



THE CITIZEN-SENSOR-NETWORK SMART EMISSION:
A 'POLICY MAKING PROCESS' REGARDING AIR AND
NOISE POLLUTION IN THE CITY OF NIJMEGEN

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*You keep putting one foot in front of the other and then one day
you look back and you've climbed a mountain.*

-Tom Hiddleston.

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Abstract

This research elaborates on policy making with administrators, scientists, citizens and developers in the citizen-sensor-network Smart Emission. Smart Emission is a partnership in which administrators, scientists, citizens and developers monitor air and noise pollution in the city of Nijmegen, the Netherlands. The citizen-sensor-network aims to gain more insights into air quality and noise pollution in the city and aims to raise environmental awareness among citizens. This research gained an understanding of how the citizen-sensor-network Smart Emission contributes to local air and noise policy making in Nijmegen. This research analyses therefore the case of Smart Emission from the perspective of the Environmental Policy Partnership framework (EPP). The EPP-framework is a model that provides guidance for policy making processes with citizens. In this model citizens and experts develop new policy by conducting a monitoring activity together. Knowledge is in the EPP-framework constructed by collectively addressed actions by participants during group discussions. When actions were collectively addressed during group discussions, new heuristics often developed. In the case of Smart Emission 6 new heuristics developed: first new heuristic is that the citizen-sensor-network needs to be a dynamic, informative and fruitful process; second is that noise will be measured in dB instead of dB(A); third is that project groups of citizens will be created in order to research specific neighbourhood issues; fourth is that there will be a city-wide focus on the issues wood heating and low frequent noise; fifth is that more citizens will be activated to participate by installing hundred more sensors in and around the city; sixth is that more expert knowledge is needed during meetings in order to answer questions about the complexity of air and noise. The new heuristics that developed in the citizen-sensor-network are approached as new knowledge constructed by participants. The research explains with help of the new heuristics how the citizen-sensor-network transforms as a policy making process into a 'new type of citizen-sensor-network'. It depicts how the scientists, administrators, developers and citizens involved in the citizen-sensor-network learn to better understand each other and how collected data gets therefore more valuable. The citizen-sensor-network therefore demonstrates how it contributes as a policy making process regarding air and noise policy.

English summary

During an interview the air quality expert from the municipality of Nijmegen, he explains that Nijmegen is encountering air and noise pollution from her industrial area and the Waal river for years already (personal communication, August 7, 2016). The air quality expert explains that Nijmegen started with projects in order to find solutions for these issues (personal communication, August 7, 2016). These projects are a monitoring network of test-tubes, noise cabinets and an online forum for the industry nuisance of the West and Weurt area (personal communication, August 7, 2016).

In this context, Nijmegen started with the experiment Smart Emission (Carton & Ache, 2015). In this project experts and citizens monitor together air and noise in the city in order to find out how the quality of their living environment can be improved and environmental awareness among citizens raised (Carton & Ache, 2015). Smart Emission therefore developed small-sensors, a website including a forum and monthly group discussions (Carton & Ache, 2015). The citizens and experts involved try to understand air and noise pollution in and around the city in order to make it able for future administrators to take in the knowledge of in the citizen-sensor-network in their policy and plans (Carton & Ache, 2015).

This research therefore gains an understanding of how the citizen-sensor-network Smart Emission contributes to policy making regarding air and noise pollution in the city of Nijmegen. The following research question is proposed: "how does the citizen-sensor-network Smart Emission contribute to policy making regarding air and noise pollution?" In order to examine this research question the case is analysed from the perspective of the Environmental Policy Partnership framework.

The Environmental Policy Partnership framework (EPP) is a model developed on basis of the DIAD-framework of Innes & Booher (2010) and the VBM-framework of Lawrence (2006). The EPP-framework approaches a citizen-sensor-network as a policy making process in which different types of participants conduct an environmental activity, learn from this activity and construct new knowledge about this environmental activity. This activity is conducted in a policy making process in where 'new' knowledge continuously develops on basis of interactions between participants involved in this process. The participants in the process collaborate in at the form of a partnership.

In the case of Smart Emission, interactions between participants took place during group discussions. When actions were collectively addressed during group discussions, shared

meanings formed. When decision making took place upon these shared meanings, new heuristics developed.

By approaching the citizen-sensor-network Smart Emission as an EPP-framework 6 new heuristics developed:

1. first new heuristic is that the citizen-sensor-network needs to be a dynamic, informative and fruitful process; second is that noise will be measured in dB instead of dB(A);
2. third is that project groups of citizens will be created in order to research specific neighbourhood issues;
3. fourth is that there will be a city-wide focus on the issues wood heating and low frequent noise;
4. fifth is that more citizens will be activated to participate by installing hundred more sensors in and around the city;
5. sixth is that more expert knowledge is needed during meetings in order to answer questions about the complexity of air and noise.

The new heuristics that developed in the citizen-sensor-network are approached as the new knowledge constructed within the policy making process. The research explains with help of the new heuristics how the citizen-sensor-network transforms as policy making process into a 'new type of citizen-sensor-network'. It depicts how the scientists, administrators, developers and citizens involved in the citizen-sensor-network learn to better understand each other and how collected data gets therefore more valuable. The citizen-sensor-network therefore demonstrates how it contributes as a policy making process regarding air and noise policy.

Dutch summary

Tijdens een interview met de luchtkwaliteit-expert van de gemeente Nijmegen op 6 augustus, 2016 legt hij uit dat de stad al jaren op zoek is naar oplossingen voor luchtkwaliteit en geluidsoverlast (persoonlijke communicatie, 7 augustus 2016). Hij geeft aan dat de stad veel overlast heeft van het lawaai uit het industriegebied, overlast heeft van het lawaai en overlast heeft van de fijnstof veroorzaakt door de rondweg en de Waal-rivier. De gemeente is daarom gestart met verschillende projecten om dit te onderzoeken. Een eerste project was een experiment met reageerbuisjes die de luchtkwaliteit meten; zelf ontwikkelde geluidskastjes die geluid meten door de hele stad. Een tweede project was een online bewonersplatform waarin gezamenlijk de geluidsoverlast van het industriegebied West en Weurt werd gemeten (persoonlijke communicatie, 7 augustus 2016).

In deze context, is de gemeente in samenwerking met de Radboud universiteit en bedrijven in 2015 gestart met een nieuw project: het burger-sensor-netwerk Smart Emission (Carton & Ache, 2015). In Smart Emission meten experts en burgers samen de luchtkwaliteit en geluidsoverlast in en om de stad Nijmegen (Carton & Ache, 2015). Hiermee hoopt men meer inzicht te verkrijgen in het meten van luchtkwaliteit en geluid en daarmee dus beleidsvorming omtrent lucht en geluid te verbeteren.

Om het burger-sensor-netwerk als potentiële methode voor beleidsvorming te onderzoeken, gaat dit onderzoek in op de bijdrage die het burger-sensor-netwerk Smart Emission levert aan beleidsvorming voor luchtkwaliteit en geluidsoverlast in Nijmegen. Om dit te onderzoeken is het burger-sensor-netwerk Smart Emission geanalyseerd als een Environmental Policy Partnership framework (EPP). Het EPP-framework is een theoretisch kader ontwikkelt op basis van twee wetenschappelijke modellen: het DIAD-framework van Innes & Booher (2010) en het VBM-framework van Lawrence (2006). Het EPP-framework ziet een burger-sensor-netwerk als een systematische methode voor beleidsvorming waarin nieuwe kennis wordt gegenereerd over vraagstukken in de planologie en ruimtelijke ordening.

Op basis van deze nieuwe kennis worden beslissingen genomen die het burger-sensor-netwerk verder ontwikkelen. Het burger-sensor-netwerk als beleidsvormingsproces is daardoor in staat een bijdrage te leveren aan beleid voor luchtkwaliteit en geluidsoverlast.

In het burger-sensor-netwerk Smart Emission zijn op basis van het proces en de analyse de volgende beslissingen genomen:

1. het burger-sensor-netwerk moet in de toekomst ook een dynamisch en vruchtbaar proces zijn;

2. geluid zal in de toekomst worden meten in dB in plaats van dB(A);
3. kleine projectgroepen door burgers worden opgericht om daardoor ook buurt gerelateerde vraagstukken te onderzoeken;
4. er zal voor de onderwerpen houtstook en laagfrequent geluid 'stadsbreed' onderzoek worden opgestart;
5. meer burgers worden betrokken door meer 100 sensoren extra beschikbaar te stellen;
6. meer expertise en kennis vanuit experts zal middels trainingen worden ingebracht om de materie van lucht en geluid beter te begrijpen en de data beter te interpreteren.

Het burger-sensor-netwerk Smart Emission laat op deze manier zien hoe het bijdraagt aan beleidsvorming voor lucht en geluid in Nijmegen. De 'nieuwe kennis' in het burger-sensor-netwerk heeft voor de lokale bestuurders en bevolking een meerwaarde omdat het lokale en specifieke kennis oplevert over lucht en geluid. Planners hebben hierdoor de mogelijkheid om in de toekomst plannen en beleid te vormen dat beter afgestemd is op lokale vraagstukken omtrent lucht en geluid.

1 Introduction

1.1 Background and problem statement

Environmental issues are increasing in cities around the world. Smog is polluting the air, chemicals of factories pollute the water, waste is causing land pollution and there is depletion of fossil fuels and flora and fauna. Governments try to challenge these issues by developing laws, regulations and policies (Ramirez-Andreotta, Brusseau, Artiola, Maier, & Gandolfi, 2014; Stepennuck, K. F., and L. Green, 2015; Carton L., Ache P. et al., 2016). Governments ask citizens to play a role in this challenge since the 17th century already (Miller-Rushing et al. 2012 and Silbertown 2009 by Stepennuck, K. F., and L. Green, 2015).

Environmental monitoring projects, in where citizens collect data about the environment is conducted for years already. This is a cheap form of data collection and helps at the same time to gain an overview of populations, species or quality of the environment. With help of these projects, citizens across the globe have helped building a valuable collection of animals, plants, rocks or fossils but also provided input for water quality, land pollution or other environmental issues, that in the end function as input for policy means (Couvet & Prevot, 2015).

Despite the long history of scientists working with citizens to gather and utilise scientific data, the monitoring programs do not provide the ability for communities to fully interact with, influence and communicate with the government about environmental issues and solutions (Ramirez- Andreotta, Brusseau, Artiola, Maier, & Gandolfi, 2014 and Couvet & Prevot, 2015). This is according to Stepennuck & Green (2015) not only the case in monitoring activities, also in participatory activities. There are according to their literature review just a few scientific articles that point to the potential for achieving synthesis between all involved stakeholders in a participatory process assessed: Danielson et al., (2005a); Conrad and Hilchey, (2011); Jordan et al., (2012); Shirk et al., (2012) by Stepennuck & Green (2015).

Stepennuck & Green (2015) furthermore discuss that scientific literature about participatory processes or policy making processes often considers content knowledge assessments, were the outcomes show that the policy making process was a success because the content related goals were achieved. But, research does often not consider assessments were skills from citizens related to things as data synthesis, personal learnings, experiences, changing behaviour or changing attitudes are researched.

Why is involving citizens in all stages of an participatory activity so important than? Shepard et al. (2004) argue that solving local environmental issues is most effective when scientists, officials, industry and the affected community are fully engaged in the process (Ramirez-Andreotta,

Brusseau, Artiola, Maier, & Gandolfi, 2014). The National Research Council (2008) argues that when done well, public participation improves the legitimacy and quality of decision making. It furthermore, builds capacity of everyone involved to engage in the process and leads to better results in terms of environmental quality and other social objectives (Ramirez-Andreotta, Brusseau, Artiola, Maier, & Gandolfi, 2014).

Couvet & Prevot (2015) and Lawrence (2006; 2009) argue that when citizens become involved in a monitoring activity as a partner, positions and values of citizens change. The monitoring activity will then forge new relationships between participants and their environment. In order to research how a participatory activity, such as monitoring with citizens, could contribute to policy making, this research assesses the case of the citizen-sensor-network Smart Emission.

Smart Emission is an experiment in the city of Nijmegen, Netherlands. In this project citizens and experts monitor air and noise pollution in order to gain an insight in the quality of their living environment ("Update 13 juni 2016: Participatie is de sensor tegen overlast", 2016). The participants involved have a sensor attached to their homes. This sensor collects every 15 seconds data about the current air and noise pollution ("Update 13 juni 2016: Participatie is de sensor tegen overlast", 2016). The data and findings derived from the sensors are discussed in monthly group discussions and at an online forum.

In an interview with Nijhuis, H. the air quality expert from the municipality of Nijmegen, he explains that the city are intensively monitored with citizens for two years now. But that they now arrived at a moment where they would like to find out if it was actually useful to engage citizens in this activity (personal communication, August 7, 2016).

The citizen-sensor-network Smart Emission is therefore assessed in this thesis as the Environmental Partnership Policy Framework (EPP). The Environmental, Partnership, Policy framework (EPP) is based upon a combination of the Diversity Interdependence Authentic Dialogue framework from Innes & Booher (2010) and the Volunteered Biological Monitoring framework from Lawrence (2006). The EPP-framework is a theoretical framework for policy making. In this research the Environmental Partnership Policy framework (EPP) approaches the citizen-sensor-network Smart Emission therefore as a policy making method. The claim therefore is that Smart Emission contributes to policy making regarding air and noise pollution in Nijmegen. The objective of this research is to examine how the citizen-sensor-network Smart Emission contributes to air and noise policy making in Nijmegen. The main research question proposed for this research is: *How does the citizen-sensor-network Smart Emission contribute to policy making regarding air and noise pollution in Nijmegen?*

By choosing for one particular case this research is able to conduct an in-depth analysis on the case of Smart Emission. This gave this thesis the advantage to gain into detail what and how citizens and experts learned and experienced. This research therefore was able to gain an in-depth understanding of how the citizen-sensor-network Smart Emission, when approached from the Environmental Partnership Policy framework, contributes to policy making regarding air and noise pollution in Nijmegen.

The following chapter elaborates on to the theoretical framework used for this research. In the third chapter the purpose statement and research questions are described. The fourth chapter explains the case orientation. The fifth chapter shows how the research is conducted by explaining the methodology. The results of the research can be found in chapter six and the last chapter contains the discussion and conclusion of the research.

2 Theory

The citizen-sensor-network of the city of Nijmegen will be analysed in this research through a combination-lens of the DIAD-framework from Innes and Booher (2010) and the VBM-framework of Lawrence (2006). I found for these two approaches inspiration in Complex adaptive systems theory, because both frameworks, DIAD and VBM focus on interactions and relations within a dynamic system. I will in this chapter first briefly introduce complex adaptive systems, then the DIAD-framework and VBM-framework and at last I will explain how and why this research uses a combination of both frameworks.

2.1 Complex adaptive systems

For the 'overall lens' of the research, the concept of Complex adaptive systems is used as bonding component. According to Innes & Booher (2010) the concept of Complex adaptive systems is a lens that gives an understanding about illuminating and transformative ways of what is going on in the world. Complex adaptive systems have their focus on the larger dynamic system within which actions take place, it suggests that society issues need a holistic and interactive approach (Innes & Booher, 2010).

Complex adaptive systems emerge from different scientific disciplines, different understandings in physical as well as biological sciences, mathematics and computer sciences (Innes & Booher, 2010). In social science, complexity theory was first known as 'chaos theory'. Over the years it became clear that 'chaos theory' actually demonstrates a complex system, showing how patterns of behaviour work (Innes & Booher, 2010).

Because complexity science emerged from many different scientific fields, different understandings and approaches are developed in order to offer fertile ground for innovation to policy and the 'out of the box' thinking (Innes & Booher, 2010). In order to understand complexity in the context of planning, Innes & Booher (2010) and Manson (2001) argue that the following features need to be kept mind:

The participants: The system has to include individual participants that participate within multiple networks. These participants need to be diverse and serve as the 'components' or 'chain-links' within a system (Innes & Booher, 2010).

Interactions: The participants have to interact in a dynamical way. The participants exchange information and energy according to principals set in the system. These interactions create a memory that is distributed throughout the system itself (Innes & Booher, 2010).

Nonlinearity: The system is nonlinear. Interactions between the participants and their context include circular (feedback) loops which change the system from within. These loops are direct and indirect returning to the participants (Innes & Booher, 2010; Lawrence, 2006).

System behaviour: The systems behaviour is determined by the interactions between the participants involved and not settled from above. The system is open to her environment (Innes & Booher, 2010).

Adaptivity and robustness: The system has the capacity to maintain its viability and the capacity to evolve at the same time. Sufficient diversity causes a chain reaction whereby heuristics evolve adapt via feedback loops. The internal structure of the system can be reorganised without outside interventions (Innes & Booher, 2010; Manson, 2011).

Inspired by complexity theory, Innes and Booher (2010) developed a framework for analysis of participatory policy making. Innes & Booher (2010) build up their framework with help of many case studies showing that complex systems can provide new ways to make collaborative processes more effective, adaptive and resilient. Innes & Booher (2010) see complex systems as a type of policy making that jumps back and forward as an formulation of tentative solutions.

According to Innes & Booher (2010) these jumps lead to new questions that may alter the goals, require new analysis and lead to changed understandings that result in the revisiting of all of the steps. Innes & Booher (2010) argue therefore that participatory processes create new knowledge and unanticipated policies and practices. Participatory processes can result in changes of values, goals, shared understandings and underlying attitudes of participants involved in a process (Innes & Booher, 2010). Innes & Booher (2010) created on basis of their experience and inspiration by complex adaptive systems theory, the Diversity Interdependence Authentic Dialogue framework (DIAD).

2.2 The Diversity Interdependence Authentic

Dialogue framework

The Diversity Interdependence Authentic Dialogue framework (DIAD) is a framework narrowly related to the concept of Complex adaptive systems (Innes and Booher, 2010). The DIAD-framework is an approach that frames how and why collaboration in planning processes works in a contemporary and always changing world (Innes & Booher, 2010). In order to make a planning process successful, outcomes need to be valuable and opportunities need to be created. Innes & Booher (2010) divided the DIAD-framework into three phases. The first phase is the characteristics of participants phase, the second phase is the Authentic dialogue phase and the third phase is the System Adaptations phase.

1. Characteristics of participants

The 'Characteristics of participants' phase is a phase where conditions for collaboration need to be set. This phase consists of three conditions that need to be ensured in order to get valuable outcomes and to create opportunities (Innes & Booher, 2010) The three conditions are the following:

Condition 1: Diversity. The first condition is the condition of diversity which implies that a collaborative process needs to include participants with power and participants with little or less power (Innes & Booher, 2010).

Condition 2: Interdependency. The second condition is the condition of interdependency. This condition argues that participants must depend on each other until a significant degree and in a reciprocal way in order to gain a wide range of knowledge (Innes & Booher, 2010).

Condition 3: Equality. The third condition Innes & Booher describe is equality. Equality requires that participants engage equally on a shared task. This is an important feature for understanding system behaviours (Innes & Booher, 2010).

When the start of a planning process is in line with these conditions, valuable outcomes can be ensured. The planning process now can move over to the next phase, the 'Authentic dialogue' phase (Innes & Booher, 2010).

2. The Authentic dialogue

In the second phase the participants share their interests by interacting with each other in a dialogue 'the Authentic dialogue'. During the Authentic dialogue participants discover the

reciprocal nature of their interests. Participants become aware that meeting their own interests can come from working with the reciprocal interests of others (Innes & Booher, 2010). The Authentic dialogue changes therefore relationships between participants because they share their interest and therefore gain new understandings from others about certain interests. Participants therefore gain a new appreciation of what it is like to walk in someone else's shoes. Innes & Booher (2010) argue that this new appreciation emerges because of (invisible and visible) 'learning' loops in the dialogue. The participants involved discover new thoughts about subjects and develop new means to achieve their interests (Innes & Booher, 2010).

3. Adaptations of the system

In the third phase, second and third order effects from the Authentic dialogue occur. These effects are explained by Innes & Booher (2010) as the system adaptations. These adaptations are agreements achieved in the process itself. In this stage first *shared meanings* between participants develop because they shared their interests in the previous phase the Authentic dialogue.

Shared meanings are defined by Innes and Booher as an 'issue' that is seen holistically because it plays a part in the overall welfare or dependency of the society. Furthermore, the participants develop *shared identities*. Shared identities are defined by Innes and Booher as the role that someone or something perceives when participating in a certain context.

During the process also new heuristics develop. **New heuristics** are defined by Innes & Booher (2010) as: "collectively addressing actions that ... in the future carry over into actions beyond the process" (p. 38). When actions collectively are addressed, decisions are made, the new heuristics can therefore be approached as principals that adjust or develop the system in itself.

In general we can say that the participants involved in the system learn ways of how to deal with local issues and being consistent with the sustainability of the system, without having to wait for direction from some hierarchical activity. According to Innes & Booher (2010) this results in participants that are able (over time) to turn their ideas over into actual actions. To strengthen this, Innes & Booher (2010) refer to Giddens structuration theory (1984). Giddens (1984) suggests that even when participants are influenced by the structure of norms and institutional arrangements their new ideals, beliefs and norms can gradually alter this structure (Innes & Booher, 2010). The diagram in figure 1 (Innes & Booher, 2010, p. 35) shows the three stages of the DIAD-framework representing the dynamics in a planning process.

