SENSORS FOR GENERATIVE JUSTICE
LESSON PLAN

Summary:
Students will build and use sensors to explore their own hypotheses about moving towards generative justice. Students will be researching how sensors help detect what goes wrong (dimensions of environmental contamination and public health around air, noise, soil and water) and how to contribute to correcting these imbalances (agroecology; sensors for and share what they learned. After that they will select a specific problem domain to explore and conduct research using environmental sensors to make visible the otherwise hidden dimensions of environmental health and generative justice. The final presentation will challenge students to prove their hypothesis with both literature and their experiments and think about further research they could conduct in their own communities.

As an option, teachers can allow the students to take the sensor boxes they developed home with them and receive a handout with resources to further tinker with them on their own — encouraging further experimentation and learning beyond the workshop.

Sensing for generative justice:
Environmental sensors establish a distinct relationship in and with the environment. Sensors uncover hidden elements of our surroundings impacting communities and their health. Yet, in extending what can be perceived, sensor data can “mute” other aspects of the issue. For example if you only look in places that are easy to access, you might miss how pollutants vary by family income and occupation. If we only look at harm, we miss opportunities to help communities create value. Value can come in many forms: ecological value (food); labor value (enjoyable work); social value (recreation, communication, friendship, and so on). When value comes from the grassroots of the community, and returns to that community, we call that “generative justice”.

In this workshop we aim to have students explore both the technical and this social side of the relationships, using a systems science perspective. To make sensors part of the system that generates value from the grassroots, they will need to have exercises that help them take a thoughtful approach, and see how the numbers only take on meaning when you take into account the context and procedures we develop for them. Students will develop experiments, deploy sensors, collect data and interpret their findings in an systems perspective. Data production and environmental sensing can be taught as a means for generative justice: to help things that facilitate creating value, and avoid things that degrade that generation. Air, water, and soil quality testing can be associated with improving the health of all aspects of our sociotechnical ecosystem.

Students will learn:

- how to measure/sense the environment scientifically through experimental/empirical methods,
- how to critically and scientifically interpret data in order to identify environmental problems and challenges;
- how to explore the relationships between soil quality, pollution, health, and their own communities through generating and interpreting data, and
- how to develop solutions for communities affected by environmental challenges based on the interpretations of their data

Sample Workshop Schedule

Day 1 WED	Day 2 THUR	Day 3 FRI
	SETUP 7.30am	**SETUP 7.00am**
	9:00-11:15 - Going into the Map - Planning the Experiment - Making a Protocol - Building the Sensor Boxes	**8:30-9:30** - Making PPP
		10:00-11:35 - PPP
SETUP AT NOON	**SETUP FOR PM**	**Debrief**
2:00-3.30: - Introduction Systems Science - Sensor Expo - Brain Dump	**12:30 - 3:30** - Field Research 1	
3.30-4.45 - Background Research - Poster Share-out	**3:30 - 5:00** - Documentation - Analysing the Data, Drawing Connections - Begin Preparing Presentations (esp. maps)	
Cleanup, Setup for Day 2	**Cleanup, Setup for Day 3**	

Day 1: Wednesday, May 30

2.00 pm - 4.45 pm (team meets at noon)

Set-up: Main table along the large white board. Three student group stations next to the small whiteboards; Sensor expo to the right of the door towards the back; map in front part of room. Group stations are set up with laptops – with ron's material and background readings already and writing utensils (paper, markers for white board) and notebooks; Main table is set up with sensors in the center, post-its and writing utensils.

Materials: Computer and pot. Adapter to project things, drive with student materials; 14 computers; post-its; markers; whiteboards with markers; writing utensils; paper; poster materials; expo materials; Title cards for the individual stations; notebooks;

Worksheets: 1, 2

SCHEDULE:

noon - Meetup and briefing, setup
2pm - Students arrive (**expect students for 1.30**)
4.45 - Students leave for dinner
- De-Brief / Cleanup and setup for day 2

SET-UP **noon - 1.30pm**

Team convenes in studio, setting up the workshop prior to student's arrival.

	Set up sensor exploration stations at the group places		Wipe off whiteboards
	Set up computers for background research and group exploration		Arrange room
	Print and prepare worksheets		Have simulations ready to go
	Layout Maps		Have lesson plan printed out for all facilitators
	Send out morning briefing		

1| INTRO 2.00pm - 2.50 pm

Students are asked to sit down on the main table set up at the front of the room.

