one of possible 200 in the future correctly. We are operating in 70 countries, where the sensors are located. We are receiving every two and a half minutes the data from more than 40.000 sensors and have generated over 14 billion datapoints.

And by the amount of sensors and amount of datapoints we are, just a comparison of numbers - I'm not expressing quality - but the amount of sensors and the amount of datapoints, we are more than 4,5 time bigger than the collective European network of air quality station and we are growing much faster than them. The point is that we never express that we have any intention saying we are better than them its only we see ours as an addition. Later on, I can also refer to what RIVM – National Institute for Public Health and the Environment in the Netherlands in terms of putting both data sets from the official station and our stations together.

Maria: Okay, so you are growing quite big as you say. But have you had any impact on initiatives in Stuttgart?

Lukas: Yeah, in Stuttgart, we have established our network with more than 800 sensors and there is the live visualization map, which is like used by citizens, so they open it up when they stay, and they go out for a walk with the dog or with the child or when they go running so they can decide how is the situation now and they can also click on their sensor and they see how it was in the last 24 hours so they see if they're on a downside, fallingside or a uprisingside. So based on the data, they make the decision, how the situation is. And when you say we have grown quite far, we think that it's very low so like the 40.000 sensors is like close to nothing for us. It's only a lot in comparison to the official, but we think that it is very, very little and we have a different idea. We think that Sensor.Community is now not a local project, but a global platform and that means two things. 1, that it has to cover the whole world, and secondly it has not only to stick with airquality, but also capture other fields of interest, so we have set up a second network that is special noise which is also a very hot topic and then we want to expand it in the future to many more fields, like soil moisture, water quality, there is like many more fields. So in terms of covering more fields and rising the perspective from the global scale, we are more kind of like aiming for 50 million sensors on a global scale. So then if you have this in mind, then 40.000 is not that much anymore.

Maria: No. But do you wish in the future that governments look at your data and go to you for inspiration?

Lukas: Yes, now you trigger me. That is my topic, that is my role, my position in the team, that is what I was working on the last six years. So here I have many things to share with you and let me start with the really amazing people from the RIVM. I can share all the links with you as well. So this is their official health and environment ministry in the Netherlands and they have seen that we have many local communities being acted so participating in Sensor.Community. And just in comparison of numbers, there are to my knowledge 45 official measurement stations and close to 2000 of Sensor.Community in the Netherlands. And they have opened up a lot, they have fully integrated Sensor.Community into their correctives on measuring on national level and what does it mean? They have developed a data portal that is called "Sammenmeten" and there they have fully integrated their whole dataset, so that means that historical data, the archive, into their data portal so it is available there as well. Then they are

using our RPI which is like the connection where we receive the sensor data and then we distributing it to others so they receive the live values. The third pillar is they visualize the Sensor.Community data on their map to citizens and then the fourth also very important pillar for us, is that they official communicate with the citizen. Whenever a citizen writes to RIVM and say 'I'm from a village or from a city where there is no official station nearby and I won't know how the status is. Then they tell them, you can become a member of Sensor.Community because the moment you send the data to them it ends up in our portal and then we can use it.

And then now to your question. Yes, they are bringing the data of our sensor-network with the official stations together on a national level. They are applying in addition to its correction factor because this type of sensor, when there is a humidity above 80 % it can be that the laser beam is detecting water droplets in combination with the particles. So, then they have worked the last years on a correction factor which they apply and that is also all described on the website, why they do it, how they do it. And then in another point is that they take the datasets and then there is a working group that is called Fairmode and in Fairmode there is, it is under the umbrella of The Joint research center. The center is basically the technical arm of the European Commission with I think 3000 world's best scientist and they are like in north of Italy in the headquarter. And in this Fairmode group there are like all institutions to my knowledge from Denmark I think, but for sure from France and from Italy and from Belgium that are working with the same datasets as RIVM but each of them has different approaches on how to merge our data with the official measurement station data. So, I hope I could answer your question, that what you asked, like it's being done by Netherland's ministry, but then in the Fairmode group on European level. Also another point, two weeks ago VMM, which is in Flanders Belgium, they have basically announced that they release officially, exactly the same what RIVM has done, so the live-data, visualization and recommendation to the citizen.