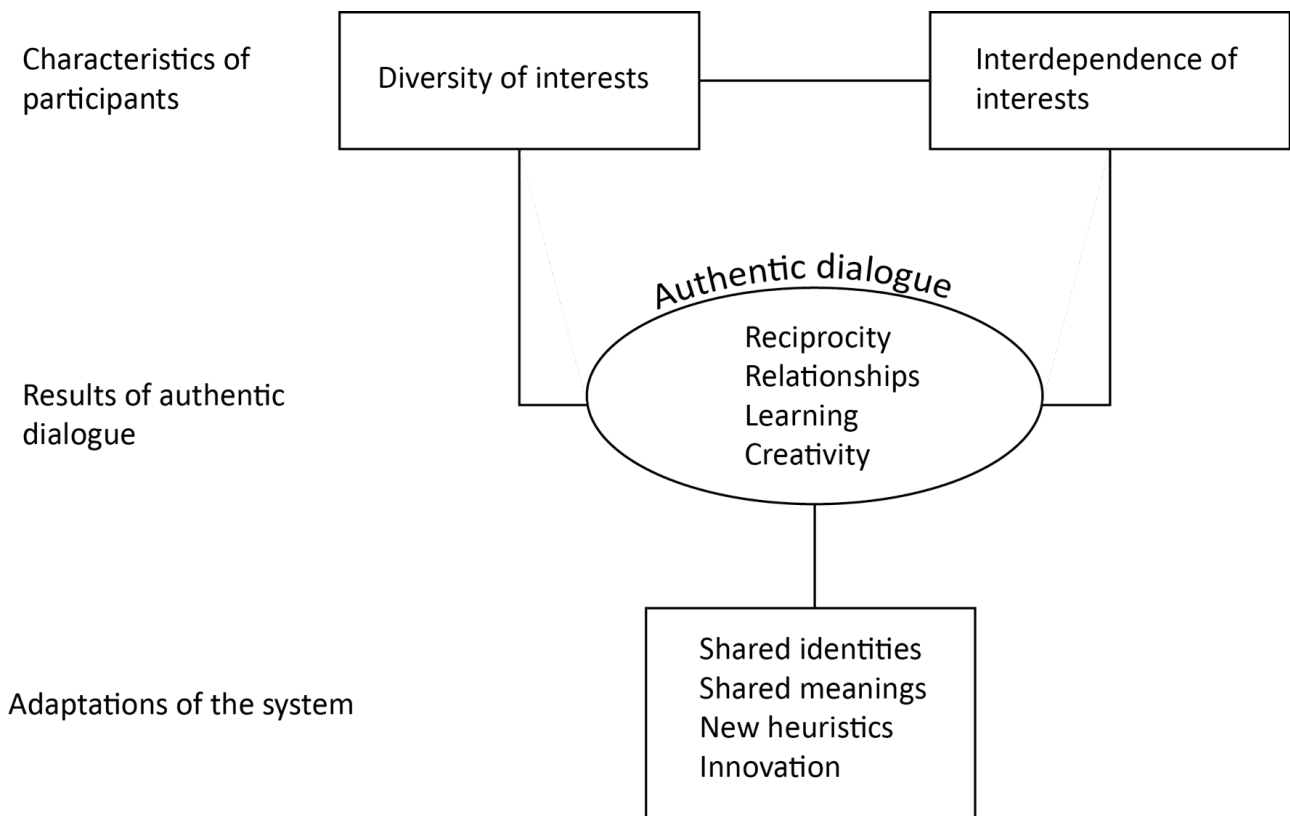


Figure 1. Representing the DIAD network dynamics. Adapted from *Planning with complexity: An introduction to collaborative rationality for public policy* (p. 35) by J. E. Innes & D.E. Booher, 2010, Abingdon: Routledge. Copyright 2010 by Judith E. Innes and David E. Booher.

The diagram shows the three phases: First the ‘Characteristics of the participants’ phase, secondly the ‘Authentic dialogue’ phase and third the ‘Adaptations of the system’ phase. Within the Authentic dialogue participants develop relationships, learn from each other, learn from their context and use their creativity. From the Authentic dialogue shared meanings, shared identities and new heuristics develop. The new heuristics help to adapt the system (Innes & Booher, 2010).

A pitfall of this framework is that Innes & Booher (2010) do not consider how external factors, such as information, technical development or collected data influence the system. Innes & Booher (2010) do not consider how the environment within which participants participate may influence the process. Furthermore, Innes & Booher (2010) do not show how citizens develop shared meanings and how these may change with help of feedback loops that occur because of the adaptations of the system.

In order to fill this gap a second framework is sought. The second framework found is derived from environmental sciences. Lawrence (2006) developed her framework on the link between society and nature. Citizens in environmental sciences are involved in monitoring activities for

years already. These 'participatory activities' have often already standard-process-formats which have been developed through the years and are accepted by governmental organisations as well qualified standard methods. The next section therefore introduces the Volunteered Biological Monitoring (VBM) framework of Lawrence (2006).

2.3 The Volunteered Biological Monitoring framework (VBM)

The VBM-framework of Lawrence describes the process of how amateurs (citizens) experience a participatory environmental activity (Lawrence, 2006). An example of a participatory environmental activity is conducting a bird survey, monitoring rainfall or monitoring plant species. According to Lawrence (2006) a 'participatory environmental activity' is a multidimensional activity because it embraces two types of participation happening at the same time: instrumental participation and transformative participation.

Lawrence (2006) defines instrumental participation as a participatory activity defined in a task by others. Lawrence (2006) defines transformative participation as a participatory activity that changes meaning, power or social organisation (Lawrence, 2006).

Lawrence (2006) sees transformative participation as a type of participation that results in a greater commitment to the environment and its conservation. She argues that the commitment of participants in transformative participation grows because participants gain during the participatory environmental activity new values for themselves, for others and for the environment (Lawrence, 2006). For themselves by gaining new insights upon the issue monitored, for others by sharing the data collected during the monitoring activities and for the environment by broadening their knowledge about the monitored issue. Participants involved in a participatory environmental activity receive often volunteer training in order to create valid data and objective and scientific acceptability of their results (Lawrence, 2006). Through these factors participants not only gain a greater commitment but also develop themselves by learning about a phenomenon, increase their knowledge and develop a closer relationship to their research topic (Lawrence, 2006).

Lawrence explains that: "volunteers data can be used to change housing development plans (Bathe, 1993; Key, 1993), to protect livelihoods , and to change policy plans (Evans et al., 2000) (Lawrence, 2006 p. 291)". With the VBM-framework Lawrence (2006) depicts how she frames participatory environmental activities as a transformative type of participation. In the framework she assesses participatory environmental activities in terms of 'external values' and

'internal values' of participants (Lawrence, 2006). Lawrence (2006) defines the external values and internal values of participants as follows:

External values: external values in a participatory monitoring activity is the interpretations of data shared by participants, accessible for the other participants involved. The interpretation of the external values is therefore important because it gives a meaning or focus to the dialogue between participants in a participatory monitoring activity (Lawrence, 2006). On basis of the interpretation of an external value, the public usefulness of the external value becomes clear which leads to decision making within such an activity (Lawrence, 2006).

Internal values: internal values are defined by Lawrence (2006) as the contribution of the participatory monitoring activity to the personal learning facet, self-development and the relation of participants to the environment (Lawrence, 2006). The internal values are the personal learning experiences (which do not persé have to be useful for the participatory monitoring activity). The personal learning experiences are related to participants their consciousness, to their learnings and meanings for them or their community.

In order to make clear how the internal values and external values in a participatory monitoring activity could interact or can be detected, Lawrence (2006) created a diagram. The following figure depicts how she (Lawrence, 2006, p. 293) places the internal and external values in an participatory monitoring activity.

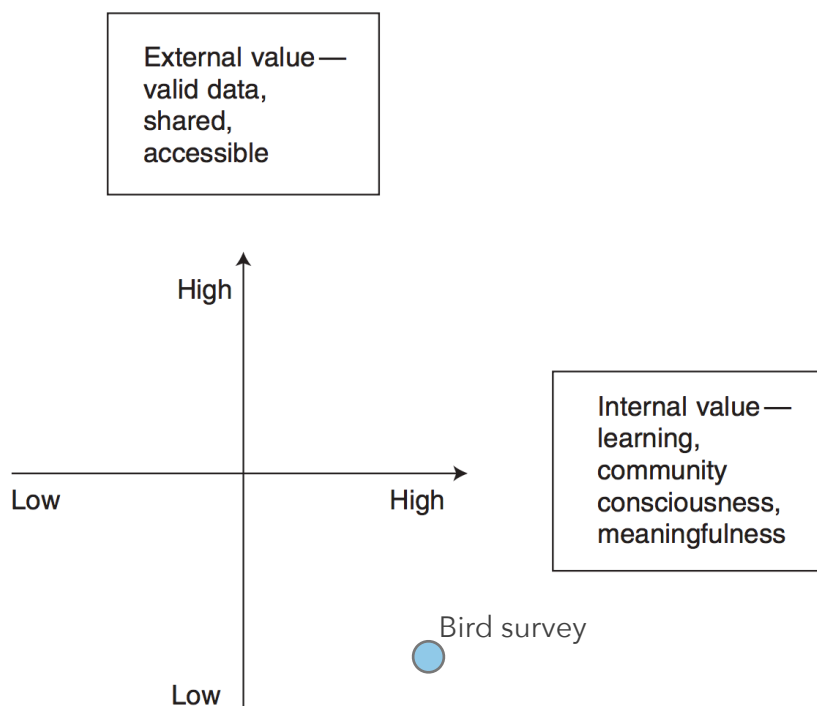


Figure 2. Representing the internal and external values in participatory environmental activities. Reprinted from *Volunteers, Biodiversity, and the False Dichotomies of Participation*, by A. Lawrence, 2006, *Ethics, Place & Environment*, 9(3), p. 293. Copyright 2006 by the Routledge Taylor & Francis Group.

Figure 2 shows the relationship between the external values and the internal values in a participatory activity. The external values are shown on top of the diagram. The external values are as explained above the data interpretations, which is shared and accessible among the participants involved. The internal values are shown on the left of the diagram.

The internal values show the personal learning experiences in terms of community, consciousness and meaningfulness (Lawrence, 2006). In order to explain the diagram, Lawrence (2006) uses an example of a birds survey as participatory monitoring activity.

When placing the bird survey on the diagram, The bird survey would receive a high internal value and a relatively low external value. The bird survey has a high internal value is because participants conducting a bird survey gain much learning experience about the phenomenon they monitor. The bird survey has a low external value, because it will be unlikely that participants will find significant 'new data', such as an unknown bird specie, that will change something to the regular management purposes (Lawrence, 2006). The public usefulness of the data for decision making is in the bird survey case not irrelevant.

Lawrence argues that by taking a closer look at the internal and external value diagram, the relationship between those two values is actually not so linear as depicted above (Lawrence, 2006). A participatory activity is according to her a dynamic process, whereby the experience that participants gain is continuously affected more than just the internal values and external values. Also the environment, the society, other environmental activities and environmental governance influence the internal and external values (Lawrence, 2006). Lawrence shows this dynamic pattern in the following model:

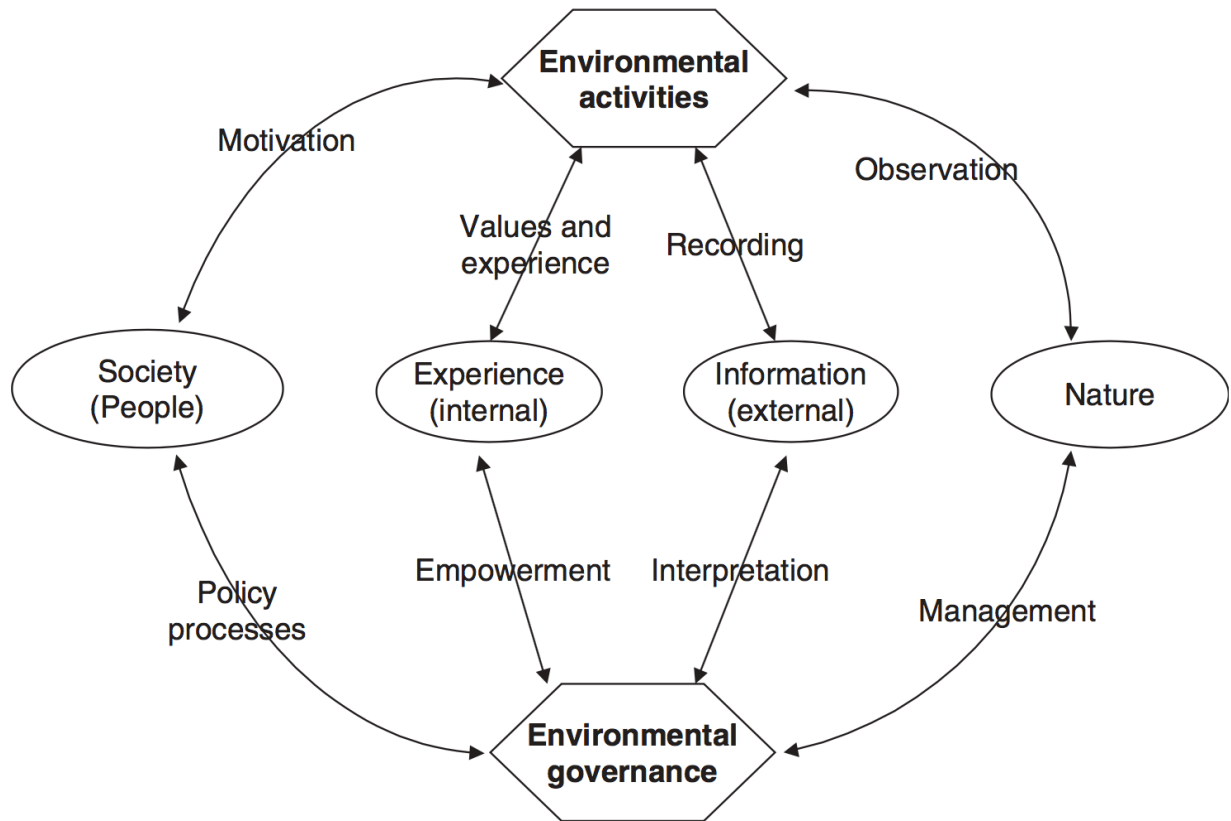


Figure 3. Dynamic interaction between data and experience, objective and subjective, action and decision in VBM. Reprinted from "Volunteers, Biodiversity, and the False Dichotomies of Participation," by A. Lawrence, 2006, *Ethics, Place & Environment*, 9(3), p. 294. Copyright 2006 by the Routledge Taylor & Francis Group.

In figure 3 (Lawrence, 2006, p. 294) Lawrence shows how the society, environmental activities, nature (the environment), environmental governance, experiences (internal values) and information (external values) are woven together in a system. The diagram has its basis in the link between between society and nature (Lawrence, 2006). The basis of the model lays in interactions between the society and nature by conducting environmental activities and forming environmental governance. All the elements in the model are connected through loops. Lawrence explains that these loops are visible and invisible (Lawrence, 2006).

The visible loops show the visible stream of data, the interpretation and recording (Lawrence, 2006). These loops are derived from the act of gathering information during an environmental activity (Lawrence, 2006). This visible stream of data can be related to the external values.

The invisible loops are the personal experiences of participants representing a personal intangible stream of experiences (Lawrence, 2006). According to Lawrence (2006) the model needs to be seen as a fusion of data and personal experience that changes continuously through feedback loops and interactions in the system (Lawrence, 2006). This invisible stream of experiences can be related to the internal values. As showed above, experience can lead to value changes and the changed values can affect in their turn the types of data collected. Lawrence (2006) argues that the act of data collection is the basis for a growing relationship

between a person and a place. According to Lawrence (2006) requires good environmental governance attention to both, human and data, thus as well as the personal learning experiences as the collected data interpretations (Lawrence, 2006). When the dynamic relation between society and nature is represented in this way, research questions can be focused around experience, changing values of participants and the conditions required for empowerment in relation to participatory environmental governance (Lawrence, 2006).

2.4 Combining the DIAD-framework and VBM-framework

In order to assess the case of Smart Emission with a combination lens of both frameworks, I searched how the DIAD-framework of Innes and Booher (2010) and the VBM-framework of Lawrence (2006) could complement each other. The table underneath depicts the differences and similarities of both frameworks.

DIAD-framework		VBM-framework
Differences		
1	Does not include the environment or context within which participatory activities take place	Framework has a basis in the link between society and nature (environment). Does include the environment or context within which participatory activities take place
2	The three conditions of diversity, interdependency and equality are present in a planning process in order to ensure valuable outcomes	Does not include conditions in order to ensure valuable outcomes in a participatory monitoring activity
3	Does not consider external values influencing the process	Does include external values, such as data, influencing the process
4	Do not describe how personal learning experiences change	Describes how personal learning experiences change with help of feedback loops 'visible and invisible ones'
5	Do not show how feedback loops run through the framework	Does show how feedback loops run through the framework
6	The environment is not an important part of the system	The environment is an important component of the system
7	Designed from a planning perspective	Designed from an environmental perspective
Similarities		
1	Participants are main components of the system	
2	Focus on personal learning experiences and interactions between participants	
3	The framework is seen as a 'learning process' that changes through input/output	

Table 1: Combining the DIAD-framework and the VBM-framework

Differences

1. As can be seen in the table above, the DIAD-framework of Innes & Booher (2010) does not consider the environment or context in which participatory activities take place. While, Lawrence (2006) her framework has a basis in the link between society and nature. Lawrence (2006) therefore describes the process of how amateurs (citizens) experience a 'participatory environmental activity' and that the act of data collection lays a basis for a growing relationship between a person and a place.
2. Innes & Booher (2010) have set the three conditions of diversity, interdependency and equality as important features in order to ensure valuable outcomes in a planning process with several stakeholders. The VBM-framework does not consider conditions in order to ensure valuable outcomes of the participatory monitoring activity.
3. The DIAD-framework does not consider how external values, such as data, shared and accessible by participants may influence the focus or direction of a process. The VBM-framework takes in both because good environmental governance gives attention to the personal learning experiences as well as the data interpretations collected in personal learning experiences (Lawrence, 2006).
4. The DIAD-framework does not describe how personal learning experiences change within the framework. The VBM-framework describes how personal learning experiences change with help of feedback loops that show the elements of an environmental governance process.
5. The DIAD-framework has its focus on interactions between elements in a system, just like the VBM-framework. A difference between both frameworks is the DIAD-framework does not actually show how feedback loops, visible and invisible run through the diagram. The VBM-framework does show these feedback loops.
6. In the VBM-framework the environment is an important element of the system. The participatory activity always takes place in a certain environment related to an environmental issue. The DIAD-framework does not include the environment as an important element of the system.
7. The VBM-framework is designed from an environmental perspective and the DIAD-framework is designed from a planning perspective. The environmental perspective is therefore focused on participatory environmental activities, while the DIAD-framework has its focus on a planning process.

Interesting is that even though, both frameworks have another perspective and maybe use another terminology, the actual purposes seem to be similar. Lawrence (2006) aims to achieve 'good environmental governance' and Innes & Booher (2010) aim to achieve valuable outcomes and opportunities out of a planning process. Some similarities between the frameworks are the following.

Similarities

1. Both frameworks consider participants as main components of a system. In the VBM-framework the participants are the ones conducting an environmental participatory activity. In the DIAD-framework the participants are the ones who form the shared meanings and identities that eventually will lead to new heuristics.
2. The personal learning experiences and interactions between participants are in both systems important elements.
3. Furthermore, both systems are approached as a learning process that changes constantly through input and output.

With this comparison I found out that both frameworks complement each other. The DIAD-framework from Innes & Booher (2010) complements the VBM-framework by forming a solid basis at the start of a process with ensuring the three conditions, diversity, interdependency and equality. The DIAD-framework furthermore, gives a clear overview for research analysis because it is divided into three phases. The VBM-framework from Lawrence (2006) provides on the other hand a much clearer overview of personal learning experiences (internal values) and data interpretations (external values) that run through a process. The DIAD-framework does explain that the outcomes of the authentic dialogue are; learning, reciprocity, relationships and creativity but, they does not elaborate on how these outcomes are formed and does not define what these outcomes mean. Therefore the internal values and external values of the VBM-framework can be inserted.

The DIAD-framework finds out in the adaptations of the systems phase how shared meanings, shared identities and new heuristics in a process are formed. The personal experiences and data interpretation streams from the VBM-framework can be used in order to find shared meanings and shared identities. In order to come to good environmental governance in the VBM-framework, or in the DIAD-framework to come to new heuristics, decisions have to be made. These decision may lead to 'as described in the DIAD-framework' over time in actual innovations.

The DIAD-framework designed from a planning perspective and the VBM-framework from an environmental perspective. The case of Smart Emission is a combination of planning and the environment. In order to assess this case through the lens of both frameworks, I combined the DIAD-framework of Innes and Booher (2010) and the VBM-framework of Lawrence (2006) into the Environmental Partnership Policy framework (EPP). The following sections elaborate on this framework.

2.5 The Environmental Partnership Policy framework (EPP)

The Environmental Partnership Policy framework (EPP) is a framework for policy making regarding environmental issues in a partnership with citizens. It is therefore a framework that guides a participatory policy making process. In the EPP-framework different types of participants conduct an environmental activity, learn from this environmental activity and construct new knowledge about this environmental activity in the context of a policy making process. The participants in the process collaborate therefore in the form of a partnership.

The EPP-framework consists of five phases, whereby each phase ends up with outcomes that may change through feedback loops in the next phase. The table underneath depicts the phases of the framework:

Phases	Characteristics of participants	Group discussions	Effects of the group discussions	Adaptations of the system	Innovations
Framework	DIAD	VBM	DIAD & VBM	DIAD	DIAD & VBM
Key-elements	Diversity, Interdependency Equality	Internal values External values	Shared meanings Shared identities	New heuristics	Second and third order effects
Technical innovations alongside the system					
Relevance	Framing the context, ensuring a fruitful process	Analysis of the current framework, what are the learnings and experiences	Feedback loops and dialogue cause identification of the shared meanings. Shared identities are the roles of participants	Decision making leads to new heuristics. New heuristics adapt and evolve the system	Ideas and initiatives from participants that occur beyond the process

Table 2: Phases of the EPP-framework

The framework starts in its basis with the DIAD-framework. First, the three conditions for collaborative rationality need to be ensured in order to create social valuable outcomes and adaptiveness of opportunities and challenges (Innes and Booher, 2010). The conditions ensure the organisation of a 'good' planning process. When the conditions are met within the planning process the process moves on to the second phase.

The second phase includes the internal and external values of the VBM-framework. In the third phase shared meanings and shared identities develop which is derived from the DIAD-framework. The fourth phase is the innovation phase. In this phase the effects on the long-term occur. These effects are idea's and initiatives from participants. The five phases of the table are the innovations. The model underneath depicts the phases of EPP-framework. The model shows how the elements in the policy making process are interrelated with each other via feedback loops.