Setting the Theme: System Science and Generative Justice
Young researchers arrive, rounds of introductions. We discuss the context of the workshop, contextualizing it through the concept of systems science.

- Intro: Sensing the environment for environmental justice; concrete examples; How sensors make visible certain aspects of the world, but we also have to think about what we are missing or ignoring. We use sensors and the contexts of their relevance to facilitate change. We briefly introduce both the sensors available as well as give them a clear goal for them to achieve during the workshop: "You will build one or two of these sensor systems to gather information about the environment."

1A| Brief history of systems science 2:10 - 3:00pm

Break students into three groups. Each reads their section and then presents back on what they found. Each part has a simulation and a little flowchart they assemble themselves (cardiac simulation, tourism and hydrophication, snails and salinity) --- segway into the larger theme.

At then end students share their findings, with us projecting their results

1B| GENERATIVE SENSOR EXPO 3:00 - 3:15pm

We introduce them to the workshop theme and what we set out to do by helping the students encounter the sensors in different contexts of application. This is in a small expo-setting on the group tables, extending what was discussed in the simulations. Through visiting the individual stations, students will get a first sense of the sensors and how they operate. We centrally focus on the core concepts: sensors; dependent, independent and influencing variables; experimentation; systems science.

Sensors Expos:

- **Monitoring Heart Rate:** (independent var: running speed, dependent var: heart rate)
- **Digital Microscope:** Viewing pond water under a microscope
- **Light + Salinity Sensor:** Seeing Salt (independent var: salt, dependent var: conductivity)

Student Instructions:

1. Students discuss with facilitators of the expo what the independent/dependent variables for each of the stations in context of systems science are. They also should discuss what facilitators for generating value would be, and what threatens or degrades value

generation. The value could be ecological (food), labor (enjoyable forms of work), social (recreation, communication, interaction, etc.).

2. After the exercise students are asked why independent and dependent variables are important concepts, how experiments work,etc.

2| EXPLORING ISSUES, DEVELOPING RESEARCH 3:15 - 4:30pm

Wrap up: Ties things together, pointing to: a) system interdependencies, externalities, pollution and social justice, how sensors can help in counteracting degradors and foster facilitators of generative justice; the relevance of hypotheses in that, and that hypotheses are created based on prior knowledge (background research). We segue into the shared discussion (see 2A). Questions for students > what are systems that you explored? > can you think of other systems? >Can you think of what could degrade one of the self-sustaining systems that you mention? >Can you think what may be facilitators of self-sustaining systems?

2A) Exploring Issues, Applications and Practices 3:15 - 3:30pm

Students read through **worksheet 1** to learn about the different topics they can explore. Then they decide which topic they want to learn more about over the course of this workshop.

2B) Background Research 3:30 - 4:00pm

Material Title cards, WS 2, Laptops, Notebooks, Paper, Writing utensils, worksheet no. 2.

Students go to their research stations. Stations have a title card in the center of the table. **mentors write the student's names** on the sign. **Students receive a notebook**. They write their names and the group title on the first page. Four laptops are set up per group with the respective research folder already open.

Moderation: Lead instructor So let us get started with our experiments. You will go into your groups now and then you will start doing your research. Every research starts with learning as much about the topic you are investigating as possible. That is just as detectives do. And the people in the stories did the same thing when they started addressing their problems. Informed by your background research you will then develop experiments in areas you think are most important, fascinating, exciting, fun — or urgent to solve.

Student Instructions:

1. Students are asked to go to one of the stations that represents their interest. (If there are already four students, the lead mentor of the exercise asks the students about what other topics they find interesting and why before asking volunteers to change to another station)
2. Group mentors say their name and ask the students for theirs. Students should write their name on the group title card. Then the students should discuss what they want to do based on their shared interest and come up with a group title that describes their research. Write it down on the title card. The title card is placed by the mentors at the center of the table.
3. Students receive their laboratory notebooks and empty sheets of paper.
4. Students are asked to each read one of the articles. Encourage students to note down what they find particularly important to share with their colleagues
5. After 20 minutes latest ask the students to share their findings with each other by filling out **Worksheet No 2**. Collect answers on the whiteboard before noting the one down you agree with most.
6. For facilitators and degradors, Mentors reflect with students on additional ones beyond the articles before filling in.

If students are done they can read through the other material.