And now something totally new comes that both of the institutions are working on. Analytical tools where you can basically have a tool where you can merch sensor types so for example (US) citizens go on an app and you click on the Sensor Community sensor and then on one of the stations, of the official ones. And then the data is being on their servers merched and then overlapped and then there is a graph being drawn, where you

can see how close or how far they are from each other with the values.
So, and then a totally different layer is on the European commission level, because there was like the release of the WHO guidance. A new guidelines for air quality levels. And then the day after there was the event of the European Commision revision online meeting or conference. What a crazy name. And basically there we spoked also that we are very, very happy about what RIVM and VMM is doing. That's amazing that they have this data portal and they have fully integrated the data set into their activities but when we accelerate into the future, right, our job is not to go to other institutions, knock on their doors, and tell, "hey we are not citizens try to convince you to do this, but maybe you want to talk with or RIVM and VMM, so you speak with the same like you, another institute, your language, and they can tell you how they did and how they took to them. How it benefit them. And maybe through time we can convince more institutions. But the point is that, when we see 5-6 years in the future, we gonna end up having, in Europe just alone, 80 institutions doing the same. So we gonna have 80 different portals, and isolated. And why not starting now, a European activity and having one data portal where all 80 institutions can contribute. Because it is already open source, open data. The point is only that we raise in this European commission, called a "who to talk with", because in the European commission there is nobody taking care about coordination. So the whole system in Europe is still based on competition. One project, one original project against the other one, and everybody wants to be better than the other one. It is competition based. And Sensor.Community because we do not have limitations like borders, and we are not doing it only for Europa but on global scale, but we have to start somewhere. We would love to have something that, brings institutions together, and collaborate on a solution. And as Sensor.Community is being deployed also in Africa, South America, Asia, this European solution could be also provided to them. But yeah, there is no counterpart to the European Commission or EEA or JRC to discuss this or set up something like that. And yeah, that is quite sad, but Sensor.Community tries to do that.

Maria: Yeah.
Luna: Yeah.

Maria: Okay.

Luna: Just a second. So, with all those sensors you got going on, is it difficult to quality check the data that comes out?

Lukas: Yeah, so we do not do calibrations prior to roll out. So, we also do not sell the sensor. So we basically operate the website where you can find at the top the guides. These guides are provided 24 languages and is basically a step-by-step guide, how to like, it tells you which hard parts to buy, and because in every country there are different stores, so different online shops. And once you receive the parcels the steps, the step-by-step guide tells you how to connect the parts and the sensor with the mini computer. The next step it tells you how to install the throughware which is basically, it makes everything alive. And that is what I mentioned before is the open source. So if you are capable of reading code, you can really look into it and see how it works and what it does. And because it's open source, many programmers contribute code and through that it is a collective improvement on a continous way. And then you basically go to our website and register the sensors telling us where is the location. Is it in the backyard, in the frontyard? Is it at first, second or third level of the house, and you provide us one email address, where it can be like push notification that is sent to you once the sensor does not provide data in the last 24 hours as a reminder, right? So you can check and see if someone unplucked the little power supply, which is like the same like you use for your mobile phone. Or if the data broke down or something else has to be checked. Perhaps the winds took it away, or yeah. But eh, sorry I'm trying to answer like most of your many more questions and you asked that. Coming back, can you repeat your question again? That was specifically about?

Luna: Yeah, it is about like quality checking your data points.

Lukas: Ah yes, I made a big po... Quality checking is, yeah. Quality checking is in that form, that the official institutions say they compare one local sensors, which the size 17 euros, with one official station which depends can be between 10.000 and 1.000.000 euros and can be like shipping size, and then they have also staff that maintain it. So, in such a comparison this is what these institutions have done. The Meterit Institute right? When they put it into the chamber and the field, and they make the report. And this report has been done by RIVM, VMM and JRC. So we at Sensor.Community never

express about the quality of the sensors we only refer to this document and say “this report where between 20 and 30 of the stock sensors have been tested, based on their criteria the SDS011 has performed very well for what we want it to detect, the PM2,5 values, in comparison to official station.” So, this report stated that this sensor is behaving very, very well, and very, very well means how fast it can follow whether there is an upcycle and how close it is to the values, right?

Maria: Yeah.