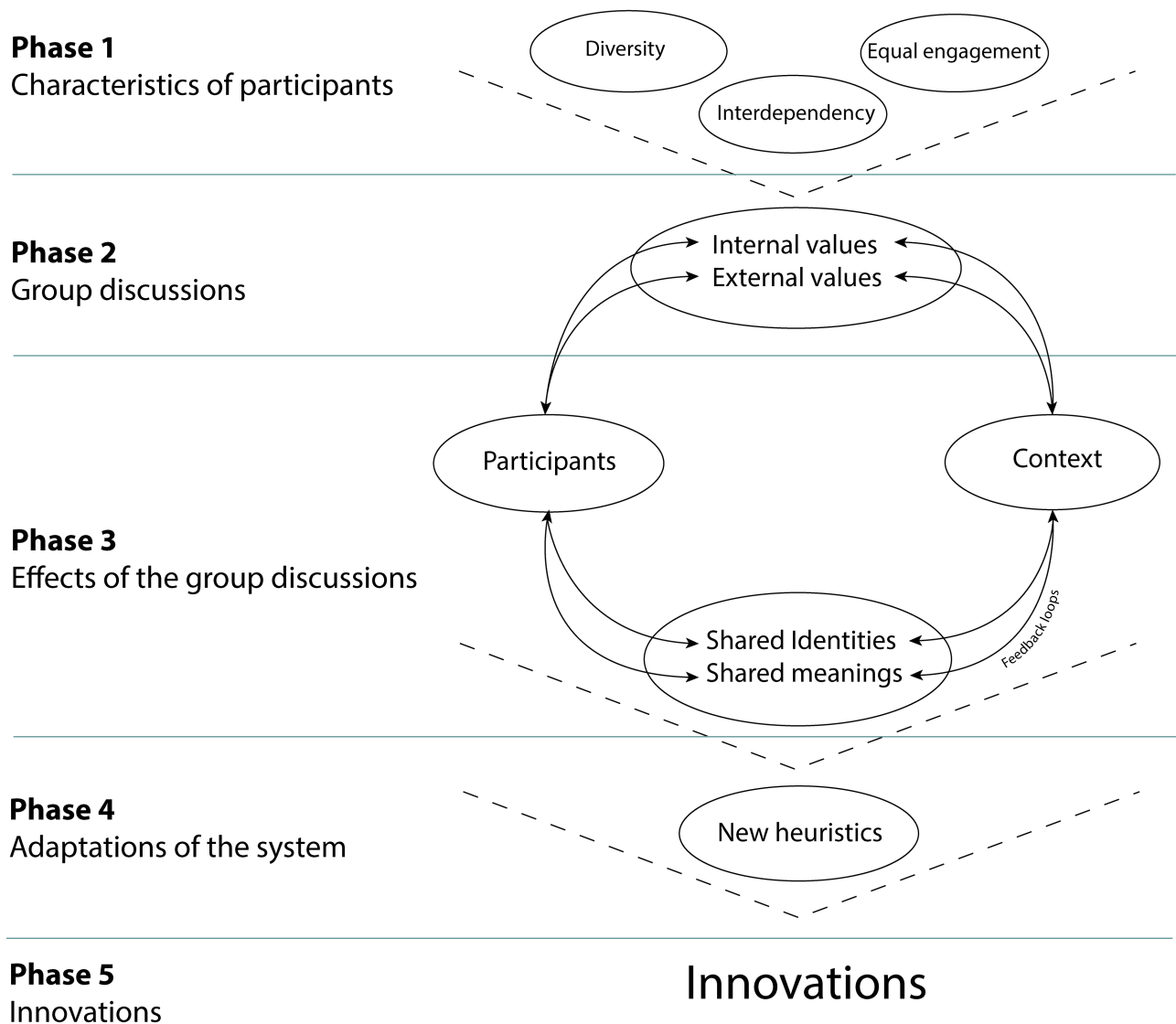


Figure 4: Diagram of the EPP-framework

Phase 1: Characteristics of participants

The first phase is about exploring the characteristics of participants, here the first information about the system is gathered. In this phase the conditions of diversity, interdependency and equality are researched. These conditions are important to because they ensure that valuable outcomes and opportunities will be created in the process (Innes & Booher, 2010). The three conditions are in the EPP-framework approached as follows:

The condition of diversity: this condition argues that the policy making process needs to include participants with power and participants with little or less power (Innes & Booher, 2010). In a policy making process this means that a policy making process needs to include several stakeholders such as citizens, scientists or administrators.

The condition of interdependency: this condition argues that the participants involved must depend on each other until a significant degree and in a reciprocal way in order to construct knowledge in a process (Innes & Booher, 2010).

The condition of equality: this condition argues that the participants involved have to engage equally on a shared task. This is important in order to create a partnership between all types of participants such as administrators, scientists and citizens (Innes & Booher, 2010).

Phase 2: Group discussions

In the second phase the group discussions start. During meetings participants share their personal learnings experiences and data interpretations related towards the participatory activity they conduct. Because, the participants involved start to interact with each other in this phase personal learning experiences and data interpretations become clear. The personal learning experiences and data interpretations are in the VBM-framework approached as the internal values and external values (Lawrence, 2006). In the EPP-framework these internal values and external values are interpret as such:

Internal values: the internal values in the EPP-framework are the personal learning experiences that participants gain by conducting an activity which is part of/or related to a planning process on city-level.

External values are defined by Lawrence (2006) as the data which is shared and accessible among the participants involved.

External values: the external values in the EPP-framework is about the data interpretations that comes forward from the actual act of data collection by the participants involved. The data

interpretations derived from the group discussions, is therefore in the EPP-framework the valid data that is interpreted and shared by participants in a policy making process.

Phase 3: Effects of the group discussions

In the third phase, the effects of the group discussion phase, the participants develop shared meanings. In the first two group discussions there needs to be found out what participants their personal learning experiences and data interpretations are (the internal and external values).

From the third or fourth group discussion it is possible to connect the dots and to find shared meanings among participants. When participants share their personal learning experiences (internal values) and data interpretations (external values) to other participants, the perception from an individual participant on an individual issue can change. When participants start to link one or two internal values or external values to other participants their internal or external values, participants start to see 'issues' from this point holistically (Innes & Booher, 2010). At this point shared meanings develop.

We need to keep in mind that phase 2 and phase 3 are part of an iterative process. This means that when shared meanings develop, at the same time new internal values or external values may appear. When analysing a policy making process, this is an important feature to take in mind.

Next to shared meanings, participants also develop shared identities. Shared identities are defined by Innes and Booher (2010) as a role that someone has in a certain context. In this framework the shared identities are approached as the role that a participant perceives in a policy making process. These roles develop during the group discussions and may change over the process.

Phase 4: Adaptations of the system

The fourth phase is the adaptations of the system phase. In this phase the shared meanings that have developed during the group discussions are able to develop into a new heuristic. Taking in the definition of a new heuristic from Innes & Booher (2010) their DIAD-framework, the new heuristics are in the EPP-framework approached as follows:

new heuristic: is based upon an issue or action that is collectively addressed by at least 2 or more participants. When other participants involved agree upon this issue or action, decision making took place wherefore a new heuristic develops.

The new heuristics are in the EPP-framework therefore approached as the new principals set for

a policy making process. The EPP-framework shows in this way how new knowledge in a policy making process is constructed in order to move forward. Due to the new heuristics set, the system adapts in itself.

Phase 5: Innovations

In the fifth phase the innovations occur. Innovations are second and third order effects which occur actually on the long term, this happens when the policy making process is finished. In this phase ideas or initiatives from participants occur because of their earlier experiences in the policy making process. These ideas go therefore beyond the initial process and evolve on the long term into actual innovations (Innes & Booher, 2010).

3 Research focus

3.1 Purpose statement

In order to understand the contribution of (citizens) participation towards policy making in the context of a citizen-sensor-network, this research examines the case of Smart Emission. Smart Emission is a citizen-sensor-network in which administrators, citizens, scientists and developers collaborate as partners in order to monitor air and noise pollution in the city of Nijmegen.

The case of Smart Emission is in this thesis therefore analysed with help of the EPP-framework. The Environmental Partnership Policy framework (EPP) is a framework for policy making regarding environmental issues in a partnership with citizens. The case of Smart Emission is therefore approached in this research as policy making process. The claim therefore is that Smart Emission is a policy making process regarding air and noise pollution in Nijmegen. The objective of this research is to examine how the citizen-sensor-network Smart Emission contributes to policy making regarding air and noise pollution in Nijmegen.

3.2 Research questions

Main research question:

How does the citizen-sensor-network Smart Emission contribute to policy making regarding air and noise pollution in Nijmegen?

Sub research questions:

1. Who is involved in the citizen-sensor-network and why?
2. What are the internal values and external values from the participants involved?
3. How have shared meanings and shared identities developed in the citizen-sensor-network?
4. How have shared meanings developed into new heuristics?

4 Case orientation

4.1 Citizen-sensor-network Smart Emission

Currently, in the Netherlands monitoring air and noise is a task conducted by the National Institute for Public Health and the Environment (RIVM, 2011). The monitoring activity is conducted with approximately twenty-five large 'sensors' located throughout the Netherlands.

These large 'sensors' are permanent professional stations, often placed outside city boundaries and performing air and noise quality analysis by modelling based on traffic counts or the NIBM calculation (Carton & Ache, 2015).

The National Institute for Public Health and the Environment develops and uses these special models in order to calculate the average yearly pollution at any location in the Netherlands. These calculations are in the Dutch planning system used as guidelines for developments and therefore implemented into policies and regulations. The models provide input to set 'political' norms for air and noise concentrations. With these calculations planners, administrators and experts from municipalities are able to 'test' if a certain development fits at a certain place (RIVM, 2016).

With already an active history in involving citizens in especially air quality projects, the municipality of Nijmegen and the Radboud University of Nijmegen decided to start with the project Smart Emission. Smart Emission has the philosophy of 'bottom-up measuring' with many stations at the local level (34 sensors) instead of a limited amount of stations at the national level (25 sensors) (Carton & Ache, 2015).

Nijmegen and the Radboud started this project in collaboration with their consortium partners: Intemo, Geonovum, the national institute for Public Health and the Environment (hereafter RIVM) and CityGIS. The project is about a city-wide citizen-sensor-network that builds upon new technical and social knowledge in order to improve the local air quality and noise pollution in dedicated places. In the project citizens and experts are collaborating in a community of practice (Carton & Ache, 2015).

Nijmegen aims to raise awareness by actively involving citizens in their living environment. The city uses knowledge, experience and data from citizens to improve the living environment. Geonovum and CityGIS are conducting research for the technical infrastructure that is needed and the planners of the Radboud University research how the collaboration between citizens and municipality can adapt to this new form of 'bottom-up' planning process (Carton & Ache, 2015).

The project measures the urban air quality by using an innovative sensing method. Therefore, the company Intemo developed new, low-cost sensors with a wireless framework in order to communicate real time data. The sensors are attached to citizens their homes and to places where citizens work.

With wireless Wifi the sensors send out a refined data-flow towards online viewers showing air quality concentrations of Ozone (O₃), Nitrogen Dioxide (NO₂), Carbon Dioxide (CO₂) and in Carbon Monoxide (CO) (Carton & Ache, 2015). The noise pollution is measured in dB(A) levels. Participants involved in the citizen-sensor-network are able to communicate and share information on a forum and are able to post messages online at a logbook. Every month meetings are organised to share data and findings (Carton & Ache, 2015).

5 Methodology

5.1 Introduction

In this chapter is explained how the research is conducted. According to Boeije (2014) research is comparable with a film production (Boeije, 2014). He explains that the role of the methodology is the 'making of the research' whereby the researcher shows how the elements of the process together create the research (Boeije, 2014). This chapter starts with explaining the worldview and role as a researcher in order to explain from which perspective this research is conducted. Section 5.3 elaborates on the research design. After this section the data collection and the data analysis follow. In the last section ethics and validation are discussed.

5.2 Worldview

World views are general orientations about the world and the nature of research that a researcher holds. World views are shaped by the discipline area of a researchers background, the beliefs of the researcher advisers and past research experiences of a researcher (Creswell, 2014). This research is most related to the transformative worldview, caused by past experiences I had as researcher within participatory planning projects.

According to Creswell (2014) the transformative worldview arose during the 1980's and 1990's . This worldview arose from individuals who felt that the post positivist assumptions did not fit them. Creswell explains that transformative research often contains an action agenda for reform, that may change lives of participants or institutions in which participants act. In transformative research issues are in general related to empowerment, inequality, oppression, domination, suppression and alienation (Creswell, 2014).

In my opinion, the transformative worldview fits in this research because the issues addressed are highly related to the political agenda of the municipality of Nijmegen. Furthermore, the research has a focus on understanding 'how a phenomenon, in this case the citizen-sensor-network, contributes to something' and it gains an understanding of how the 'institution of current policy making' slowly changes because of involving citizens in these processes.

The citizen-sensor-network Smart Emission as a policy making process can therefore be approached as a partnership between citizens and experts. According to Healey (2010): "partnerships are in literature of collaborative planning and communicative planning often treated as if the aim is to 'neutralize' power" (p. 625). When I reflect this argument upon the DIAD-framework of Innes & Booher, this framework is treats in a similar way. Innes & Booher

found their inspiration in Habermas notion of communicative rationality. This is implemented in the first phase of their framework that emphasises on achieving the three conditions equality, diversity and interdependency (Innes & Booher, 2010).

Personally as researcher, I do understand that there is a need for a certain 'equality' within a planning process in order to make a collaboration between several stakeholders easier. But, I do not share the idea that everyone in a process needs to be 'equal' on the same level and I also do not think that equality needs to be achieved first before moving on in a process. I think that in situations where decisions have to be made, there always is some play of forces. Therefore, I would not choose to take in Habermas notion of communicative rationality. I choose to take the perspective from the notion of Healey (2003). Healey (2003) argues that there is always some 'power' necessary in a planning process in order to make decision. She therefore sees the play of forces as a means to an end, and not as an end itself (Healey, 2003).

By taking in this notion, the citizens and experts in the citizen-sensor-network are seen as individuals that have more or less power when interacting with each other. Interesting is that the development of shared meanings may change the power-relations because individuals can become more powerful when collaborating. It also gives individuals the possibility to influence or steer a policy making process into a certain direction (Creswell, 2014).

According to Mertens (2010) by Creswell (2014), the key features in transformative research are lives and experiences of diverse groups that by making use of a program theory beliefs how something works and why problems of oppression, domination and power relations exist" (Creswell, 2014).

In this research the case of the citizen-sensor-network Smart Emission is seen as the EPP-framework, or in Creswell's (2014) terms 'the program theory' that searches for how and why something works.

5.3 Role of the researcher

If we take a look at the role of the researcher, qualitative research is seen as interpretative research, with the researcher being involved in a sustained and intensive experience with participants (Creswell, 2014). In this research I have been involved in the citizen-sensor-network as student-researcher and participant-observer. I therefore actively participated in the citizen-sensor-network by interviewing the participants and by observing the participants during group discussions. To collect data, I started with in-depth interviews in order to get to know the participants and to create social bonding with the participants. Afterwards, I observed the participants during group-discussions. Participants were willing to share a lot of information with

me during the group discussions because they knew me already from the interviews. Therefore the data I gathered was much more detailed and useful than when I had chosen for another type of data collection. For example, I first tried to collect data through a survey, because I thought that I would reach a larger group of people. I tried this with participant 11, because this person was not able to do a personal interview. The answers she gave were superficial and did not contain the information I needed. The answers gained from the first in-depth interview were much more valuable and detailed. For me, this was a good lesson learned.

During the group discussions I observed how the participants of the citizen-sensor-network discussed the issues. In order to prevent bias in my data, I did not ask questions during these discussions.

To prevent bias in my data because of my personal background, I asked a student-assistant from the Radboud University if he wanted to observe with me during the group discussions. In the end, two student assistants helped me with noting during the group-discussions. In this way I was able to observe the participants from different perspectives. During the group discussions I created observation memo's describing all the thoughts and experiences participants were sharing.

I tried to anticipate beforehand on ethical issues. I have been involved in the citizen-sensor-network as researcher, so I did have a role that could influence the outcomes of the citizen-sensor-network. To prevent this, I explained my respondents in the introduction of every interview that I was conducting research for my masterthesis and that I did not represent the municipality or any other organisation. I also asked participants before the start of the interview to be open and honest and had some small talks with them. This would help for them to open up and for me to get connected with them. In this way, it was a perfect position to collect detailed information and to gain participant's opinions.

Furthermore, I discussed my results during the data collection and analysis with other student-researchers in Wageningen and a professor from the Radboud University of Nijmegen. The position for me as student from Wageningen University conducting a research in which Radboud University and the municipality of Nijmegen were involved gave an advantage in collecting information. I had data access to the WUR-Library and the Radboud Library and I was also able to discuss the outcomes with other student-assistants and teachers from Radboud University as well as Wageningen University.

5.4 Research design

Research designs are types of inquiry (or strategies of inquiry) within qualitative, quantitative and mixed methods research. For qualitative research multiple designs are available such as: narrative research, phenomenology research, grounded theory research, ethnographic research and case studies (Creswell, 2014). Let's take a brief look into the type of studies available as proposed by Creswell (2014):

Narrative studies cannot start from an explicit theoretical assumption; phenomenology describes the lived experiences with a strong philosophical grounding; Ethnography needs a long period of time for conducting valid research, while this research needs to be conducted in approximately five months. Grounded theory could be a fit because I seek for an understanding using theory to build up a new framework; action research seeks to understand the world by trying to change it in a collaboration with other stakeholders, this could also fit; than we have case study design where deeper understandings of a certain phenomenon are researched (Creswell, 2014). I like to seek for the deeper understanding of the citizen-sensor-network and how it contributes to for policy making regarding air and noise. Case studies give the opportunity to go in depth for an understanding and has a lot of freedom to the research design, this made for me a case study the best fit.

By conducting this brief exploration and taking a look at the purpose of the research, the case study is chosen as best fit to this research. According to Creswell (2014) case studies are a design of inquiry for in-depth analysis of processes, activities and events in a particular case, providing context-dependent knowledge. All case study research starts from the same compelling feature Creswell (2014), namely the desire to derive a close or in-depth understanding of a single or small number of 'cases' in their real world contexts (Creswell, 2014).

Bleijenbergh (2013) argues that the case study is the perfect research method to study a social phenomenon in order to draw conclusions about underlying patterns or processes (Bleijenbergh, 2013). She explains that the case study includes a triangulation of open interviews/participatory observations and document collections, which gives the possibility to research a phenomenon into depth (Bleijenbergh, 2013). Furthermore, the type of questions proposed in research is pertinent, because it provides an important clue regarding to the most relevant research strategy to be used (Creswell, 2014).

Yin (2009) argues that three steps need to be taken before researchers are able to start with a case study. First step is about defining the case. A case can be a person, organisation, behavioural condition or other social phenomenon. Second step is that a case study design needs to be selected. Case studies can consist of single or multiple cases and can even have

embedded units within the main unit. The third and last step is that a theory needs to be defined and used as lens for designing the case study. The theory is the main vehicle for generalising results because it provides guidance in the design and for collecting relevant data (Yin, 2009). For this research I therefore choose to walk through the three steps of Yin.

Step 1. Defining the case

In this research, the citizen-sensor-network Smart Emission is chosen as case. By choosing for just one case I am able to go into depth within this 'best practice' (Bleijenbergh, 2013). I hope to demonstrate with this case analysis that a citizen-sensor-network could contribute as policy making process regarding air and noise pollution. There are just a few other experiments related to the citizen-sensor-network Smart Emission in the Netherlands. These experiments are: AiREAS in Eindhoven and Smart citizen kit in Amersfoort (Kerssemakers, 2016). These experiments are, at the moment of conducting this research, not as far developed as the citizen-sensor-network Smart Emission in technology and in collaborating with citizens in a partnership. This why the case is interesting for analysis because it could give some insights in understanding the phenomena air and noise when assessed in partnerships.

2. Case study design: Single-case with embedded units of analysis

Within case studies, the two designs often used are the singular case study and the multiple case study. Within these two types of case study design, one specific unit of analysis can be researched or more (embedded) units of analysis can be researched. For this research there is chosen for a single-case with embedded units of analysis. The case is the citizen-sensor-network Smart Emission and the embedded units of analysis are the participants of Smart Emission. Figure 5 (Yin, 2009, p. 46) shows the embedded units of analysis.

Context: citizen sensor network

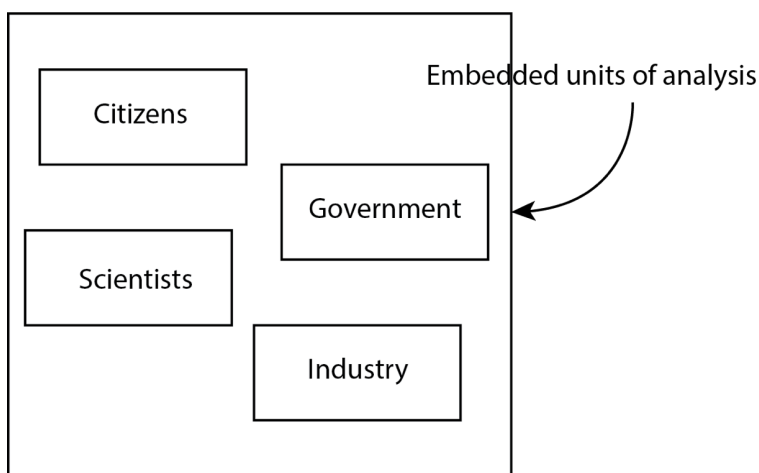


Figure 5. Basic model of case studies. Adapted from "Case study reserach: methods and design," by R.K. Yin, 2009, 4th ed., pp. 3-124). Thousand Oaks, California, Copyright 2006 by SAGE Inc.

3. Defining a theoretical framework

The theoretical framework used for this research is the EPP-framework, derived from a combination lens of the DIAD-framework of Innes & Booher (2010) and the VBM-framework of Lawrence (2006). Both frameworks are derived from different scientific disciplines, planning literature and environmental sciences. By using the EPP-framework I was able to extract the new knowledge constructed within the citizen-sensor-network. Therefore the contribution of the citizen-sensor-network Smart Emission to the policy making process regarding air and noise pollution in Nijmegen is demonstrated.