[mentor responsibilities: Help the students work through these instructions and keeping them in time.]

2C) Share-out **4:15 - 4:45pm**

Material Poster Material

Student Instructions:

1. Using what they wrote down on worksheet 2, make a poster. Each poster should include
    a. a title
    b. what you want to investigate
    c. The most important facilitators and degradors in the topic they investigate
    d. What they hope/expect to learn
2. Students present their posters to the whole class.

Collect all notebooks, station signs, worksheets, take a picture of the whiteboard from the brain dump

End of day tasks:

ToDo:

	Put code into computers		Collect all documentation materials and scan them
	Collecting Sensors and related equipment for each group		Take pictures for documentation where necessary
	Clean up		Prepare threshold worksheet as much as possible
	Set up next day as much as possible		print

Day 2: Thursday, MAY 31

9.00am - 5.00pm (team meets at 7.30am), Location: Studio
Set-Up: Group stations are without laptops, notebook and worksheets are put back on their tables, Group signs are put back on their tables. Main table has all the sensor materials ready to go for students to pick-up later that day
Materials and WS: Sensor Shopping List, Worksheet 3, Small maps, Worksheet 4, Worksheet 5, Worksheet 6, phones to take pictures for on site documentation

SCHEDULE:

7.30am	- Meetup and briefing, setup
9.00am	- Students arrive
11.15am	- Students go to lunch
Lunch and Afternoon Setup	
12.30pm	- Students return
5.30pm	- Students leave for dinner
	- Cleanup and Debrief

SET-UP **7.30 - 9.00am**

Team convenes in studio, setting up the workshop prior to student's arrival.

1| PLANNING THE EXPERIMENTS 9.00am - 10.00am

Start: Students present Posters **9:00 - 9:20am**
Students remind each other and themselves about their research

1A) Developing the experiments **9:20 - 10:00am**
Students plan their experiments in detail. For this, students begin by exploring possible sensors to use for their experiments. Identifying the degradors and facilitators they want to investigate, and articulate, students use a "shopping list" of sensors to make decisions on what they can feasibly measure, and why they plan on doing so.

Student Instructions:

1. **[Mentors, hand out sensor shopping list]**.
2. Fill in **worksheet 3**. This will help you to develop your research interest. Use your background research, the notes on **worksheet 2** and **your background research** to fill in all the information you need. **[Mentors, hand them worksheet 3]**.

Walking into the map, localizing research
In "walks into the map" students ground their research locally why applying a systems thinking. Associating their abstract interest with the local socio-geographical makeup of the area, students begin reflecting relationship within a larger systems perspective. For this purpose, students work with worksheet 4.

Student Instructions:

1. **[Mentors, hand out worksheet 4 and small maps]**.
2. It is important to connect your general research interest with the specific places you are investigating in order to fully understand how systems interact. That way your science can also be generative for the communities by strengthening facilitators and counteracting degradors.
3. With your mentors, go into the maps to decide where you want to conduct your experiments in order to have your science be as generative as possible. Complete **worksheet 4** for this purpose.

Making the Research Design Explicit.
Now the students will complete their research design, tying all the information the generated together and completing **worksheet 5**. INFORMATION SOURCES FOR WS 5

Worksheet 2: Define general research interest
Worksheet 3: Make decisions on what to measure
Worksheet 4: Localize research

Student Instructions:

1. It is time to make explicit what your experiment is about. **Worksheet 5** helps you do this. Fill it out with as much detail as possible.

Making A Protocol

Finally, the students need also to decide on what might also be important to take into account in their experiments. Leo discusses the relationship between dependent and independent variable. (Wax/Candle example). We discuss how this is not possible if you do experiments outside the laboratory. Therefore it is necessary to measure additional things that might influence your results. All results are documented in protocols, so you can later remember where your data came from and what happened at the locations you took the measurements.

Student Instructions:

Fill-in **worksheet 6** to make your protocol. **[mentor, hand them WS 6]**.

1. Fill in worksheet 6 to create your protocol. A protocol includes the measurements for all the additional environmental factors that may influence your results, the location, time, date, a description (this can be a photo), who took the measurement and anything else you might think could be important information later on.
2. In order to create your protocol, follow the instructions on the worksheet and discuss with your mentors. You will take this protocol with you into the “field” (that is your research site, the location you conduct your experiments).
3. **In worksheet 5** - fill in any additional sensors you decided to use (for example, if you measure the temperature, you will need a temperature sensor.) Use the “shopping list in order to find out what kind of sensors measure what you need.