Lukas: Or when how fast it can detect when there is a downcycle and how close it is to the value. Which is basically the key. There is a second layer of argumentation that is done, when you have massive network, so basically when you have not one sensor compared to one sensor, but like the situation in the Netherlands where you have 45 official stations compared, merged with 2.000 sensors, right? When you take the approach of the mash, the behavior is totally different, so for example when you have one sensor, that has 500 as a value, which is like the maximum and it sticks to that for days you can say okay that sounds like something is broken, so you can identify this one sensor has something faulty and you just take it out of the pool of 2000, and in relation to the other sensors there are close by you see that these says, and see what kind of values they had in the last 24 hours and when they go up and down. So basically, it's different approach when you have 1 to 1 or you have 2000 merging with 45, right? So, 1 vs. 1 and the other one is like 2000 plus 45, right so? And then under other considerations there is what type of sensor it is and merging it with weather data and humidity data and that’s basically what RIVM and we are doing on scale and what has merged to this Fairmode group, this other institute who are also doing this, so you have to build up the expertise to be able to work with this massive amount of data so if you want to break it down its just like 1 sensor with 1 sensor and I'm sure you can find some point that you dislike or think this is not good enough for you, yeah.

Luna: And then we have one last question, and that is what the target demographic is for sensor.community?

Lukas: Everyone like ehhh the 3 years prior to the pandemic I was travelling all over Europe and I was at many conferences and many local groups and teams and

participated in workshops and I must say we have seen all sorts of people ehhh like if you say by age it's like younger, middle-aged, older people ehhh man, woman ehhh like from all sorts of jobs. The point is that if you have built this with your own hands then you will walk out of such a workshop you don't say "I have a sensor", but "this is my sensor" because you understand all the functions of all 4 parts you know how it works and prior to the workshop people think oh I can never build a computer and its expensive like a car and the size of a shipping sized container but when you go out and see it in your hand and be around your friends, your meighbours your colleges ehhh this is very convincing and through this dynamic you don't target specific groups as if you were selected in like a dropbox or facebook advertising, you can reach everyone cause like they speak in their circle and through that it became from 300 to now 40000 and honestly the role out could be much more massive, its currently restrained by these global supply chain limitation the world has with sensors and chip manufacturing so we have reached these 40000 by individuals so one by one. But currently there is a new dynamic that institutions and they have to possible apply through funding for money and they are ruling out systems like in batches of between 500 to 1000 sets. So for ex. one group that is related with air quality with sensors and thousands of people and also by the nation's aggregate money and are ruling out in an area of paris 500 of them in Reihn in a city in Normandy 200, and in the south also 200, so in a very short time we are gonna have 900 additional sensors only for Paris ehhh in university in Groningen they want so rule out 800 sensors in a few months harbor and Rotterdam we now hear between 600 and 1000 sensors they are planning to rule out so we have bigger ehhh batches let's say. And ehh there could be much more if it could be done a bit more coordinated and but yeah ehhh, so but ehh I just mentioned we never sold sensors that's not the business case for us so we don't make any money with this we are citizens creating services for citizens and we basically tell people we provide infrastructure for others because what works here is also needed somewhere else ehhh. We have emails in our boxes from Chile, Mexico, the same like in ehhh Nepal or Asia or anywhere in Europe and we have calls where we teach them what we leant by community building and it's like very different even in Europe like f.x. in eastern Europe is super different from in Scandinavia and in central Europe as well. So, it always needs 3 layers of adaption which is language, culture approach cause every culture speak about certain

things differently, and the local adaption inside of a country, like different cities have problems with f.x. some of them in harbors, some in airports and the other one in combinations. So we need always these 3 layers and these 3 layers are being done by the community in minor steps, we stay in touch and have these networks and that's basically the community of hundreds of volunteers operating workshops and ehhh pingpong messages with us us and ehhh though that serving thousands of people connecting sensors to the network. And then there are like hundreds of thousands of people that consume the data on the map because the map is ehhh integrated as an Eye frame in lots of news websites so it will carry f.x. if our map is only down for a minute we receive a call and they say like "yeah people are missing the data"

Luna: So that was everything we had, so we wanna thank you for participation it was very helpful.

Lukas: Thank you very much, maybe you can let us know where this ends up

Maria: Yes of course, we will write to you

Lukas: Allright, thank you and have a good time

Everyone: Thank you, you too!

Interview med medlemmer af Sensor.Community

GDPR-disclaimer og spørgsmål vi sendte til medlemmerne:

“Thank you for wanting to be a part of this interview and helping us with our university project.

For GDPR reasons we have to inform you about how we store and process your data.

“The answers you provide in this written interview, will be stored. The data will then be analyzed and conveyed in an anonymous manner in our project report and can be used in our further studies. None of the personally identifiable data will be given to any third party. Participation in this interview is voluntary, and legally we can't store or process your data without your consent.”

Please inform us if you agree with and understand this information, before you answer our questions, thank you.

We would like you to answer the following questions. Answer as in depth or shortly as you prefer. The most important thing is that you give personal answers about your experience with and thoughts about sensor.community, sensors, and Citizen Science.