Five common misunderstanding of case studies

Case studies are often criticised by researchers because they are seen as not reliable to provide information about a broader class (Abercrombie, Hill, & Turner, 1984 p. 34 by Flyvberg, 2006, p. 220). Because I think that this criticism is a misconception, I used Flyvberg (2006) to justify the use of a singular case study as research design for this research.

According to Flyvberg (2006) the general criticism on case studies is derived from the conventional view on science, which is described by Campbell & Stanley in 1996 (Flyvberg, 2006). According to Flyvberg (2006) Campbell & Stanley (1996) argue that case studies do not have any scientific value because there is an absence of control, absence of absolute knowledge and absence of intrinsic knowledge. Therefore research about singular isolated objects is found to be illusory (Flyvberg, 2006).

As countermovement Flyvberg (2006) argues that there are in general five common misunderstandings about case studies. He therefore explains that when he first became interested in research, he tried to understand complex issues such as 'power-relations' and rationality by applying case-study research (Flyvberg, 2006). To his amazement, his teachers and colleagues dissuaded him continuously from using the case study as methodology for his research. Flyvberg (2006). Therefore he started to research why and where these critiques came from. He therefore found five common misunderstandings about case studies (Flyvberg, 2006). In order to overcome this issue for my research-design I will elaborate on these five misunderstandings from Flyvberg (2006):

1. The first common misunderstanding is that theoretical knowledge is more valuable than practical knowledge;
2. The second common misunderstanding is that a case study does not contribute to scientific development because 'one' is not able to generalise outcomes on basis of the analysis from 'one' case;

3. The third common misunderstanding is that the case study is only useful for generating a hypothesis, only useful for the first stage of a research process and that other methods fit better to hypothesis testing and theory building;
4. The fourth common misunderstanding is that case studies contain bias where through there is no verification of the results;
5. The fifth common misunderstanding is that case study research is not able to summarise and develop general propositions and theories (Flyvberg, 2006).

The first misunderstanding is revised by Flyvberg (2006) as follows: "Predictive theories and universals cannot be found in the study of human affairs. Concrete, context-dependent knowledge is therefore, more valuable than the vain search for predictive theories and universals" (p. 224). The second misunderstanding is according to Flyvberg a typical misunderstanding between proponents of natural sciences. Flyvberg (2006) explains therefore that Galileo's experimentalism for gravity did not involve a large random sample of trials of objects falling from a wide range of randomly selected heights, including the wind conditions, sun conditions and so on. It was rather a single experiment, that can also be seen as a case study (Flyvberg, 2006). When taking this perspective into social sciences, a strategic choice of just a singular case can also add to the general knowledge (Flyvberg, 2006).

Flyvberg (2006) therefore reads the second misunderstanding as such: *"One can often generalise on the basis of a single case, and the case study may be central to scientific development via generalisation as supplement or alternative to other methods. But formal generalisation is overvalued as a source of scientific development, whereas "the force of example" is underestimated (p. 228)"*.

The third misunderstanding where scientists argue that the case study is claimed to be most useful for the first steps of a research process and forming a hypothesis is based on the second misunderstanding (Flyvberg, 2006). Therefore Flyvberg (2006) argues that we indeed are able to generalise from one case study what makes that the case study is also useful for generating and testing hypotheses.

The fourth misunderstanding is misunderstood because the question of subjectivism and bias towards verification is something that applies to all type of research methods, not only qualitative research methods and case studies. In quantitative studies the choice of categories and variables is an element of arbitrary subjectivism. In these type of studies the probability is high that the subjective survives without being corrected in the study. Therefore the results can be affected because a quantitative researcher does not get that close to the 'units of analysis' (Flyvberg, 2006).

Case studies on the other hand, are able to 'close-in' on real life situations and therefore test views directly in relations towards a phenomenon in practice (Flyvberg, 2006). Scientists in case studies experience more often falsification instead of verification. Pre-assumptions, pre-views and pre-concepts from researchers are often wrong and revised during the study.

Flyvberg (2006) revised the fourth misunderstanding therefore as such: "the case study contains no greater bias toward verification of the researchers preconceived notions than other methods of inquiry. On the contrary, experience indicates that the case study contains a greater bias toward falsification of preconceived notions than toward verification (p. 237)".

The fifth misunderstanding is reformulated by Flyvberg (2006) as follows: "It is correct that summarising case studies is often difficult, especially as concerns case process. It is less correct as regards case outcomes. The problems in summarising case studies, however, are due more often to the properties of the reality studied than to the case study as a research method. Often it is not desirable to summarise and generalise case studies. Good studies should be read as narratives in their entirety (p. 241)". The choice for a singular case-study as research design is for this research a way of gaining detailed information and knowledge from participants which is able to bring forward valuable outcomes that can also be used in other 'partnerships'.

5.5 The process of data collection and analysis

Data collection and analysis methods in case studies do not have a strict routine. Case study data collection does not include a formal protocol, because the specific information that may become relevant to a case study is not readily predictable (Yin, 2009). Good case studies benefit from multiple sources such as interviews, participatory observation or document analysis (Creswell, 2014).

Case studies can include both qualitative and quantitative data. In order to provide some steering to the data collection, I operationalised the elements of research under the research questions. Therefore the following table is developed.

Research questions	Data collection method	Elements of research	Key results
Who is involved in the citizen-sensor-network and why?	In-depth interviews (semi-structured) Observing during group discussion	Participants involved: citizens Scientists Government Industries	Participants Personal interests Other interests Background interests
What are the internal values and external values from the participants involved?	In-depth interviews (semi-structured) Observing during group discussion Document analysis	Participants involved: citizens Scientists Government Industries	Internal values External values
How have shared meanings and shared identities developed in the citizen-sensor-network?	In-depth interviews (semi-structured) Observing during group discussion Document analysis	Participants involved: citizens Scientists Government Industries	Shared meanings Shared identities
How have shared meanings developed into new heuristics?	Observing during group discussion In-depth interviews (semi-structured)	Participants involved: citizens Scientists Government Industries	New heuristics

Table 3: Operationalisation of questions, methods, elements and results

The table shows the research questions, the methods used in order to collect the data for the research questions, the element of research and the key results gained per research question. The following section explains how the process of data collection and data analysis is conducted.

The process of data collection and analysis is divided into 3 phases. In all of these phases is described which instruments are used to collect data, how these instruments were valuable for the data collection process and which to results these instruments have led.

Phase 1: Interviews with participants involved

I collected the first data by conducting individual in-depth interviews with participants. The interviews gave therefore an insight into research question 1. The interviews gave a first idea of who was involved in the citizen-sensor-network and why. This gave a first perspective on participants their personal interests, their background interests and other interests. The interviews gave also a first insight in the personal learning experiences (the internal values) and the interpretations of the data stream (the external learning experiences). Which gave the first data for the 2nd research question.

The interviews furthermore gave an insight into the shared identities. During the interviews I namely asked participants how they perceived their role up till now in the citizen-sensor-network. This gave the first data for the 3rd research question.

In order to find participants who wanted to be interviewed I called and send e-mails to all the 34 participants in the citizen-sensor-network. Eventually, I gave 17 participants a call by phone and I have send to 19 participants an e-mail. In the end 11 participants contributed to the interviews for the research. Every participant in the research received a number, the participants (P) that contributed to the interviews were: P1, P5, P6, P7, P10, P11, P12, P13, P14, P15, P16.

In order to interview the participants I developed an interview protocol. In the first three interviews I tested the interview-protocol. Together with the first three participants interviewed I developed and perfected the interview-protocol by going through all the questions with the participants after the interview was conducted. The questions therefore changed and received more focus in order to collect useful data. This resulted into a final protocol. This protocol can be found in appendix 1 of this research.

In order to conduct the interviews I made an appointment with participants at their homes. This was a conscious choice because by interviewing participants at their homes, I had the opportunity to really get to know them, to take time for them and to gain trust with them. Furthermore, the participants could show me where their sensor was attached/or hanging and what their sensor monitored. Participants therefore really seemed to open up and shared their thoughts with me as researcher. Sometimes an in-depth interview took even more than 4 hours. The in-depth interviews helped therefore in the whole process to gain even more interests, experiences and data interpretations during the other phases of data collection.

In order to collect all the data in detail and to have a qualitative, good conversation with the participants, I recorded all the interviews. Before every interview I introduced myself and asked participants if they were 'okay' with recording the interview. I therefore explained the participants that it would be then easier for me to have a talk with them. Directly after each interview I transcribed the interviews. In the transcriptions the participants stayed anonymous. The participants therefore received a letter and a number. Every participant is indicated with an P and received a number that was related to the number of the sensor. Together this resulted into P1, P2, P3 and so on. The interviews are recorded in Dutch, all the transcriptions are therefore transcribed in Dutch. All the answers that participants gave are first written down in Dutch and later in the data analysis phase translated into English.

The interviews furthermore, helped me to connect easily to the other participants, that did not participate in the interviews but, did participate in the group discussions. The interviews had in

this way a positive influence on the quality of the results. The group discussions took place in the second phase of data collection.

Phase 2: Observing and participating in 5 group discussions

The second phase of data collection took place during 5 group discussions. In these group discussions I collected the following data from the participants involved: the personal interests; the background interests; the other interests; the internal values; the external values and the shared identities. Furthermore, I collected the shared meanings by interrelating the personal learning experiences (the internal values) and the interpretations of the data (the external values) of individual participants, during the group discussions and directly after the group discussions. Therefore I observed the group discussions and used noting. Because the group existed of at least 10 participants at each group discussion, I also asked two students from the Radboud University to help me noting. From the shared meanings I was able to find the new heuristics. The new heuristics developed in the last two group discussions. The second phase of data collection and analysis contributed therefore the answer on research question 1, 2, 3 and 4.

The citizen-sensor-network organised (almost) every 4-weeks group discussions in order to share data and findings. Therefore I participated from September 2016 up till January 2016, in 5 different group discussions. Three of the group discussions were organised at an evening in order to inform each other about the developments in the citizen-sensor-network and to share data and findings. One of the group discussions was organised in the form of a cycling route along the sensors in the city of Nijmegen. One of the group discussions was organised in the form of a 'reflection day'. During this day the participants presented for each other their personal learning experiences and discussed their findings.

In total 34 participants are involved in the citizen-sensor-network. Wherefrom during the group discussions in total 16 participants participated. From these 16 participants, 9 participants also participated in the interviews. Which means that from the in total 34 participants 18 participants contributed to the research. The table underneath shows who contributed to the group discussions.

Group discussions	Participants involved (Indicated with P1, P2 etc.)
1. Cycling day along the sensors & discussion	P7, P11, P14, P15, P21, P14, P16, P22, P23
2. Discussion evening about air pollution	P1, P6, P11, P12, P13, P14, P15, P18, P19, P21, P22, P23
3. Discussion evening about noise pollution	P1, P7, P11, P12, P14, P18, P20, P21, P22, P23
4. Closing group discussion	P1, P6, P7, P11, P12, P13, P14, P15, P16, P17, P18, P19, P20, P21, P22, P23
5. Specific group discussion	P6, P19, P21, P13, P17, P11, P7, P15

Table 4: overview of participants in the group discussions

The first group discussion in September was organised as 'a cycling day along the sensors' with the participants. In this group discussion 9 participants participated. The second group discussion was organised in the form of an informative discussion evening about air pollution. Here 12 participants participated. The third group discussion was organised as an informative discussion evening about noise pollution. Here 10 participants from were involved. In the fourth group discussion 16 participants were involved. This was a group discussion organised as a 'closing discussion' for the citizen-sensor-network. Eventually a fifth group discussion was organised in January in order to form a specific group that would start to do research towards specific neighbourhood related topics. Here 8 participants were present. There were two participants that were interviewed but were not able to participate in the group discussions because of health issues. These participants were P5 and P10.

As mentioned above, during the group discussions the personal interests, background interests and other interests are noted by observing the participants during the group discussions. I noted every group discussion the personal interests, background interests and other interests. Furthermore, I observed how participants shared their the personal learning experiences (internal values) and interpretations of the data (external values). Every group discussion I noted which participant shared which personal experience or data interpretation. After each group discussion I compared the personal learning experiences (internal values) and interpretations of the data (external values) from an individual participant with the previous personal learning experiences (internal values) and interpretations of the data (external values) from the same individual participant when possible. Furthermore, all the new personal learning experiences (internal values) and interpretations of the data (external values) of other participants or even 'new' participants taken in the research are collected.

After the third group discussion I was able to find the first shared meanings among participants. I found these shared meanings by connecting the personal learning experiences (internal values) and interpretations of the data (external values) of individual participants to each other. I was able to connect these during the group discussion, thus when participants in the group discussion started to share opinions, but also by connecting a personal learning experience derived from an individual participant in the third group discussion with a personal learning experience derived from an individual participant from the fourth group discussion.

In the last two group discussions the participants involved made some agreements upon some of the shared meanings that have developed within the process. Interesting to see was that some personal learning experiences (internal values) and some interpretations of the data (external values) returned in these last two group discussions. These internal values and external values were the basis for explaining their shared meanings and therefore achieve agreements in

order to collectively address a certain action or issue (a new heuristic). The new heuristics developed thus at the last moment of the, in this case, policy making process. The new heuristics were game changers in a way that the citizen-sensor-network therefore developed itself.

Phase 3: coding and interrelating the data

Phase 3 can be seen as an iterative process that continuously interrelated with the other two phases of data collection and analysis.

The first phase started with the interviews. After every interview I directly transcribed the interview, resulting into the 'raw data'. For the transcriptions I used a laptop and the recording file and stopped every 2 minutes in order to write down exactly what was said. In order to organise and prepare the data for analysis I started with coding the interview. Therefore I used the coding process as proposed by Creswell (2014) in his model of data analysis (Creswell, 2014).

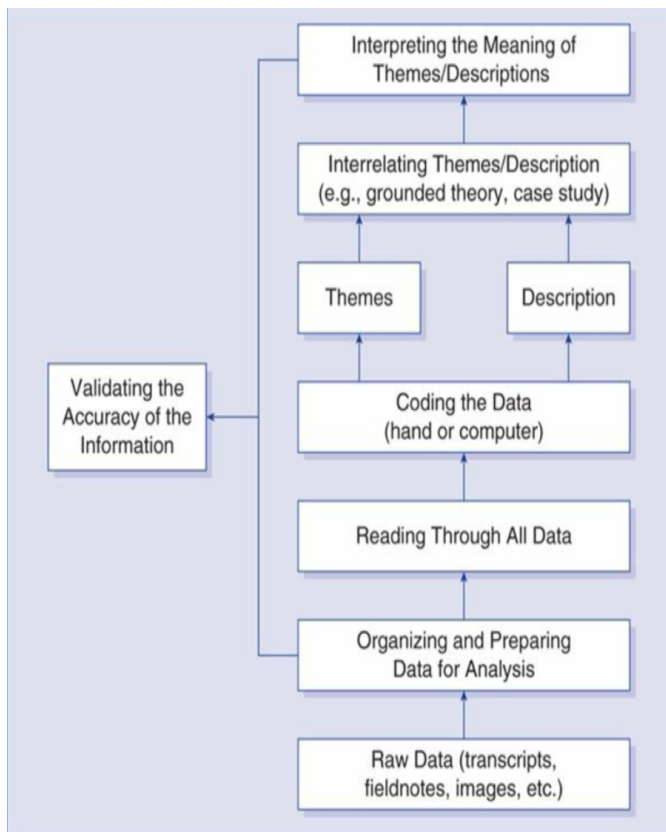


Figure 6. Model of data analysis. Reprinted from "Quantitative, Qualitative and mixed method approaches," by J. Creswell, 2014, (4th ed., p. 247). Lincoln. Copyright by (2014) SAGE Publications Inc.

After conducting every interview, I transcribed the interview as fast as possible in order to prepare it for the coding process. After transcribing I implemented the transcriptions into the the software program Atlas.ti 2011. Atlas.ti 2011 was a perfect software program in order to apply the coding process to the research. I first applied open coding to the transcriptions of the interview. After the first time coding it was hard to define some categories already. Therefore I first conducted and transcribed a second interview. After applying open coding the second

interview I found out that I was able to define some categories. I moved on with this process of coding until all interviews were coded. After this first coding steps I searched if I could find some categories that were interrelated to the concepts in the theoretical framework. The concepts I searched for were: diversity, interdependency, equality, internal values and external values.

In the second phase I observed (with help of two other students from the Radboud University) the group discussions. During the group discussions I used noting in collaboration with the other two students. This resulted also in 'raw data' that I derived from the group discussions. After each group discussion I transcribed the notes and uploaded them in the Atlas.ti 2011 software. I therefore also started with open coding. After coding one group discussion, I searched for categories in where the codings could fit. After defining the categories I started to interrelate the categories with the concepts from the theoretical framework. Therefore is searched again for the concepts of diversity, interdependency, equality, internal values and external values. This coding process of the group process repeated itself for 5 times. Interesting was that after the third group discussion I was able to interrelate internal values and external values from individual participants. These interrelated internal values and external values were than developed as a shared meaning.

In the last two group discussions the participants made agreements upon the shared meanings that formed in the first, second and third group discussion. With these agreements I was able to interrelate the shared meanings with the new heuristics that developed within the citizen-sensor-network.

5.6 Ethics and validation

The validity of the data collection in this research is ensured by triangulation of resources: scientific literature, municipal documents and empirical material from participants. This research furthermore uses triangulation of methods: document analysis, interviews and participant observation during group discussions. In order to prevent bias in the research that is caused by personal background or social status I asked two other students from the Radboud University, who were also involved in the citizen-sensor-network, to help me conduct the observations during the group discussions.

Furthermore I discussed (when approved by the interviewee) my transcriptions of the interviews with another student from the Wageningen University, with the the two students from the Radboud University that were also involved in the citizen-sensor-network and often with a professor from the Radboud University who was involved in the citizen-sensor-network as scientist. I discussed mainly the codings from the group discussions with the two students from the Radboud University in order to find out if I did interpret their observations well. The ethical considerations in this research are mainly related to privacy and sensitivity of the information

that is gathered about air and noise pollution in Nijmegen. In order to secure the privacy from participants involved all the participants are anonymous in the research. I furthermore, member-checked the interviews with the interviewees and asked the participants if they wanted to sign the interview-protocol as approval for use in my research.

6 Results & analysis

6.1 Introduction

This chapter elaborates on the results from the data collection and data analysis. The chapter starts with answering the research question of who is involved and why. Then it moves on to the shared identities by elaborating on the 'perceived roles' of participants. Section 6.4 elaborates on the internal values and external values collected during the interviews and observations during group discussions. Section 6.5 moves on with the shared meanings and shared identities that developed within the citizen-sensor-network. In conclusion this chapter elaborates on the new heuristics that developed.

6.2 The participants involved

In the citizen-sensor-network four different types of participants are involved namely: citizens, scientists, experts from industries (software- and hardware developers) and administrators (government). The citizens involved are the citizens living in and around the city of Nijmegen. The administrators involved are the air and noise quality experts from the municipality of Nijmegen. The scientists involved are the planning scientists from the Radboud University. The experts from industries involved are soft- and hardware developers.

In order to gain an idea of who these participants are and why these participants are involved, this section first provides an overview of the participants involved and then elaborates on their background interests, their personal interests and other interests.

In the citizen-sensor-network 34 participants are involved. The participants all have a sensor that monitors the air and noise pollution in the city. From these 34 participants, 11 participants have participated in the in-depth interviews. In total 16 participants have participated in the group discussions, wherefrom 9 participants also participated in the interviews. This means that in total 18 participants have contributed to this research. In total 11 interviews are conducted and 5 group discussions have taken place.

In the interviews and group discussions participants, with different gender, backgrounds and age participated. Because of privacy reasons the participants received in this research their own 'unique codenames' such as P1, P2 and so on. The letter P is related to the word participant. The number '1' is related to the sensor number of the participant. The table on the next page shows an overview of the participants who have participated in this research. In the table the types of

participants received their own colours. These colours are used through the whole report in order to indicate the contribution to the research of the different groups involved.

Codenames participants	Gender	Age	Background (professional)	Type of participant in the citizen-sensor-network
P5	M	62	Meteorologist	Citizen
P10	M	60	Biochemist	Citizen
P11	F	57	Not available	Citizen
P12	M	60	Researcher	Scientist
P13	M	24	Data scientist	Software developer (industries)
P14	M	59	Environmentalist	Administrator (government)
P7	M	37	Council member	Citizen
P6	M	67	Researcher	Citizen
P1	M	36	Artist	Citizen
P15	F	50+	Philosopher	Citizen
P16	F	50+	Environmental residents committee activist	Citizen
P17	F	50+	Environmentalist	Citizen
P18	M	50+	Not available	Citizen
P19	M	50+	Environmentalist	Citizen
P20	F	35	Researcher	Scientist
P21	M	45	Data scientist	Hardware developer (industries)
P22	M	50	Air quality expert	Administrator (government)
P23	M	50+	Noise quality expert	Administrator (government)

Table 5: Interviewed participants including codenames, gender, age and backgrounds

The table depicts that 13 of the participants are men and that 5 participants are women. The men are between 50-60 and the women are between 40-50. The background from participants are variable. There is 1 data scientist (P13) with an age of 24, there is 1 researcher (P20) with an

age of 35, there is 1 council member (P7) with an age of 37 and there is one citizen (P1) with an age of 36.

There are 11 participants that can be approached as the citizens. In this group the participants have various (professional) backgrounds. Only 2 participants have a similar background, namely P17 and P19. There are 2 participants scientists and 3 participants are administrators (government), 2 participants involved are developers from industries. There are 8 participants with a background that is related to 'environmental purposes'. This is P5, P1, P14, P16, P17, P19, P22 and P23. 2 participants (P11, P18) did not want to share their background.

In reflection to the EPP-framework it is interesting to see that the condition of diversity is embedded within the citizen-sensor-network in these 18 participants already. From the 18 participants that contributed to this research, all type of participants, or in terms of Yin (2009) all embedded units of analysis for a singular-embedded case study are represented. The condition of diversity can also be found in the variable backgrounds of participants involved. The condition of diversity is less embedded in the variety of age.

6.3 Participants interests

This section elaborates on the background interests, the personal interests and the other interests found during the interviews and group discussions. The coding process helped to distinguish these three groups of interest. Interesting finding in this case is that the background interests found have a strong relation with environmental issues and research. The personal interests are related to an issue a participant experienced in his direct living environment. One other interest found. This interest did not fit into the background interests or personal interests. The next sections elaborate on these three groups of interest by describing them more into detail.