2| BUILDING THE SENSOR BOXES 10.00am - 11.15am

Material: Sensor Worksheets, Sensors,

- On worksheet 5 students have detailed descriptions of what they measure and how, including a list of sensors they use
- Based on what kinds of sensors they use, they receive information sheets for the sensors to learn about their application and within an systems science perspective. Each

worksheet also introduces the students to elements of electronics, sensing, and arduinos.

- Following that exercise students work through a resistor workshop to learn about their functioning. Mentors help with that exercise.
- After encountering the sensors and the kinds of data they produce, they will revise their hypotheses using worksheet XX.

LUNCH BREAK **11.15pm - 12.30 pm**

3| FIELD RESEARCH 12.30pm - 3.30 pm

3A) Students go into the field with their research kids. **12:30 - 3:30PM**

Students finish their work and the sensor boxes go into the field. Before going out, Leo gives a last set of instructions

Info for mentors: Make sure that measurements are taken correctly. Students should fill out their protocols at each station they take their measurements. Make sure students do their work. In taking students, ask them: what do we do now - make them do it, or ask what needs to be done before that if they forgot to do something. The students are doing everything and are in charge, so please make sure that they feel that way if you have to adjust their course!

Student Instructions:

ABC

1. Go with your mentors to the locations and take the measurements. The mentors are there to help you, but it is your experiment and you are in charge. The mentors will give you hints and tips if you might want to do something differently to get good measurements.
2. To take a measurement follow the protocols you created and fill out every information you decided to keep track of! Take a picture for every location you took a measurement.

4| DOCUMENTATION AND ANALYSIS 3.30pm - 4.30 pm

3A) Analysis **3.30 - 4:30PM**

Set up: have the computer stations set up so they are ready data import.

Students come back from the field sites, with their devices. They take the SD out and put them into the computer and import the data into excel.
Students use worksheet “Analysis” to develop their findings. Mentors should play an active role in explaining the students how to conduct their analysis.

Student Instructions:

1. Students receive worksheet “analysis” and the threshold sheet.
2. Mentors support them in getting the data onto their computers and interpreting them
3. Students begin bringing the data onto maps and drawing circulatory systems

5| PRESENTATION PREPS 4.30pm - 5.00 pm

Student Instructions:

1. Make a presentation
2. You should begin with one slide of the background information, explaining why your topic is important to research
3. Next, you should explain what you were investigating in your research, including
    a. What system did you look at
    b. What degradors and facilitators did you consider in your research
4. Then you should explain what experiment you did --- What kinds of sensors did you use and where did you measure
5. Finally, show your map with your results, and discuss what kinds of systems relationships you found, displaying them in a flow chart.
6. In the conclusion you want to discuss if the flow chart is circulatory (self-sustaining system) or broken (extractive/degrading system) and how you could use sensors to fix it/protect it.

Day 3: Friday, JUNE 1

9am; Location: studio
Materials: Laptops; Presentation drive, picture database; thumb drive,

SCHEDULE:

7.00am	- Meetup and briefing, setup
9.00am	- Students arrive
9.30am	- Folks begin to arrive for presentations
11,35am	- Students leave, debrief, cleanup, ice-cream

SET-UP **8.30 - 9.00am**

Team convenes in PDI studio, setting up the workshop prior to student's arrival.

ToDo:

	Computer for presentations		
	Workstations for students to work on presentations		
	Picture database per group		

EVERYTHING NEEDS TO BE SET UP BY 9.00

Day Schedule:

7.00am - Meetup and briefing, setup
8.30am - Students arrive
Between 9.30am and 10am - Folks arrive for presentations

1| Finalizing Presentations **8.30 - 9.20**

Students come in, we will have a lax and excited atmosphere as we are coming close to an end now! This will be a mostly easy day for all of us:
Students finalize their presentations, especially focussing on their final results. **Take pictures of the groups with their results!** Students should again document the results of their work and make some final conclusions on their experiments (and maybe include suggestions on what the next experiment could look like based on these new results).

2| Setting up presentations **9.20-9.30**

Collect all presentations via thumb drive and set them up ready to go for folks coming. Students can decompress for a moment.

3| Final presentations **9.30**

Students give their presentations

Everything good must come to an end, so also this – we'll go for lunch and celebrate (hopefully)!