We have six questions:

- How did you hear about Sensor.Community?
    -
- Why did you choose to be a part of Sensor.Community?
    -
- How do you benefit from being a part of Sensor.Community?
    -

Citizen Science is scientific research conducted by normal citizens (non-professionals). This scientific research is usually initiated by people who want to get involved, to illuminate or to convey specific problems. It can also be conducted in an attempt to reach the government and to change the status que. Sensor.Community is a Citizen Science forum, which works with conveying air quality data.

- Are you aware that you take part in Citizen Science?
    -
- What do you use the data for?
    -
- Have you told your friends, network, and colleagues about Sensor.Community?
    -

Thank you for participating.

Kind regards

Luna, Maria, Julie & Caroline

Roskilde University”

Begge medlemmer valgte at bruge vores mail som skabelon, og indsætte deres svar under vores spørgsmål. Vi har fremhævet deres svar med blå for at overskueliggøre svarene og strukturen.

Svar fra Michael:

"Thank you for wanting to be a part of this interview and helping us with our university project.

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Please inform us if you agree with and understand this information, before you answer our questions, thank you.

- I, Michael Lazan give you consent to these answers being stored in anonymous manner in your project report and can be used in your further studies

We would like you to answer the following questions. Answer as in depth or shortly as you prefer. The most important thing is that you give personal answers about your experience with and thoughts about sensor.community, sensors, and Citizen Science.

We have six questions:

How did you hear about Sensor.Community?

- I came across it on the Internet as I like to make things, 3D print and I feel strongly about the environment

Why did you choose to be a part of Sensor.Community?

- There was (still is!) a huge gap of the sensors between the Czech Republic and Poland. I wanted to connect the white color.

How do you benefit from being a part of Sensor.Community?

- I get to meet openminded people (sadly only online) from Sensor.Community. We can compare our views and expertise. The cooperation on Github is awesome. I have to congratulate the people behind Sensor.Community: Rajko, Lucas, David - they are awesome!

Are you aware that you take part in Citizen Science?

- Yes of course! We even started our own company to promote the Citizen science concept on fair, schools, evirometal circles and ofcourse, online.

What do you use the data for?

- We use it for real time information of the state of the air in real time for our citizens. We present the data on our webpages. We offer alerts for automatization processes. We store the data measured on our servers. We are hoping to eventualy develop a platform for combining the ground data with wind and satellite data. The long term goal is forecasting and its presentation to the community.

Have you told your friends, network, and colleagues about Sensor.Community?

- Yes of course we try to promote as much as possible among friends by even installing the sensors in their homes. We cooperate with dozen of envirometal institutions and give lectures for schools, fairs and exhibitions.

What is your profession and educational background?

- I am an MBA graduate from ESMA, Barcelona - Escuela Superior de Marketing y Administración. I work in property management."

Svar fra Dave:

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Please inform us if you agree with and understand this information, before you answer our questions, thank you.

- Absolutely – I agree

We would like you to answer the following questions. Answer as in depth or shortly as you prefer. The most important thing is that you give personal answers about your experience with and thoughts about sensor.community, sensors, and Citizen Science.

We have six questions:

How did you hear about Sensor.Community?

- I was attending a session from the Wilson Center and Lukas was one of several people talking.

Why did you choose to be a part of Sensor.Community?

- Political activism at the national level in the US is hopeless. I have become involved with local bicycle issues, getting cross-walks at the schools painted, backing up the environmental club at a high school, etc. the idea of having my neighbors and friends join in this DIY activity resonated strongly with me. Goal was to distribute them to schools that are in areas with poor air quality. The cities which I targeted were East Palo Alto, Richmond, and Stockton California. I am more interested in the network that is formed than the actual results of the measurements. I am also an inveterate maker. I really like DIY projects. I have had exhibits at makerfaire. I have built things ranging from musical midi-controllers to full-size pedal-powered railroad cars.

How do you benefit from being a part of Sensor.Community?

- Technical growth, learning to work with nodeMCU. After getting AirRohr going I found other things to do with this inexpensive Arduino/wifi board.

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- That's true!

Are you aware that you take part in Citizen Science?

- Yes! And other CS projects too. This weekend I will be taking pictures of our marshlands in SF bay when the highest tide (king tide) of the year greats us. Marshland restoration is a key component of stabilizing the bay area's ecosystems

What do you use the data for?