Background interests

If we take a look at the background interests, we can see that the personal interests have a relation to the background of an participant. There are 2 participants that have a 'technical background' P5 and P6 explain for example to be much interested in the technical side of the project because of their backgrounds as metrologist and as teacher in technique.

Participant 5: "I have a more technical background. I keep myself busy with environmental pollution. I do look at the technical aspects because of my background as meteorologist".

Participant 5: "Ik kom vooral uit de wat meer technische hoek. Ik hou mezelf wel bezig met

milieuverontreiniging. Ik kijk ook meer naar de technische aspecten door mijn achtergrond als meteoroloog”.

P6 explained that he has, also because of his background, a strong affinity with this type of research and technical methods to measure air and noise.

Participant 6: “I have a strong affinity with measuring, logging and the techniques behind this. I write also about this from my professional background. I am a teacher and sometimes measure internationally. Smart Emission is as project one of the examples that is at the front-development of measuring air and noise. I feel privileged to be involved” (Participant 6, 2017).

Participant 6: “Ik heb een hele sterke affiniteit met meten, loggen en de techniek die daarachter zit. Ik ben daar ook beroepsmatig mee bezig omdat ik erover schrijf. Omdat ik het ook als lector in sommige lessen verwerk. Soms doe ik dit zelfs internationaal, dan kan ik het meenemen in een aantal voordrachten. Waarbij het Smart Emission project op dit moment toonaangevend is en voorop mee kan lopen bij internationale ontwikkelingen. Ik vind het bevoorrecht om dit te helpen uitdragen” (Participant 6, 2017).

P7 has a political background and explains that his interest in air quality started during his studies and that he wants to invest in this topic in order to put it on the political agenda. He aims for a good air quality because he sees it as an important factor for the quality of life. Furthermore, he has experienced himself in Mexico-city what an improved air-quality can mean for a city.

Participant 7: “Air is everywhere, you need to use it in order to breathe. We have in Nijmegen thought for a long time that the air was very polluted. Especially when the coal-fired power station was still in production in the area West and Weurt. Here people are telling ghost-stories for a long time already. The people living in west were not happy with the new bridge build in 2015. This bridge gave more air and noise pollution. We tried to get more green area’s along the roads in order to get cleaner air ”(Participant 7, 2016).

Participant 7: “Lucht is overal, je moet het gebruiken, je ademt het in. We hebben in Nijmegen heel lang gedacht dat de luchtkwaliteit heel erg slecht was. Met name toen de kolencentrale er nog stond bij West en Weurt. Hier is al heel lang een soort spookverhaal gaande. In de politiek speelt het al heel lang, zeker toen de nieuwe brug kwam in Nijmegen. De mensen uit west waren hier helemaal niet blij mee want daardoor kwam er nog meer verkeer en fijnstof en lawaai. Ze waren erg bezorgd over hun gezondheid en verkeer. Ze hebben heel erg gelobbyd en gepleit voor meer groen langs de weg” (Participant 7, 2016).

The participants 10 and 14 do not mention that they have a specific educational background in air and noise. But mention that they have been active in citizens-committees or NGO’s concerned with the environment for years. What is at base for their interest. Furthermore, is their

hope to contribute something to the common knowledge about air and noise pressures by participating in the project.

Participant 10: "I have been interested in air pollution for a long time already, I am also a member of another citizens-committee. I started with air monitoring in the bloemenstraat in the 80's, here are a lot of busses. The measurement-equipment was borrowed at the university. I am graduated as biochemist and know already a lot from chemicals and measuring" (Participant 10, 2016).

Participant 10: "Ik ben al heel lang bezig geweest met luchtverontreiniging, geluidsbelasting als lid van bewonerscomité: Bewoners vraag binnenstad. Ik ben begonnen met geluidsmetingen in de bloemenstraat want daar rijden erg veel bussen. We zijn er mee begonnen toen die hele straat en het busnetwerk veranderd is, dit was al in de begin jaren 80. De meetapparatuur hebben we toen geleend bij de universiteit, via de wetenschapswinkel hebben we toen geijkte meetapparatuur kunnen krijgen. Ik ben afgestudeerd als biochemicus, dus ik weet wat van chemie en meten." (Participant 10, 2016)

Participant 14: " We are actually involved at monitoring the living environment for a long time already. I have worked at the municipality for a couple of years. I know the air-specialist at the municipality and I know that he is monitoring the living environment for a long time already. I had a chat with him when he told me that the municipality wanted to start with the Smart Emission project. From there the Smart Emission project started to search for new participants. When I heard that people living outside the center of Nijmegen were able to participate, we participated" (Participant, 14, 2016).

Participant 14: "We zijn eigenlijk al heel lang betrokken bij metingen van de leefomgeving. Ik heb zelf heel lang bij de gemeente gewerkt, ik ken Paul. Ik weet dat hij bezig is met het meten van de leefomgeving en ik kwam in gesprek met hem. Toen vertelde hij dat het project Smart Emission zou gaan starten. Van daaruit is er voortdurend contact en betrokkenheid geweest. Daarna zijn ze gaan zoeken wie zijn er participanten, in eerste instantie wilden ze in het centrum zoeken. Toen hoorde we dat er ook mensen van buiten het centrum mochten meedoen. Op een gegeven moment kwam het in de Brug te staan en hebben we ons aangemeld."

Personal interests

The personal interests of participants are often related to an issue a participant experiences in his direct living environment. Questions asked by participants are for example "Am I able to recognise local sources of pollution with this citizen-sensor-network?" (P19) or "do I have to change my life expectation because of the air and noise pressures of the traffic in front of my home?" (P1). The following sections elaborate on the personal interests.

Participant 14 explains for example that he is worried about the industrial area near his neighbourhood and sees the citizen-sensor-network as an opportunity to find out how this is affecting his living environment.

Participant 14: “We are busy with the industrial area for a long time already. It is joyful to see the development of the area and to get to know what effect it has on air and noise quality. If you walk on the street for example and you smell the iron-foundry than I wonder myself if it is only the smell or if there is more in the air. Are emissions than also coming into my home?” (Participant 14, 2016).

Participant 14: “We zijn al heel lang met het industrieterrein bezig. Het is natuurlijk leuk om de ontwikkeling daarvan te volgen en te weten in hoeverre het geen of wel effect heeft. En als je dan bijvoorbeeld de straat op loopt en je ruikt de ijzergieterij, dan vraag je jezelf af is het alleen maar de geur of is het meer wat er in de lucht zit. Komt er dan ook stof mee of andere gassen in je huis.” (Participant 14, 2016).

Participants 1 and 6 are involved because of their worries concerned with the CO₂ pressures in their garden and their homes.

Participant 1: “When it became clear that more sensors were available I found it interesting to join because I wanted to know what the CO₂-concentrations were in my garden. I was also interested in how green can affect the measurements. This was my personal and local interest.” (Participant 1, 2017)

Participant 1: “Toen het duidelijk werd toen er nog meer sensors vrijkwamen, vond ik het interessant om mee te doen omdat ik graag wil weten welke CO₂ waarden ik kan meten hier in de binnentuin, want daar leven wij. Ik was daarnaast ook wel benieuwd naar een aantal groenkorsetten of deze nu effect hadden op de meting. Dat was echt m’n persoonlijke en lokale belangstelling, met de vraag hoe lokaal zijn die effecten?” (Participant 1, 2017)

Participant 6: “I like to participate in this type of research. Over the years I participated in several types of research. I think the initiative of Smart Emission is great. I am interested in CO₂ emissions inside my home.” (Participant 6, 2017)

Participant 6: “Ik heb een affiniteit met dit soort onderzoeken. Door de jaren heen heb ik aan heel veel onderzoeken mee gedaan. Ik vind het een geweldig initiatief. Ik heb zelf daarnaast erg veel last van CO₂ binnenshuis. Dit wekt met name slaperigheid op.” (Participant 6, 2017)

Participant 5 partakes because he is interested in what kind of outcomes a local monitoring network generates, if we can recognise local sources and differences in values with national monitoring systems.

Participant 5: "I am mainly interested in what such a monitoring-tool as Smart Emission can demonstrate. It is another perspective on monitoring than the current national monitoring network. This is on another scale. Are we for example able to recognise local sources? When we measure differences in values, is that because of a local source? Which could be from wood-heating emissions or a small company" (Participant 5, 2016).

Participant 5: "Ik ben wel geïnteresseerd in wat je met zo'n meetnetwerk boven tafel kunt halen. Het is een andere benadering dan bijvoorbeeld een landelijk meetnet. Het is op een hele andere schaal. Ben je dan bijvoorbeeld ook in staat om heel lokale bronnen te herkennen. Want als je verschillen hebt in waardes, dan moet dat komen omdat daar een bron in de buurt zit. Dit kan wel een houtkachel of een klein bedrijf zijn" (Participant 5, 2016).

Participant 7 his interest in air quality and noise pollution started already during his studies when he lived in Mexico city. When a project about air and noise started in Nijmegen, he had an direct interest.

Participant 7: "I have lived in Mexico city for my thesis. When I walked through the city and I came home at night my clothes were black because of the emissions in the city. This was horrible. Mexico city was located in the mountains but I never saw the mountains. I returned to the city a few years ago and thought that the air was much better. I was able to see the mountains with snow on top of it" (Participant 7, 2016).

Participant 7: "Ik heb lang geleden in Mexico stad gewoond voor driekwart jaar, daar heb ik mijn eindonderzoek gedaan. Als je daar over straat liep en je kwam 's avonds thuis, dan had je een zwarte kraag van de roet. Dat was echt vreselijk, Mexico stad ligt heel hoog maar het ligt wel in een kom. De bergen kon je bijna nooit zien, af en toe. Nou was ik daar een paar jaar geleden weer terug voor m'n werk. De lucht was zo dramatisch veel beter, ik kon alle bergen zien, vulkanen met sneeuw erop, echt schitterend. Ik kon merken dat de luchtkwaliteit enorm verbeterd was. Ik dacht toen, vooruitgang bestaat. In Nijmegen zitten we tussen het Ruhrgebied en de Randstad en hier moeten we natuurlijk ook iets mee kunnen (Participant 7, 2016)."

Participant 19 partakes because he is dealing with a wood heating neighbour. He explains to be asthmatic and that he partakes because the citizen-sensor-network provided him a tool to measure if the wood heating actually is harmful or not.

Participant 19: "For me wood-heating was a motivation to participate. My neighbour is using his furnace a lot and I have asthma thus I was bothered by it. Because of the citizen-sensor-network I solved my fight with my neighbour. He has a filter now wherethrough the air is filtered" (Participant 19, 2017).

Participant 19: "Houtstook was mijn motivatie voor participatie. Mijn buurman stookt veel, daar had ik erg veel last van door mijn astma. Door het burger sensor netwerk is mijn ruzie met de

buurman opgelost. Hij heeft nu een katalysator waardoor de lucht veel schoner naar buiten komt” (Participant 19, 2017).

I also asked participants if they had any idea why others would participate in the citizen-sensor-network. Interesting is that almost all participants mention that they think that other participants participate because of a personal issue or something else that bothers them. Participant 1 even mentions that he doubts if people are even willing to take action for the greater sake, because he thinks that people only participate because of their own goods. He explains that his frustration about this is slightly increasing because damaging the environment seems almost an aim we are born with.

Participant 1: “I have a growing issue or fascination about how we pollute the world as society. For the most people, actually also for me, as long as we live we destroy as much as possible. It seems like something we are born with” (Participant 1, 2016).

Participant 1: “Bij mij is er ook wel een toenemende ergernis over of ook wel fascinatie, hoe wij met z’n allen (als in alle mensen) geneigd zijn om onbewust de wereld te vervuilen. Voor de meeste mensen geldt, ook eigenlijk wel voor mij, zo lang als je leeft zo veel mogelijk kapot maken. Het lijkt wel een streven waarmee we geboren worden” (Participant 1, 2016).

Other interests

Another interesting observation was that there was also an participant involved with no background interest or personal interest. This participant became mainly interested in the project because of his neighbour. This phenomenon occurred when his neighbour started sharing information about his sensor with him. Participant 1 explains that he has been intrigued by the air and noise quality in his living environment for already a long time, but did not show activity around this topic until his neighbour told him about the citizen-sensor-network. Due to the enthusiasm and interesting data analysis of his neighbour he got triggered and signed up for the citizen-sensor-network.

Participant 1: “I am triggered by my roommate that lives around the corner to participate in the citizen-sensor-network. Furthermore it was my curiosity. Also my measurements show high values of CO₂ concentrations” (Participant 1, 2016).

Participant 1: “Ik ben getriggerd door mijn huisgenoot die hier om de hoek woont, dus enerzijds is het nieuwsgierigheid. Daarnaast geven zijn metingen geven verontrustende hoge CO₂ waarden weer” (Participant 1, 2016).

Interesting finding was that during the interviews, 6 participants declared that they already had an interest in environmental issues before even participating the citizen-sensor-network. Main reasons for this interest were issues that participants experienced in their direct living

environment. Another interesting finding is that the background interests are mainly related to participants their past professions or hobby's. By reflecting these findings upon the EPP-framework it shows again that in the condition of diversity is well embedded in the citizen-sensor-network. The other two conditions of interdependency and equality are not clearly identified yet with the results shown above.

6.4 Internal and external values

The internal and external values are found by collecting the personal learning experiences and the data interpretations of participants involved in the citizen-sensor-network. In order to find the personal learning experiences and the data interpretations I questioned the participants during the interviews and observed the participants, in collaboration with two other students, during the 5 group discussions. I captured the personal learning experiences and data interpretations therefore with notes, written in a notebook as well as typed on a computer.

Interesting is that during the discussions also new personal learning experiences and data interpretations in relation to the interviews appeared. The personal learning experiences and the data interpretations are, as explained in EPP-framework approached as internal values and external values. To refresh your mind as reader from this thesis, the definitions of the internal values and external values are depicted underneath.

Internal values: the internal values in the EPP-framework are the personal learning experiences that participants gain by conducting an activity which is part of/or related to a planning process on city-level.

External values: the external values in the EPP-framework is about the interpretations of the data that comes forward from the actual act of data collection by the participants involved. The data interpretations derived from the group discussions, is therefore in the EPP-framework the valid data that is interpret and shared by participants in a policy making process.

In the two following tables, all the personal learning experiences (internal values) and data interpretations (external values) that appeared during the interviews and the group discussions are depicted. The first table shows the internal values, the second table shows the external values. The internal values and external values are shown per participant. The first column presents the participants involved indicated by their 'P' numbers, as also depicted in the previous section. The second column presents the type of participant: citizen, administrator (government), scientist or developer (industries). In the third column the original internal value or external value is coded. These codes are shown in Dutch. The translated internal values and external values are shown in the fourth column.

The personal learning experiences: internal values

P	Type	Original quotation code	Quotation code translated in English
1	Citizen	Geïnteresseerd in met name CO2. Mijn metingen geven verontrustende hoge CO2 waarden weer. Deze metingen zijn buiten en zijn altijd boven de 1000 parts per million (ppm). In een binnenhuisklimaat is het boven de 500 ppm hoog en daardoor verstandig om te gaan ventileren. Dit wordt door mij als een probleem ervaren.	Im experiencing high concentrations of CO2. Sometimes my sensor measures CO2 concentrations form above the 1000 ppm. Inside my house the concentrations are just above the 500 ppm. Above the 500 ppm it is wise to ventilate. I experience this as a problem.
5	Citizen	Je leert altijd, ik ben niet voor verassingen komen te staan.	You always learn something, but nothing was new to me.
22	Administrator	CO2 wordt niet gezien als een probleem binnen luchtkwaliteit maar wordt door de hoge hoeveelheden uitstoot met name gerelateerd is aan klimaat. Hoge CO2 gehalten in een ruimte zijn niet perse ongezond maar zorgen ervoor dat er minder zuurstof zich in een ruimte bevindt. Hierdoor zijn hoge CO2 gehalten in klaslokalen bijvoorbeeld ongewenst.	CO2 is not experienced as a problem within air quality but is because of the high concentrations related to climate problems. High CO2 concentrations are not unhealthy for people inside. A higher level of CO2 means a lower level of Oxygen. Where through high levels of CO2 are undesirable.
6	Citizen	In de tweede bijeenkomst kwam ik erachter dat het ook leerzaam voor mezelf was.	Found out at the second meeting that participating in a sensor network is very informative.
6	Citizen	Ik vind het leuk om dat CO2 verhaal te bekijken omdat ik zelf ervaar dat ik snel moe wordt, maar wil me niet teveel verliezen in alle andere mogelijkheden van waarden die kunnen worden gemeten.	Interested in CO2 values because I'm bothered by it inside. Furthermore, I am trying not to loose the overview in all values measured.
6	Citizen	Met name een bevestiging van hoe ik denk over groepsprocessen. We willen allemaal geen feodale structuur meer, we willen democratie en is het wel zo democratisch als het lijkt.	Confirmation of my thoughts about a group process. Group processes are very dynamic and have a democratic character
6	Citizen	Het bestuderen van karakters. Je haalt direct de typetjes eruit.	Experienced who is participating and what types of people are involved.
7	Citizen	Gek genoeg zie ik iedere keer weer dat er veel belangstelling is voor dit soort onderwerpen. Er is toch een grote groep mensen die iedere keer weer meedoet. Ik vind dit iedere keer verassend. En Nijmegen zit vol met sympathieke mensen die het beste willen met de wereld.	Surprised by the large group of people with interest in air quality and noise pollution.

P	Type	Original quotation code	Quotation code translated in English
10	Citizen	Nee, eigenlijk niet.	Learned nothing
11	Citizen	Weet niet wat ik heb geleerd	Don't know what i've learned
12	Citizen	Dat ik aan deskundigen vragen kan voorleggen die mij een mogelijk beter inzicht in de verkregen data kunnen geven.	Actually gain insights by asking experts questions about the sensor-data.
13	Developer	Ik heb geleerd welke dingen met elkaar interacteren, welke gassen en hoe die reageren op de luchtvochtigheid en hoe je dat kunt kalibreren, waar je dan op moet letten.	Learned how gasses interact, how gasses react on air humidity and how to calibrate gasses.
14	Administrator	Ja ik heb zeker wel dingen geleerd denk ik over lucht en geluid.	I learned about air and noise
15	Citizen	Ik vond de fietstocht hartstikke leuk, vooral om het verhaal achter de sensoren te weten: waarom hebben de mensen de sensor opgehangen.	Gained knowledge about why people are involved in the citizen-sensor-network.
18	Citizen	Erg bemoedigend, burger is heel naïef. Je wilt gewoon graag lucht kwaliteit weten en dan blijkt er van alles al te zijn en te hangen.	Learned that measuring air quality is more difficult than thought. Citizens can be very naïf about this.
6	Citizen	Kerkklokken proberen te vangen, lukte ook niet, in een uur mis je veel geluid, met name schrille piepen die mis je in uurgemiddelden.	Tried to measure the noise of the church bells. Does not work because the sensors show hour averages, which is not enough for measuring short, loud noises.
20	Citizen	In een uur mis je veel korte en harde geluiden.	In an hour average a lot of short, loud noises are missed.
19	Citizen	Te rooskleurig gedacht over metingen voor geluid en lucht	Measuring air and noise is more difficult than thought.
19	Citizen	Nu, twee jaar na het opstarten van het BSN staan we aan het begin van iets met deze metingen doen	We have arrived at the point of doing actually something useful with all the data after two years.
23	Administrator	Het is slimmer om geluid te meten in dB, want dan kun je ook zien wat er laagfrequent aan de hand is.	It is smarter to measure in dB, because we can than see what happens with low-frequent sound.
19	Citizen	Ik heb geleerd dat we nu zelf kunnen meten om ons eigen milieugedrag te beïnvloeden	Learned that we can measure now by ourselves in order to influence our environmental behaviour
19	Citizen	Door het participeren in het BSN is mijn ruzie met de buurman opgelost. Hij heeft nu een katalysator voor zijn houtstook.	Experenced how partaking in the project helped me solving my problem with the wood-heater from the neighbour.
19	Citizen	Ik kwam erachter dat het meten van luchtkwaliteit en geluid erg moeilijk is. Moeilijker dan ik dacht in de eerste instantie.	I found out that measuring air and noise is more difficult than thought in the first place.

P	Type	Original quotation code	Quotation code translated in English
14	Administrator	We hebben wel eens bijeenkomsten over laag frequent geluid en wat je daartegen kunt doen. Dan verbaas je je over de diepgang van de gesprekken op die bijeenkomsten en de betrokkenheid van de mensen.	Experienced a great engagement and in depth knowledge of the group about low frequent noise.
16	Citizen	Laag frequent geluid kan de sensor niet meten want hij geeft uurgemiddelden aan en kan daarmee de pieken er niet uit halen	The sensor does not measure low frequent sound because it is showing the hour average which makes it impossible to measure short, low noise.
23	Administrator	Geluid wordt in dB(A) gemeten en niet in dB, daardoor kunnen we niet de pieken eruit halen met de metingen.	The sound is measured in dB(A) (which is a calculation) and not in dB, which means that we cannot measure noise peaks.
21	Developer	Geluid kan beter worden gemeten in dB, daarmee kunnen we de metingen preciezer maken.	The sound should be measured in dB, which makes it possible to measure more precisely.
20	Scientist	Vanuit mijn ervaring kunnen we voor voortzetting naar een voorstel voor een werkgroep toewerken. Met een actief deel, bestuur en passief deel, leden.	From my experience we should set up a project group with citizens, including a board (active) and members (passive).
19	Citizen	Vind dat we voortrekkersrol moeten nemen als project, meer mensen actief krijgen en verbinden met de plaatselijke politiek.	Should take a leading role as project. Activate more citizens to participate and search for connection with local politics.
19	Citizen	Vanuit de ervaring met mijn buurman. Mijn idee is om groepjes te gaan organiseren en dan te kijken naar verschillende onderwerpen.	From the experience with my neighbour we should organise in small citizen groups to take a look at different topics.
16	Citizen	We moeten bewoners van Nijmegen op de hoogte stellen van hoe de feitelijke situatie is dit kan door mensen te activeren en samenwerking te zoeken met het burgersensornetwerk.	Should activate citizens to collaborate with the citizen-sensor-network and inform about the facts
6	Citizen	Om meer mensen te betrekken moet het artikel herhaald worden in de Brug.	Activate more people to participate in the citizen-sensor-network by repeating the article in the city newspaper.
1	Citizen	In mijn ervaring is men zich er niet van bewust dat houtstook zo slecht kan zijn.	Experienced that in general people are not aware of the fact that wood-heaters are unhealthy.
19	Citizen	Door mijn ervaring met de buurman denk ik dat we de aanschaf van katalysatoren moeten aansporen.	In my experience we should stimulate the purchase of catalysts for wood-heating.
22	Administrator	Men is niet goed opgeleid over hoe je goed hout stookt. We kunnen een app hiervoor ontwikkelen.	In my experience people are not well educated about wood-heating. We could develop an app for wood-heating in Nijmegen.

P	Type	Original quotation code	Quotation code translated in English
1	Citizen	We moeten doel gericht kijken waar we sensoren willen hebben in Nijmegen. Nu hebben we veel gaten in het netwerk.	Not whole Nijmegen is covered by the sensors so we have some 'lacks' in the measurements. We should take a look at where we would like to place new sensors.
6	Citizen	De afgelopen periode was een goed leerproces, nu kunnen we waarde eraan gaan toekennen door de erkenning van data.	Last period experienced as a good learning process. Now there is a need to set the next step, recognising and value the collected data.
17	Citizen	Ervaar dat er veel verschillende vraagstukken onder burgers zijn.	Experience that there are several issues among involved participants.
20	Scientist	Ervaar dat wat burgers willen is heel specifiek	Experience that what citizens want is very specific.
17	Citizen	We zijn nu meer te weten gekomen over meten, maar moeten project groep opzetten en use cases helder maken.	Learned a lot about measuring air and noise but need to set up project group with use cases.
12	Citizen	Veel aandacht besteed aan geluid, wanneer ik kijk naar de exacte metingen en de tijd, dan zie je het verschil in hoge piepen of laag geluid. Elke 11 sec. meting is te zien in whale viewer. De uur metingen laten geen korte geluiden zien.	I found that loud, short noises or low frequent noise are only shown when I take a look at the exact measurements in the whale viewer. The hour average does not show the short noises
1	Citizen	Ik kwam erachter tijdens de tweede groepssessie dat het burgersensornetwerk erg leerzaam is.	During the second group discussion, I found out that participating in the citizen-sensor-network is very informative.
12	Citizen	Je moet theoretisch onderlegd zijn of worden en van daaruit hypothesen opstellen van wat je verwacht dat de data laten zien	You need to have a professional background and set a hypothesis in order to gain some understandings from the data.

An in depth-look into the personal learning experiences: internal values

As in the table depicted in total 43 internal values are found. In the type of participant 'citizens' 33 internal values are found, in the type of participant 'scientists' 2 internal values are found, in the type of participant 'administrators' 6 internal values are found and in the type of participant 'developers' 2 internal values are gained. Interesting finding in the internal values is that the most internal values are found in the 'citizens' group. From these internal values the interrelated personal experiences can be derived.

Interrelated personal experiences on high value of CO2 concentrations

P1 and P6 have both a personal learning experience with CO2 concentrations. P1 and P6 explain that they both have an interest in CO2 concentrations and that their sensors measure high values of CO2. The participants can be interrelated to each other by the following statements:

Participant 1: "I'm experiencing high concentrations of CO2. Sometimes my sensor measures CO2 concentrations from above the 1000 ppm. Inside my house the concentrations are just above the 500 ppm. Above the 500 ppm it is wise to ventilate. I experience this as a problem" (participant 1, 2016).

Participant 1: "Ik ben geïnteresseerd in met name CO2. Mijn metingen geven verontrustende hoge CO2 waarden weer. Deze metingen zijn buiten en zijn altijd boven de 1000 parts per million (ppm). In een binnenhuisklimaat is het boven de 500 ppm hoog en daardoor verstandig om te gaan ventileren. Dit wordt door mij als een probleem ervaren" (participant 1, 2016).

Participant 6: "I am interested in CO2 values because I'm bothered by it inside. Furthermore, I am trying not to lose the overview in all values measured" (participant 6, 2016).

Participant 6: "Interested in CO2 values because I'm bothered by it inside. Furthermore, I am trying not to lose the overview in all values measured" (participant 6, 2016).

Participant 6: "Ik vind het leuk om dat CO2 verhaal te bekijken omdat ik zelf ervaar dat ik snel moe wordt, maar wil me niet teveel verliezen in alle andere mogelijkheden van waarden die kunnen worden gemeten" (participant 6, 2016).

Interrelated personal experiences on the topic group process

P1, P6, P7, P15 and P17 have the interrelated personal learning experiences related to the process of policy making in the citizen-sensor-network.

Participant 1: "During the second group discussion, I found out that participating in the citizen-sensor-network is very informative" (participant 1, 2016).

Participant 1: "Ik kwam erachter tijdens de tweede groepsessie dat het burger-sensor-netwerk erg leerzaam is" (participant 1, 2016).

Participant 6: "confirmation of my thoughts about a group process. Group processes are very dynamic and have a democratic character" (participant 6, 2016).

Participant 6: "Met name een bevestiging van hoe ik denk over groepsprocessen. We willen allemaal geen feodale structuur meer, we willen democratie en is het wel zo democratisch als

Participant 6: "Experienced who is participating and what types of people are involved" (participant 6, 2016).

Participant 6: "Het bestuderen van karakters. Je haalt direct de typetjes eruit" (participant 6, 2016).

Participant 7: "Surprised by the large group of people with interest in air quality and noise pollution" (participant 7, 2016).

Participant 7: "Gek genoeg zie ik iedere keer weer dat er veel belangstelling is voor dit soort onderwerpen. Er is toch een grote groep mensen die iedere keer weer meedoet. Ik vind dit iedere keer verassend. En Nijmegen zit vol met sympathieke mensen die het beste willen met de wereld." (participant 7, 2016)

Participant 15: "Gained knowledge about why people are involved in the citizen-sensor-network" (participant 15, 2016).

Participant 15: "Ik vond de fietstocht hartstikke leuk, vooral om het verhaal achter de sensoren te weten: waarom hebben de mensen de sensor opgehangen" (participant 15, 2016).

Participant 17: "Experience that there are several issues among involved participants" (participant 17, 2016).

Participant 17: "Ervaar dat er veel verschillende vraagstukken onder burgers zijn" (participant 7, 2016).

Interrelated personal experiences on complexity of air and noise pollution

P18, P19 and P12 have the interrelated personal learning experience that monitoring air and noise is very complex. Participant 19 also explains that he underestimated the monitoring.

Participant 18: "Learned that measuring air quality is more difficult than thought. Citizens can be very naïf about this" (participant 18, 2016).

Participant 18: "Erg bemoedigend, burger is heel naïef. Je wilt gewoon graag lucht kwaliteit weten en dan blijkt er van alles al te zijn en te hangen" (participant 18, 2016)

Participant 19: "I found out that measuring air and noise is more difficult than thought in the first place" (participant 19, 2016).

Participant 19: "Ik kwam erachter dat het meten van luchtkwaliteit en geluid erg moeilijk is. Moeilijker dan ik dacht in de eerste instantie" (participant 19, 2016).

Participant 12: "You need to have a professional background and set a hypothesis in order to gain some understandings from the data." (participant 12, 2016).

Participant 12: "Je moet theoretisch onderlegd zijn of worden en van daaruit hypothesen opstellen van wat je verwacht dat de data laten zien" (participant 12, 2016).

Interrelated personal experiences on noise peeks and monitoring

P6, P12, P16 and P20 have interrelated personal leaning experiences in monitoring noise. Participants therefore explains that they tried to monitor noise peeks but that this did not work because the sensors were showing averages in an hour.

Participant 6: "Tried to measure the noise of the church bells. Does not work because the sensors show hour averages, which is not enough for measuring short, loud noises" (participant 6, 2016).

Participant 6: "kerklokken proberen te vangen, lukte ook niet, in een uur mis je veel geluid, met name schrille piepen die mis je in uurgemiddelden" (Participant 6, 2016).

Participant 12 tried to measure short noises and low frequent noise.

Participant 12: "I found that loud, short noises or low frequent noise are only shown when I take a look at the exact measurements in the whale viewer. The hour average does not show the short noises" (participant 12, 2016).

Participant 12: "Veel aandacht besteed aan geluid, wanneer ik kijk naar de exacte metingen en de tijd, dan zie je het verschil in hoge piepen of laag geluid. Elke 11 sec. meting is te zien in whale viewer. De uur metingen laten geen korte geluiden zien" (participant 12, 2016).

Participant 16: "The sensor does not measure low frequent sound because it is showing the hour average which makes it impossible to measure short, low noise" (Participant 16, 2016).

Participant 16: "Laag frequent geluid kan de sensor niet meten want hij geeft uurgemiddelden aan en kan daarmee de pieken er niet uit halen" (Participant 16, 2016).

Participant 20: "In an hour average a lot of short, loud noises are missed" (Participant 20, 2016).

Participant 20: "In een uur mis je veel korte en harde geluiden" (Participant 20, 2016).

Interrelated personal experiences on project groups and actions

P6, P16, P17, P19 and 20 have interrelated personal learning experiences in their actions of setting up project groups that focus on specific neighbourhood topics. The participants can be interrelated to each other by the following statements:

Participant 6: "Activate more people to participate in the citizen-sensor-network by repeating the article in the city newspaper" (participant 6, 2016).

Participant 6: "Om meer mensen te betrekken moet het artikel herhaald worden in de Brug" (participant 6, 2016).

Participant 6: "Last period experienced as a good learning process. Now there is a need to set the next step, recognising and value the collected data" (participant 6, 2016).

Participant 6: "De afgelopen periode was een goed leerproces, nu kunnen we waarde eraan gaan toekennen door de erkenning van data" (participant 6, 2016).

Participant 16: "We should activate citizens to collaborate with the citizen-sensor-network and inform about the facts" (participant 16, 2016).

Participant 16: "We moeten bewoners van Nijmegen op de hoogte stellen van hoe de feitelijke situatie is dit kan door mensen te activeren en samenwerking te zoeken met het burger-sensor-netwerk." (participant 16, 2016).

Participant 17: "I learned a lot about measuring air and noise but need to set up project group with use cases" (participant 17, 2016).

Participant 17: "We zijn nu meer te weten gekomen over meten, maar moeten project groep opzetten en use cases helder maken" (participant 17, 2016).

Participant 19: "Should take a leading role as project. Activate more citizens to participate and search for connection with local politics" (participant 19, 2016).

Participant 19: "ik vind dat we voortrekkersrol moeten nemen als project, meer mensen actief krijgen en verbinden met de plaatselijke politiek" (participant 19, 2016).

Participant 19: "From the experience with my neighbour we should organise in small citizen groups to take a look at different topics" (participant 19, 2016).

Participant 19: "Vanuit de ervaring met mijn buurman. Mijn idee is om groepjes te gaan organiseren en dan te kijken naar verschillende onderwerpen" (participant 19, 2016).

Participant 20: "From my experience we should set up a project group with citizens, including a board (active) and members (passive)" (participant 20, 2016).

Participant 20: "Vanuit mijn ervaring kunnen we voor voortzetting naar een voorstel voor een werkgroep toewerken. Met een actief deel, bestuur en passief deel, leden" (participant 20, 2016).

The data interpretations: external values

P	Type	Original content	Quotation code
5	Citizen	Ik ervaar een aantal grootheden, die in wat onduidelijke eenheden worden weergegeven. Het meeste is nu microgram per kuub of decibel dan is het duidelijk genoeg.	Experience that units are not clearly shown in the online viewers.
7	Citizen	Ik vind de ontsluiting van de data van de website nog niet zo makkelijk altijd. Ik vind ook de meetgegevens moeilijk af te lezen, het is niet moeilijk om de data te vinden alleen de interpretatie is lastig.	It is not easy to access the data, to read the data, to interpret the data and to find where I can download the data from the viewers.
12	Citizen	Ik maak tijdreeks-analysen en vertel aan mensen in mijn omgeving dat ze op de smart app moeten kijken om te zien wat mijn sensor aangeeft.	From the data monitored I am conducting time analysis and share this data with people in my environment
12	Citizen	Moeite met het lezen van de eenheden.	Experience that it is hard to understand and read the units.
16	Citizen	Geleerd dat de plek van de meter verreweg belangrijkste is. Geluid meten op een muur is namelijk niet te doen. De drukverschillen bij een muur zijn heel gek, daarom moet de sensor altijd 1,5 meter van de muur worden opgehangen. Daar is in het begin van het project echter geen rekening mee gehouden omdat de focus van het project vooral lag op emissies.	Learned that the sensor needs to be placed on 1,5 metres from a wall. In the beginning of the project this is not taken into consideration.
16	Citizen	De data laat gemiddelden zien van 60 minuten, die zijn gemeten aan gemiddelde waarden per 10 seconden. Dus het gaat hier om gemiddelden van gemiddelden, maar het zou van meer waarde zijn als de data ook inzichtelijk wordt voor kortere tijdsperiodes en niet alleen uurgemiddelden.	Data shows averages of 60 minutes, measured by averages of 10 seconds. It would be more useful give insights in shorter time periods in order to measure short noises.
16	Citizen	Het geluid is gemeten in dB(A) niet in dB, dit betekent dat de sensoren gemiddelden laten zien. Daarom kan ik geen geluidspieken meten.	The noise is measured in dB(A) instead of dB. The sensors therefore show average calculations. It is not possible to measure noise peaks then.
12	Scientist	Wat geluid betreft komt hij zo veel indicatoren tegen, terwijl hij eigenlijk alleen de datum, de tijd, de gemeten waarden en de gemiddelden nodig heeft, kortom de dingen die hij specifiek nodig heeft. Daarnaast vindt hij het jammer dat de waarden worden weergegeven een range van 1 tot 5, hij zou namelijk ook graag uitschieters willen zien. "Dat geeft mij meer inzicht in de minimum en maximum waarden, zodat ik ook cyclische bewegingen kan meten".	I experience many indicators while I only would like to see the date, time, averages and values. It is furthermore unfortunate that data in shorter time periods is not shown in order to detect short and loud noises.
17	Citizen	De sensor meet niet in dezelfde waarden als de RIVM kast. Er zit ruis in de sensor (bepaalde bandbreedte die we daarvoor toepassen in de kalibratie). De sensor heeft op het moment nog maar twee seizoenen waarover het iets kan zeggen aangezien de data alleen nog maar op twee seizoenen is gekalibreerd.	The sensor is not measuring in the same units and values as the national measurement system.
18	Citizen	NO2 blijkt niet zo goed te zijn in de metingen.	NO2 measurements are not reliable

22	Administrator	CO2 wordt niet wordt gezien als een probleem binnen luchtkwaliteit maar wordt door de hoge hoeveelheden uitstoot met name gerelateerd is aan klimaat. Hoge CO2 gehalten in een ruimte zijn niet perse ongezond maar zorgen ervoor dat er minder zuurstof zich in een ruimte bevindt. Hierdoor zijn hoge CO2 gehalten in klaslokalen bijvoorbeeld ongewenst.	CO2 is not a air pollution problem but it is because of it's pollution related to the climate. High CO2 concentrations are not unhealthy for people, but cause less oxygen in a room. Therefore high CO2 concentrations are undesirable.
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In depth-look into the data interpretations: external values

As in the table depicts in total 11 external values are found. In the external values table. In this table one administrator and further the citizens as 'participants-type' are represented. In comparison to the internal values, the external values are limited. An explanation for this can be found in the content of the external values. The citizens involved have many difficulties with interpreting and understanding the data. Within the external values collected, the following interrelated external values can be found.

Interrelated external values of difficulties with interpreting data

P12, P19, P7 and P5 have difficulties with the interpretations and understanding the data. Therefore the following interrelated external values are found:

Participant 12: "The computer-systems are hard to understand. How do I gain information online? How do I upload data in a datafile?"

Participant 12: "Ik vind de computersystemen moeilijk begrijpbaar. Hoe haal ik de informatie eruit? Hoe zet ik de data in een databestand?"

Participant 5: "I experience that units are not clearly shown in the online viewers" (participant 5, 2016).

Participant 5: "Ik ervaar een aantal grootheden, die in wat onduidelijke eenheden worden weergegeven. Het meeste is nu microgram per kuub of decibel dan is het duidelijk genoeg" (participant 5, 2016).

Participant 7: "It is not easy to acces the data, to read the data, to interpret the data and to find where I can download the data from the viewers" (participant 7, 2016).

Participant 7: "Ik vind de ontsluiting van de data van de website nog niet zo makkelijk altijd. Ik vind ook de meetgegevens moeilijk af te lezen, het is niet moeilijk om de data te vinden alleen de interpretatie is lastig" (participant 7, 2016).

Participant 19: "I have thought too easy about monitoring air and noise".

Participant 19: "Te rooskleurig gedacht over metingen voor geluid en lucht".

Interrelated external values on the units of measurement

P6, P16, P17 and P18 found that the units of measurement are not always reliable or useful in order to monitor air and noise. Therefore the following interrelated external values are found:

Participant 6: "I tried to monitor the noise from the church, this did not work because of the hour averages which are measured. I am missing these in hour averages."

Participant 6: "Kerkklokken proberen te vangen, lukte ook niet, in een uur mis je veel geluid, met name schrille piepen die mis je in uurgemiddelden" (participant 6, 2016).

Participant 16: "The noise is measured in dB(A) instead of dB. The sensors therefore show average calculations. It is not possible to measure noise peeks then" (participant 16, 2016).

Participant 16: "Het geluid is gemeten in dB(A) niet in dB, dit betekent dat de sensoren gemiddelden laten zien. Daarom kan ik geen geluidspieken meten" (participant 16, 2016).

Participant 16: " the data shows averages of 60 minutes, measured by averages of 10 seconds. It would be more useful give insights in shorter time periods in order to measure short noises" (participant 16, 2016).

Participant 16: "De data laat gemiddelden zien van 60 minuten, die zijn gemeten aan gemiddelde waarden per 10 seconden. Dus het gaat hier om gemiddelden van gemiddelden, maar het zou van meer waarde zijn als de data ook inzichtelijk wordt voor kortere tijdsperiodes en niet alleen uurgemiddelden" (participant 16, 2016).

Participant 17: "The sensor is not measuring in the same units and values as the national measurement system" (participant 17, 2016).

Participant 17: "De sensor meet niet in dezelfde waarden als de RIVM kast. Er zit ruis in de sensor (bepaalde bandbreedte die we daarvoor toepassen in de kalibratie). De sensor heeft op het moment nog maar twee seizoenen waarover het iets kan zeggen aangezien de data alleen nog maar op twee seizoenen is gekalibreerd" (participant 17, 2016).

Participant 18: "NO₂ measurements are not reliable" (participant 18, 2016).

Participant 18: "NO₂ blijkt niet zo goed te zijn in de metingen" (participant 18, 2016).

Another interesting finding is that even though, participants experience difficulties interpreting and understanding the data, participants find that measuring and collecting data is really valuable (see therefore the internal values). Participants therefore argue that they learned that monitoring air and noise is much more complex than thought beforehand.

When participants shared their personal learning experiences (internal values) and data interpretations (external values), some of these formed shared meanings. Section 6.6 elaborates further on the shared meanings that developed.

Before moving on to the shared meanings, I also researched if some shared identities could be identified from the act of data collection and the act of participating in the group discussions. I therefore asked the participants how they 'saw' themselves in the citizen-sensor-network. Therefore the next section will elaborate on the shared identities.

6.5 Shared identities

In order to gain an image of the shared identities I asked during the interviews how participants experienced their role in citizen-sensor-network. I asked them if they felt to have an active role or that they were felt that they were able to make a difference? With these questions I tried to 'catch' the feeling and believe of participants about the citizen-sensor-network and therefore the shared identities that developed (or not).

Looking at the perceived roles, four of the participants (P11, P12, P10 and P1) declare that they see themselves just as participants without an influencing or specific role in the citizen-sensor-network. Participant 11 (a participant without a sensor) even mentions that she does not feel to have a role in the network because she is not an owner of a sensor.

The five other interviewed participants P5, P6, P7, P13, P14 declare that they do feel that they have a role in the citizen-sensor-network. Participant 5 explains that he is, because of his health problems, not able to be present at meetings but that he communicates online with the other participants when he notices something and in this way feels to be part of the network. Participant 6 explains that he feels to be an initiator by bringing knowledge and experience to the project and in this way has a role.

Participant 6: "I have the feeling that because of my knowledge, experiences and affinity with this type of research, I have an influencing role within the group of participants. I am one of the participants that asks questions during group discussions. I am always invited when there are feedback moments and one of the few participants that was active on the forum. I think my role is to be an initiator" (Participant 6, 2016).

Participant 6: "Ik heb wel het gevoel dat ik door kennis, ervaring en een stukje affiniteit een best wel beïnvloedende rol binnen de groep heb. Ik merk dat ik een van de vraagstellers ben op een van de avonden, ik word opgemerkt op het moment als er een evaluatie is, ik ben een van de weinige deelnemers die actief is geweest op het forum. Ik denk dat ik een initiator ben."

According to him he is one of the persons that is asking questions at meetings and one of the few who has been active already at the online forum (at the moment of interviewing). Participant 7 sees his role as a participant who has the resources to bring input in the project via politics.

Participant 7: "Yes, I am a participant. My input is from the politics. Last Tuesday I mentioned at the council meeting that it is important to measure air and noise pollution in Nijmegen. Projects such as Smart Emission need therefore to be subscribed by politics. I want to stimulate this. In Nijmegen East and Nijmegen Hatert are no sensors yet." (Participant 7, 2016).

Participant 7: "Ja ik ben deelnemer. Via de politieke lijn breng ik natuurlijk ook input. Afgelopen dinsdag heb ik bij de vergadering aangegeven dat ik het belangrijk vindt dat er meer gemeten wordt. Omdat het duurder is dan zo'n Smart Emission project dan moet de gemeente daar een warm hart aan toedragen. Dus ik wil me daar graag hard voor maken. Oost en Hatert hebben bijvoorbeeld nog geen meetstation. Ik wil graag dat er meer meetstations komen. Ik ben gemeenteraadslid dus via deze weg kan ik dus ook inbreng geven" (Participant 7, 2016).