- Well, A friend and I learned how to generate fancy java-based graphs from it. We compared the data to purple air. But that's one of the unexpected findings of AirRohr project. I don't know if anyone will ever use it. I have talked with local (paid) environmental scientists who are rolling out pollution plans per CA Assembly Bill 617. (https://ww2.arb.ca.gov/capp) Millions of dollars of investment. Except it doesn't trickle down to the communities very well. So - there are dozens of aspects to remediation and monitoring particulate levels is only a tiny part of it. Moreover, because these (AirRohr) instruments are not certified – the data can't be presented to substantiate of claims of pollution. Second concern is the data format and the lack of API documentation. As mentioned below, all other air monitoring systems must comply to some standards. Scott and I tried to start the discussions about documentation (NOOA example) but there just isn't bandwidth to do this in an all volunteer product. Also, CSV sucks. I wrote some of the scripts to extract and it's a challenge.

Sometimes the servers are not up. Some sort of relational database with locational references is needed to do any large scale analysis. Oddly, I found one that is available through our county government for free which is called Socrata. (https://dev.socrata.com/data/) But who has the time to convert that data. I went as far as engaging with CSAM (https://www.aqmd.gov/aq-spec/special-projects/csam-project) which is the authoritative government body for citizen science – soon to be part of the EPA. I shipped three of my systems to the Air Quality Management District in Southern California to have them validated (not certified). Unfortunately we didn't get the support we needed from Germany to finish the validation and so had the systems mailed back. It was holidays and there was some confusion about why this was happening so quickly. Maybe next time. The other thing is that Scott chose to no longer offer the product and CSAM requires that the device is commercially available. I set up a distributorship with a friend (http://www.argentdata.com/catalog/) who has sold thousands of low-cost weather stations in the past few years. He added airRohr to his catalog while he evaluated. In this case we needed to document the libraries that he would modify to support airRohr to be similar to what he does for other governmental organizations such as NOOA (https://projects.osd.noaa.gov/SPSRB/standards_software_coding.htm) . I think the limit of available resources with Sensor Community and the fact that validation by the US government wasn't a top goal played a role in this falling apart. Scott no longer wants to support this platform. But we tried, learned, and made small bits of progress. I am still building more airRohr. About 30 so far with ten back for re-works. I am upgrading from DHT to BME280 sensors. As my wife says, "it keeps him off the streets at night". And perseverance is key. I have been talking to a friend who owns a small store for the past year – and we finally have one installed in his showcase window.

Have you told your friends, network, and colleagues about Sensor.Community?

- Yes – but there seems to not be a lot of interest in air quality, even among my friends who are avid environmentalists. In one sense, having the data doesn't really change anything. Also, purple air is everywhere. My intent was to work

with groups like the Richmond Air Rangers (Richmond has a Chevron refinery which has caused thousands of illnesses and deaths in the local population since the 1930's.) This to me is where it is at. And (was it Claus) one of the Sensor Community folks was sold on schools as a target base too. (http://www.groundworkrichmond.org/air-rangers.html). Measuring air particulates is only a part of any program – it's not the whole thing. Especially with high-schoolers. Look, here's your data. The amazement lasts only 10 minutes. What's next? How to we change things ? This network between highschoolers and DIY folks is the important result. California is called the "left coast" but the bulk of our citizenry is … clue-less. Mid-west is scary dumb. But in California, the struggle to survey and thrive tends to push environmental issues to the wayside. Why should I care, how does it affect me (duh – your kids bozo?) We have had horrible wild fires that turned our skies orange for two weeks, but they go away and people go back to status-quo. We are positively running low on water (worst drought in 120 years) and my neighbor just put in a new lawn. Increase small particle particulates are an indicator of covid mortality – everyone nods their head but no one cares.

What is your profession and educational background?

- I've been in tech in California for decades now, and no one really looks at education much. My background is Liberal Arts with a minor in Computer Science. I have owned a company with about 60 programmers for 27 years (mindsource.com) and am now retiring. Back to the college degree – many of our best programmers have studied things ranging from philosophy to anthropology. As mentioned, I am an inveterate maker – creating things ranging from digital musical instruments to pedal-powered rail karts. So that is sort of liberal studies I suppose! I have had exhibits at maker faire and created things for burning man. Etc etc. My hope here is still to connect with a high school group. Getting into the curriculum takes years, and covid slowed that down. I am involved with a similar effort to get school-aged kids into bicycling. It's about 4 years to get the program really rolling. And changes all the time. Ideally the program is handed down each year by seniors as a new batch of freshman arrive.

- Here are three of my model A (first iteration) airRohr. I generally set them up in pairs.

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