Participant 13 explains that he is having a double role, he is the person who calibrates the sensor, thus in this perspective someone who informs other participants about what the sensor is measuring and how it is calibrated. But, he is also a participant who shares his data with other participants.

Participant 14 sees himself as an participant on one side and on the other side as a ambassador of the project. He explains it as follows: "I give support and attention in the publicity and as participant I try to empower the project."

Participant 14: "I see myself as citizen and I also see myself as ambassador. I am one of the persons that brings the citizen-sensor-network a step further. I am trying to empower and support the project. I don't know how my role will be in the future" (Participant 14, 2017).

Participant 14: "Aan de ene kant ben je burger en doe je mee, aan de andere kant ondersteun je ook en zorg je dat het verder komt. Je geeft publiciteit en support en je probeert het project wat meer te empoweren en input te leveren. De rol in de toekomst, dat weet ik niet hoe die eruit gaat zien" (Participant 14, 2017).

When taking these 'perceived roles' together we can see that the perceived roles are divided onto the type of participants group as follows:

Type of participants: Citizens	
Participants	Perceived role
P12, P10, P1	Participants
P5	Does feels to have a role in the citizen sensor network. Does not mention a specific role.
P6	Initiator
P7	Politician
P13	Participant
P14	Ambassador
P11	No role in the sensor-network
Type of participants: Developer	
Participants	Perceived role
P13	Calibrator

Participants see themselves as ambassadors, initiators, politician, participants and as non-participants of the citizen-sensor-network Smart Emission. Interesting to see is that the type of participant citizens perceives diverse roles.

6.6 Shared meanings

This section elaborates on the shared meanings that have developed in the citizen-sensor-network Smart Emission. Therefore participants their personal learning experiences (internal values) and interpretations of the data (external values) are connected to each other that resulting into the shared meanings. The shared meanings developed into new heuristics when agreements are achieved about collectively addressed actions in the group discussions. The shared meanings and new heuristics are therefore depicted in the research model of the EPP-framework (as explained in the theory chapter). In this model a connection is made to the participants who acknowledged upon a shared meaning. The sections on the following page elaborate on each shared meaning that developed during the group discussions.

1. CO2 is experienced as a health problem

The first shared meaning found is based upon the interrelated internal values of participant 1 and participant 6. Both live, near to each other and are bothered by CO2. Participant 1 as well as participant 6 are bothered by the CO2 concentrations inside their homes. Participant 1 is anxious because he measures high CO2-values, participant 6 has an interest because he gets tired quickly. They shared their values during the discussion evenings, where through they formed the shared meaning that they both experience CO2 as a problem within air quality, especially for CO2 concentrations inside.

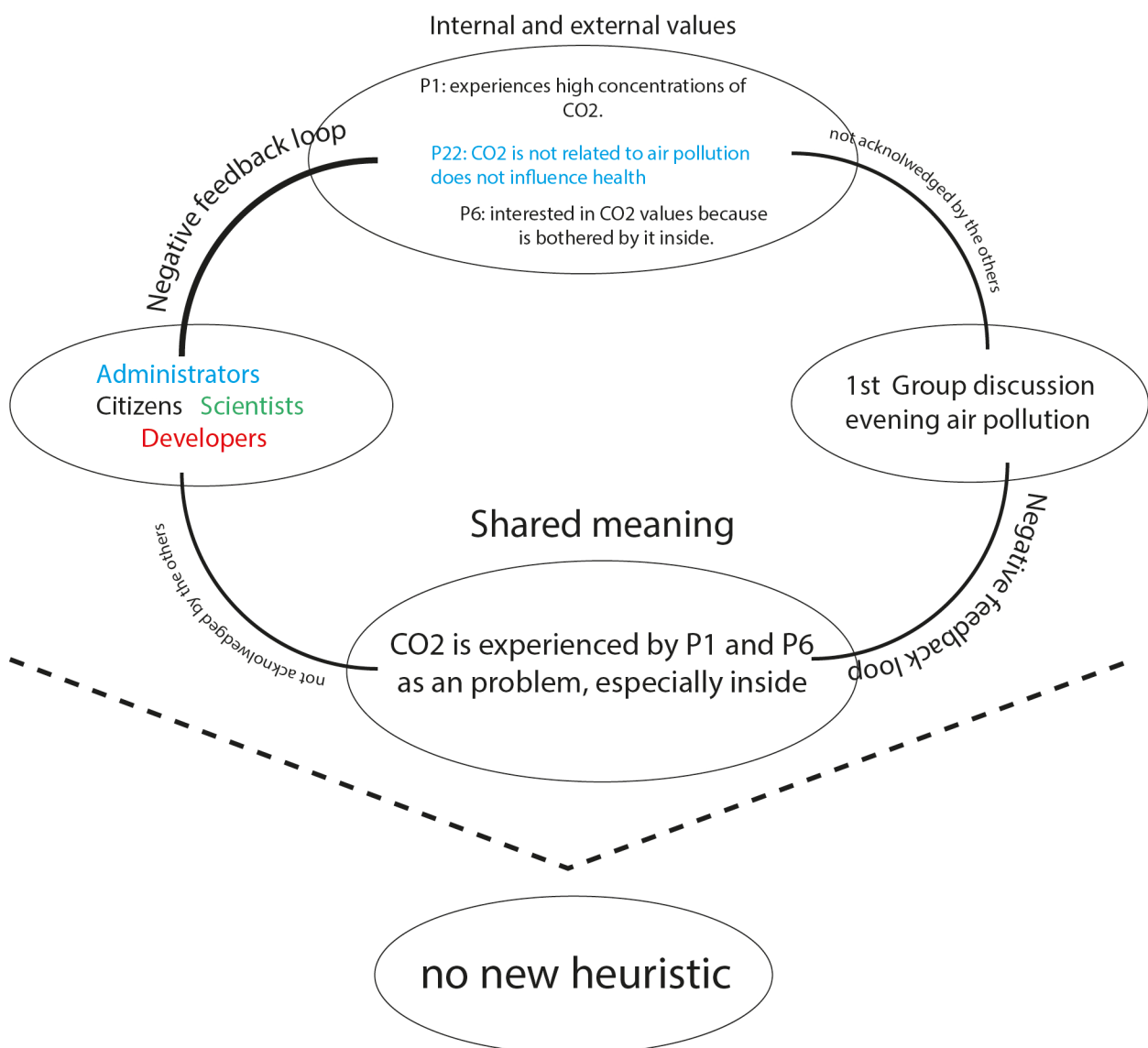


Diagram 1: CO2 is experienced as a health problem

2. The citizen-sensor-network is a dynamic and informative group process

Four participants have the internal value of finding it interesting who and why was partaking to the project. They noticed that due to people involved a group process can be very dynamic. Participant 17 also experienced that there are many issues among all the involved participants. This makes that they come to the shared meaning that they gained knowledge about people in group processes.

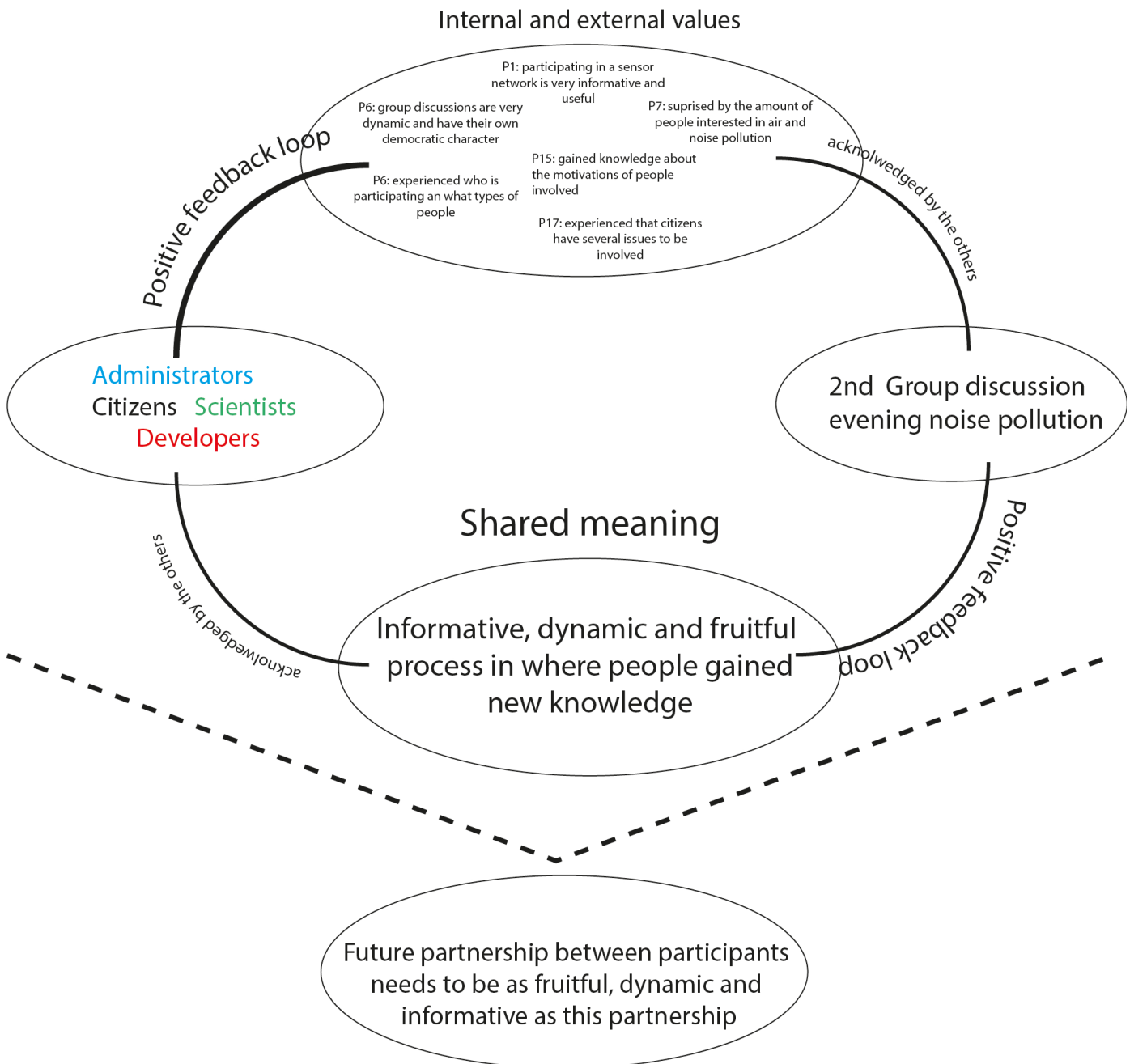


Diagram 2: Shared meaning the citizen-sensor-network is a dynamic and informative group process

The shared meaning is acknowledged by the other participants in the group discussion. Therefore the new heuristic: 'future partnership needs to be as fruitful, dynamic and informative as this partnership' developed.

3. Measuring air and noise is experienced as a complex matter

Five participants experienced difficulties or complexities with understanding the matter of air and noise. Especially interpreting the meaning of the data or trying to use it for online analysis has been for many participants difficult.

Participant 12 for example mentions that you almost need a theoretical background in air or noise in order to understand what values or measurements mean. Participant 5 experiences that units are not clearly shown in the online viewers where data can be accessed. During the group discussions the other involved participants agreed upon the shared meaning that measuring air and noise is complex and that the data is hard to interpret. The internal and external values are enlarged on this page, the model is depicted on the following page.

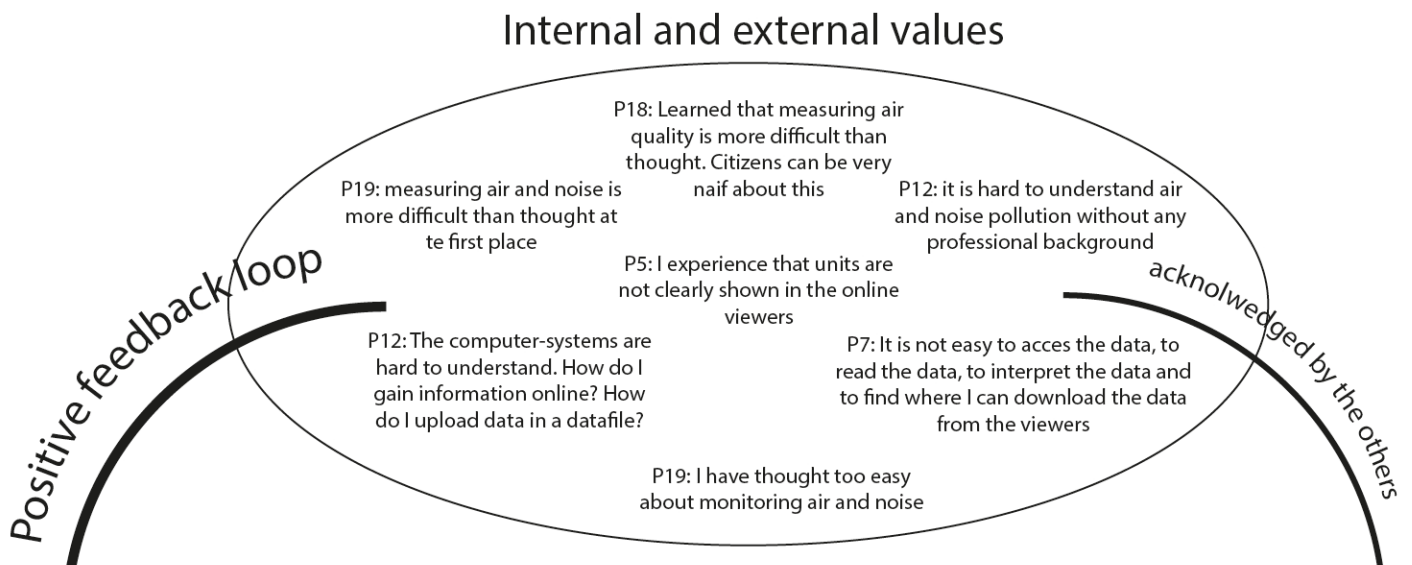


Diagram: 3 the internal and external values interrelated regarding the complexity of air and noise pollution

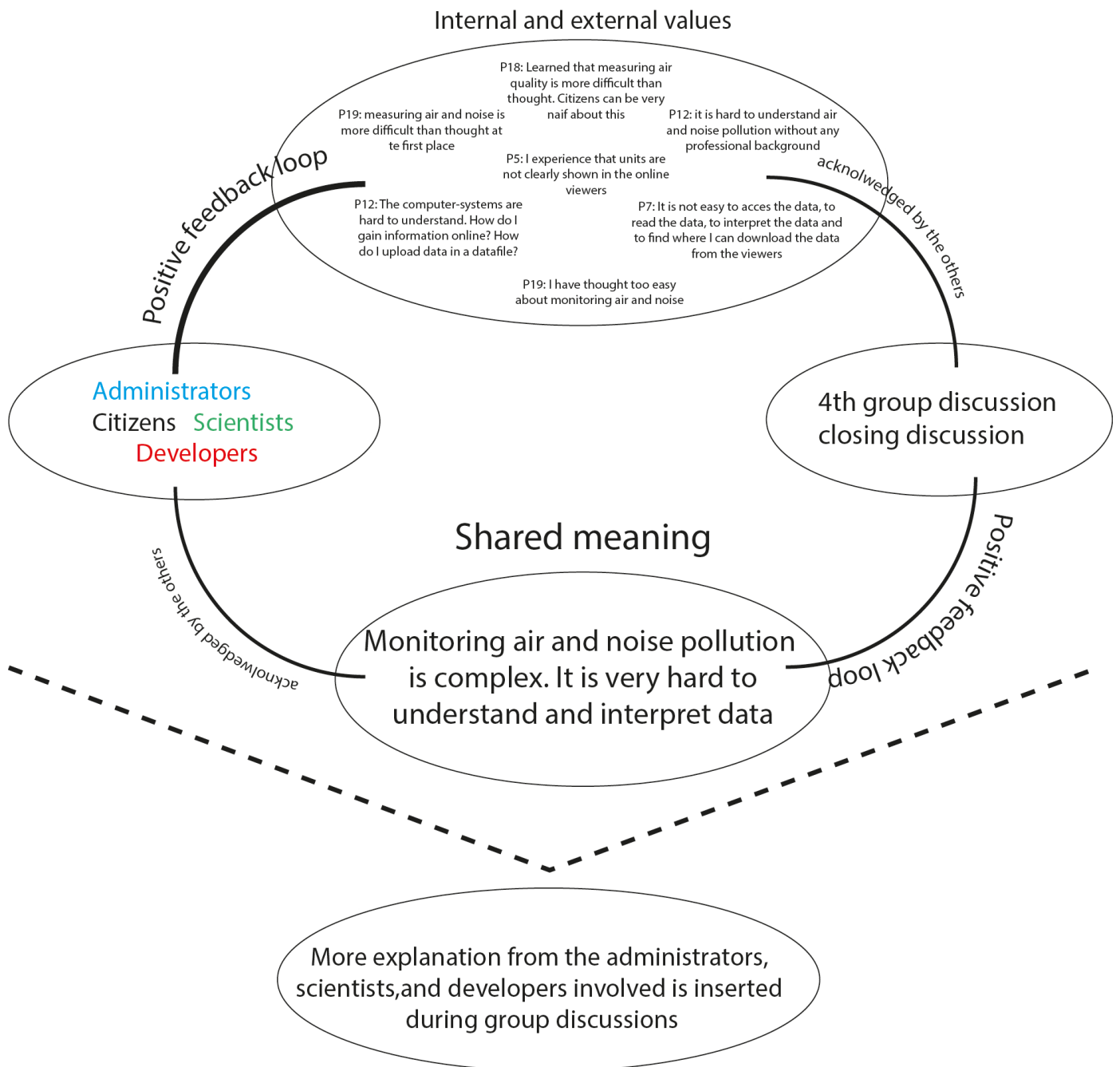


Diagram 4: Measuring air and noise is experienced as a complex matter

The shared meaning is acknowledged by the other participants during the group discussion. Participant 12, 13, 19, 7, 5, 1 and 6 agree that there are always difficulties. This led to the new heuristic that more explanation from experts will be inserted during meetings in to understand the matter of air and noise and to interpret data.

4. Hour averages in dB(A) are not useful in order to monitor noise pollution detailed enough

Six participants experienced difficulties in measuring the noise due to the hour averages which are shown in dB(A). Participant 6, 20, 16 and 12 share the meaning that the hour averages in dB(A) are not useful to measure short noises or noise peeks. The participants remark that they would like to detect short noises or peeks, low frequent as well as high frequent. During the group discussions Participant 21, 16 and 23 came with the proposal to measure noise from now on in dB and not in dB(A). This is acknowledged and agreed by the other participants. The new heuristic developed is that the CSN will also measure in dB in order to make it possible to capture short noises and noise peeks. The internal and external values are enlarged on this page, the model is depicted on the following page.

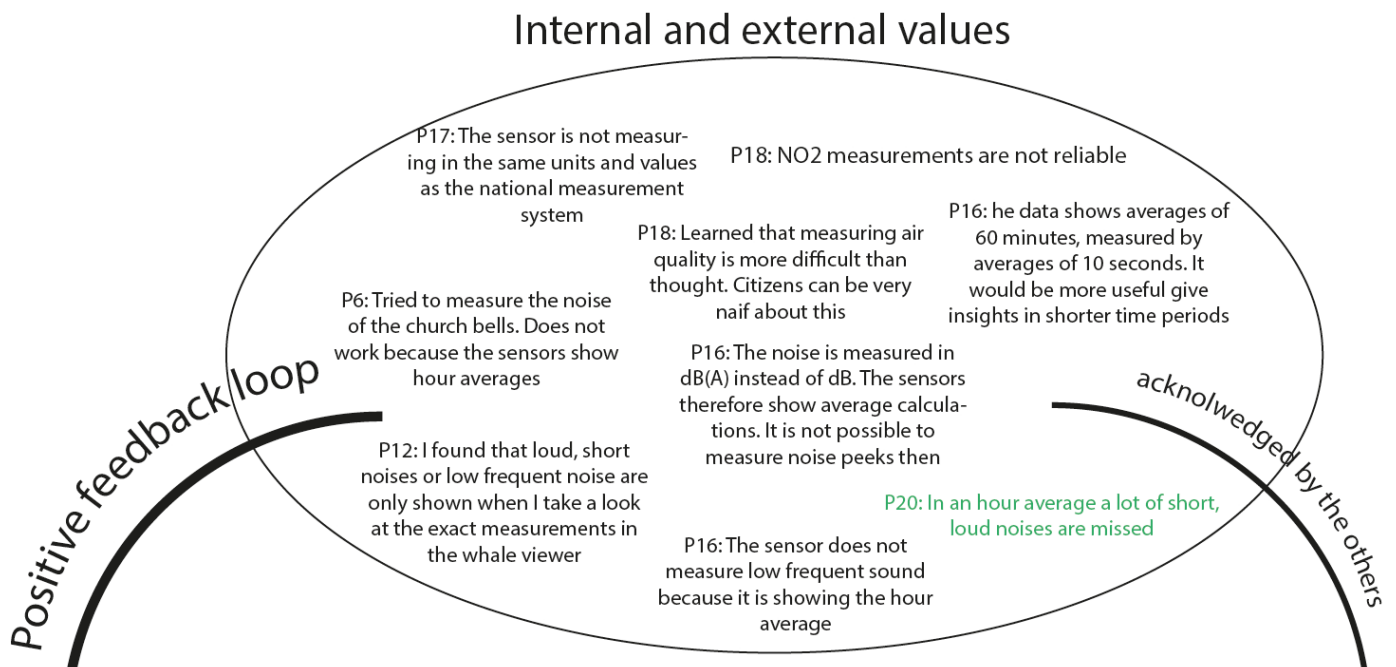


Diagram 5: The interrelating internal and external values regarding units of measurement

Internal and external values

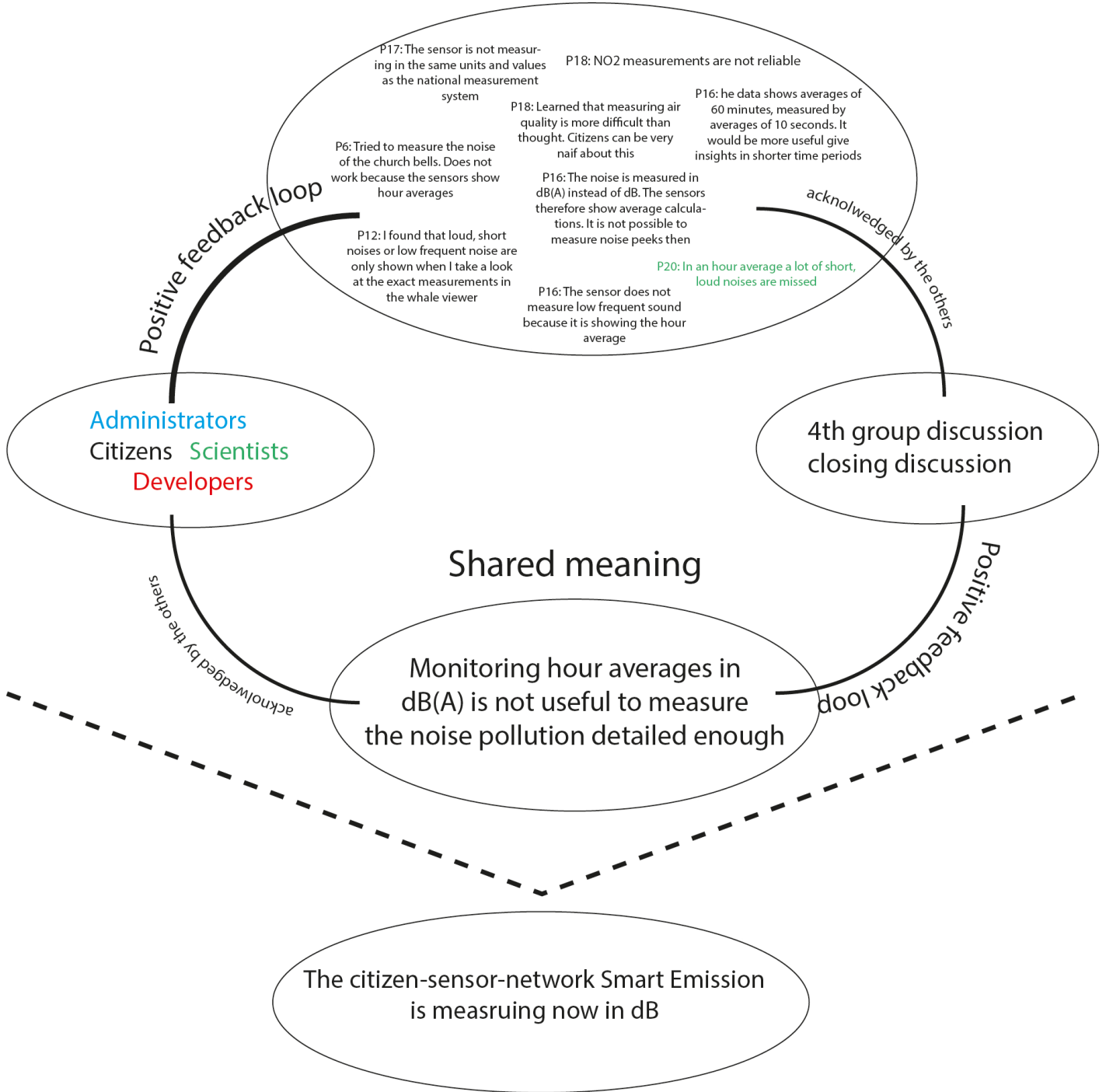


Diagram 6: Shared meaning of hour averages in dB(A) are not useful in order to measure short noises or noise peeks.

5. Start small project groups with focus on topics of interest and activate more citizens to participate in the citizen-sensor-network

Five participants mentioned during the discussion evenings that we should create smaller project groups whereby citizens can focus on their topics of interest and discuss their data results and analysis of the data. Furthermore, participants would like to activate more citizens to participate (see quote participant 19). As participant 1 mentioned for example, we need to have a sense of purpose in order to find out where we would like to place new sensors.

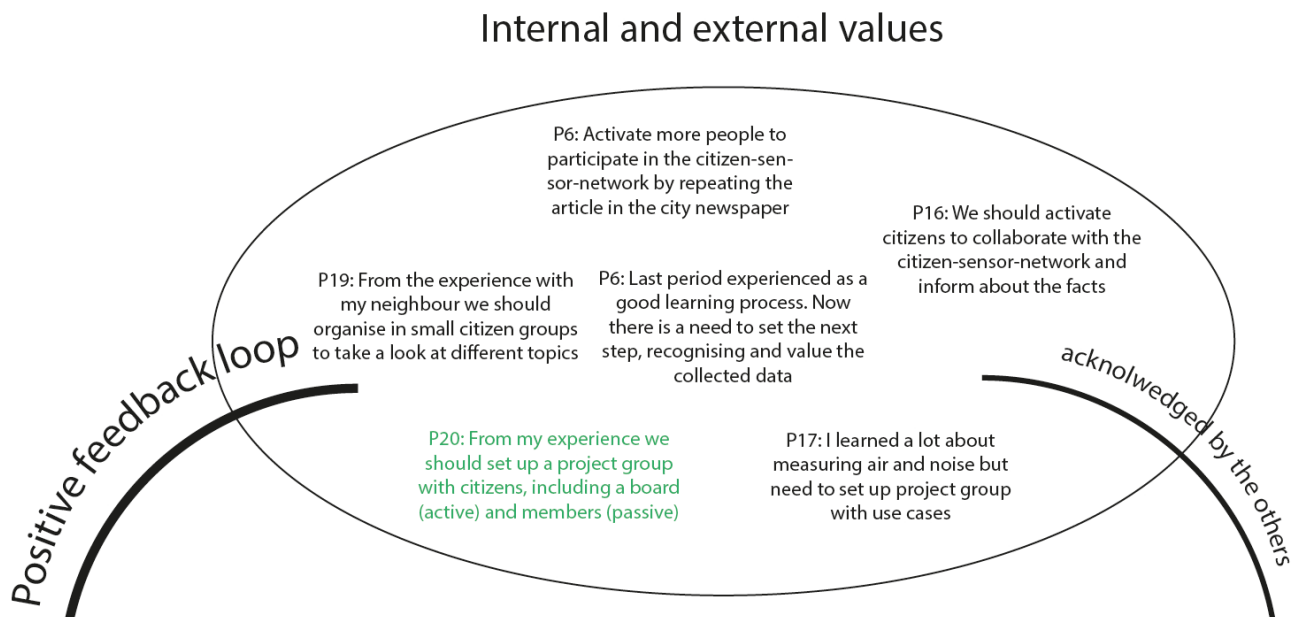


Diagram 7: the interrelated internal values regarding project groups and activation of citizens

In this case three shared meanings are identified on basis of the internal values of participants: start with small project groups of citizens; activate more citizens to participate and start to focus on specific topics of research. During the group discussions the participants made agreements on the shared meanings. The next diagram depicts the shared meanings.

Internal and external values

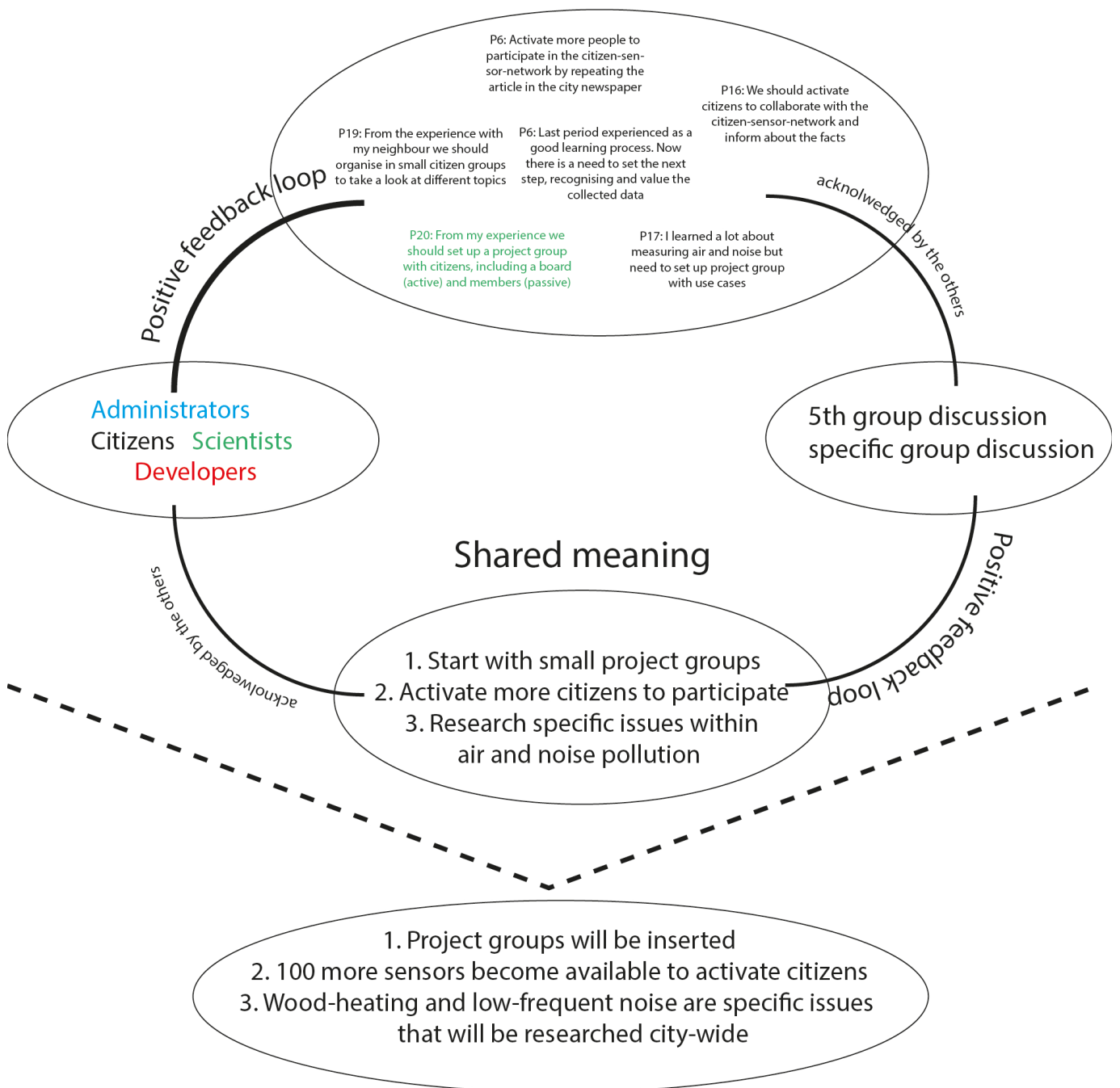


Diagram 8: Shared meaning and new heuristics focus on small project groups, activate more citizens to partake, focus on topics of interest

Interesting finding in all of the shared meanings found is that the type of participant 'citizens' contributed with 33 internal and external values to the development of shared meanings, the type of participant 'scientists' contributed with 4 internal and external values to the development of shared meanings and the type of participant 'administrators' contributed with 1 internal value. From these shared meanings the new heuristics developed. The following section elaborates on the new heuristics.

6.7 New heuristics

From the shared meanings that developed, there have been agreements reached. These agreements are seen as the six new heuristics that have developed in the citizen-sensor-network. These new heuristics developed when the participants in the citizen-sensor-network collectively addressed a certain action (a shared meaning) and agreed or made a decision upon this certain action within the group.

The first new heuristic that developed is that the citizen-sensor-network needs to be a dynamic, informative and fruitful process; the second new heuristic is that noise will be measured in dB instead of dB(A) because it gives more detailed information about noise pollution; the third new heuristic is that project groups of citizens will be created for researching specific issues; the fourth new heuristic is that there will be a city-wide focus on the issues wood heating and low frequent noise; the fifth new heuristic is that more citizens will be activated to participate in the citizen-sensor-network by installing 100 more sensors in and around the city of Nijmegen and the sixth new heuristic is that more expert knowledge from scientists and administrators will be inserted during meetings. The following sections further elaborate on the development of these new heuristics.

The first new heuristic, that the citizen-sensor-network in the future needs to be an informative, dynamic and fruitful process, is derived from the shared meaning of the group of citizens involved.

The second new heuristic, that the CSN will measure noise in dB instead of dB(A), is derived from the urge of group of citizens to collect new data about noise peaks. When measuring in dB instead of dB(A) the participants involved in the citizen-sensor-network have the possibility to monitor the short noises and noise peaks. Interesting is that therefore, the context in which participants monitor changes. This because the 'units of measurement' changed. By reflecting this upon the EPP-framework, the personal learning experiences and the data interpretations from the participants involved will change too. Participants gain therefore new knowledge about monitoring noise pollution.

The third new heuristic, that a project group of citizens is composed in order to focus on specific topics of interest, is derived from the shared meaning citizens like to start with small project groups. The new heuristic of starting with project group is initiated by the experiences citizens have with monitoring air and noise in their own environment. In the last group discussion, the question to subscribe for project-groups was raised. The participants therefore agreed that the topics of citizens interest will be written down and that when more than 5 persons subscribe to a certain topic it would be formed as 'official' project group in the citizen-sensor-network. The

project groups will therefore exist of an active group of participants and a passive group of participants. The active group of members will organise meetings, share data and findings with other participants and will organise excursions to other projects. The passive members are the active members online who share their findings, remarks and data with the active group of citizens.

Participant 20: "We start with a project group" (Participant 20, 2016).

Participant 20: "We starten een werkgroep" (Participant 20, 2016).

The project groups will from now on function as the leaders of the content that will be monitored. Therefore the citizen-sensor-network is able to experiment with which topics are experienced by the participants as the most interesting. Furthermore, all the active members of the project group will from now on receive his or her own role.

Participant 19: "My idea is to start with small project groups and therefore look at several topics of interest. For me this is wood-heating" (Participant 19, 2016).

Participant 19: "Mijn idee is om groepjes te gaan organiseren en dan te kijken naar verschillende onderwerpen. Voor mij is dit houtstook" (Participant 19, 2016).

With the start of the project groups the dynamics and focus of the citizen-sensor-network changes. Participants are from now on able to act on in their small-project groups within the network, without always sharing their actions with the other participants involved. This gives the participants the ability to conduct their own in-depth analysis, but also the disadvantage that some knowledge will stay at the project groups and will not be reflected upon the whole group of participants. This affects the questions and focus of the citizen-sensor-network.

The fourth new heuristic, that the topics wood-heating and low-frequent noise will be researched city-wide, is actually narrowly related to the third new heuristic. Wood-heating and low-frequent noise are the first two topics that appear to be the 'specific issues' of research in the continuation of the citizen-sensor-network. As the participants mentioned during this discussion:

Participant 22: "In my experience, people are not educated well in order to burn wood. We could develop an app for this" (Participant 19, 2016).

Participant 22: "In mijn ervaring is men niet goed opgeleid over hoe je goed hout stookt. We kunnen een app hiervoor ontwikkelen" (Participant 19, 2016).

Participant 19: "In my experience, people are not aware of the pollution caused by wood-heating" (Participant 1, 2016).

Participant 19: "In mijn ervaring is men zich er niet van bewust dat houtstook zo slecht kan zijn" (Participant 1, 2016).

The fifth new heuristic, that more citizens will be activated to partake, is taken responsible by the municipality of Nijmegen. The municipality promised that they will subsidise more sensors in order to recruit more citizens for the project. By activating more citizens to participate in the project the citizen-sensor-network gets more dense. In the future, the citizen-sensor-network will therefore have more reliable data about air and noise pollution in Nijmegen. The 100 new sensor will provide another view on the data, again changing the personal learning experiences and the data interpretations of the participants involved.

Participant 20: "There will be a subsidy in order to recruit more citizens for the project" (Participant 20, 2016).

Participant 20: "Subsidie vervolg op BSN, gemeente Nijmegen heeft ook geld vrijgemaakt voor het project" (Participant 20, 2016).

The sixth new heuristic, that more expert knowledge will be inserted during meetings in order to answer questions and explain the complexity of the phenomena air and noise, gives participants more knowledge in order to interpret and understand the data in the future.

When we relating the new heuristics to the EPP-framework, the 6 new heuristics transformed the citizen-sensor-network into a 'new citizen-sensor-network'. The new heuristics are from now on set as the new 'baseline' where the citizen-sensor-network will build upon.

7 Conclusion & Discussion

This chapter elaborates on the discussion and conclusion of the research. The discussion takes a brief look at the results, the limitations of the research and elaborates on the possibilities for further research. The conclusion summarises briefly the research questions and provides an answer on the main research question.

7.1 Discussion

The new heuristics derived from this research show that new knowledge can be constructed in a partnership such as a citizen-sensor-network. The new heuristics steer policy making into the direction of researching local issues. The citizen-sensor-network gives therefore another dimension to air and noise policy making. The policy making process for air and noise policy is in the case of Nijmegen much more synchronised with the issues experienced by citizens, administrators, developers and scientists living in the city itself. The new heuristics contribute therefore to policy making regarding air and noise pollution in Nijmegen.

The citizen-sensor-network as policy making process points out that bringing together 'local' knowledge and 'expert' knowledge is very valuable for policy making (Innes & Booher, 2010; Lawrence, 2006; 2009). A policy making process such as the citizen-sensor-network Smart Emission alters in this sense the hierarchical and traditional structure in policy making and planning for our living environment as explained by Giddens (1984).

The new heuristics reflect furthermore, upon the many difficulties that are experienced within policy making in a partnership. The new heuristic that more expert knowledge and explanation is needed during meetings depicts for example that measuring air quality and noise pollution in a partnership is still a very unknown activity for citizens and experts. Lawrence (2006) acknowledges this in her research by stating that many cases related to environmental activities involve trainings in order to educate the participants involved (Lawrence, 2006). She also argues that when different types of participants are involved, the outcomes of a process are even more valuable (Lawrence, 2006).

The new heuristic to start project groups and the new heuristic to focus on the specific issues of wood-heating emissions and low frequent noise, reflects upon the argument of Lawrence (2006) that the act of participation lies the basis for a growing relationship between a person and a place (Lawrence, 2006). Interesting outcome, because these two 'specific issues' were not considered or prioritised in air and noise policies before.

An interesting example of a grown relationship between a person and place is the case of P19. This participant was fighting with his neighbour about air pollution, caused by his neighbour's wood burning stove, for years already. When P19 started as participant in the citizen-sensor-network, he monitored the air pollution from the wood burning stove for a couple of weeks. P19 shared after three weeks of monitoring his data with the neighbour. His neighbour was shocked by the high concentrations of air pollution caused by his wood burning stove. Since knowing this, the neighbour of P19 installed a filter in order to clean the air in- and outside the house and also signed up to participate in the citizen-sensor-network.

This act reveals how just a small issue from just one participant is solved by the act of monitoring. The data provided for both persons new insights into the issue of wood burning stove. P19 and his neighbour initiated therefore during the fourth group discussion to research wood-heating emissions city-wide. Lawrence (2006) explains this phenomenon as follows: "...when laypersons are engaged in structured observation and interpretation...their values change and possibly even converge with those of others" (p. 295).

This thesis is written from the perspective of me as researcher in spatial planning. I can imagine that planners will not relate air and noise pollution directly to their profession. Air and noise pollution are not objects experienced as physical tangible interventions in space. What I therefore would like to emphasise in this research is that air and noise pollution are actually narrowly related to planning. A good air and noise quality are important elements in order to create a healthy living environment. We maybe do not notice it directly because air and noise are not physical experienced objects in space, but air and noise pollution do initiate many spatial interventions in our living environment.

In New York for example, Kheirbek et al. (2014) conducted research about air and noise pollution in relation to planning by analysing outdoor and personal exposures to air and noise pollution in New York. As one of the outcomes of the research Kheirbek et al. (2014) recommended guidelines of when people during the day should expose themselves to these emissions and when it would be healthier to stay inside (Kheirbek et al., 2014). In order to research this Kheirbek et al. (2014) divided New York into 'more polluted areas' and 'less polluted areas'. This resulted into a new user-interface of the city. The interface gives people insights in how to make use of the city.

In Madrid research is conducted by Chasco & Le Gallo, (2015). They applied in their research a hedonic housing price model in order to estimate the willingness to pay for less air and noise pollution by the Madrid residents. This research showed that prices for a clean and quiet

environment differed substantially across the housing markets and were influenced by 'clean air' or 'quiet environment' (Chasco & Le Gallo, 2015).

The outcomes of the research show that citizen-sensor-network as policy making process has potential to influence air and noise policy and this way planning of our cities. By monitoring cities in a policy making process such as a citizen-sensor-network, spatial interventions could be implemented on basis of the outcomes from this process. With the input of citizens and experts, the 'local' knowledge and 'expert' knowledge a citizen-sensor-network contributes to both; finding solutions for a cleaner air and less noise pollution and air and noise policy making. Municipalities could use this form of policy making in order to create healthy living environments within the city.

Furthermore, there are of course also some limitations that can be ascribed to the research. First is that the representation of participants in the case of Nijmegen is not a reflection of the whole society living in the city Nijmegen. It is hard to achieve a full representation of the society because participating in the citizen-sensor-network takes time. But, when not having a representative group of participants, important issues related to air and noise pollution in the city could be missed or not taken into consideration.

Another limitation is that the participants involved in the citizen-sensor-network Smart Emission are volunteers. Volunteers have to fit the participation-act into their daily lives. Resulting into a mixed number of participants that attended the group discussions. Then there is also a time-aspect to a policy making process. Policy making in a citizen sensor network is a time-consuming process. It took almost 6-8 months in the citizen-sensor-network to develop new heuristics. The citizen-sensor-network furthermore started as an experiment two years ago. After two years, the participants are finally able able to monitor some 'useful' and 'reliable' data. Before it took a long time in order to develop, test and calibrate the sensors. Now after two years, the citizens and experts are finally able to discuss the first reliable data.

A last issue that needs to be concerned is the issue of privacy. The citizen-sensor-network is a policy making process where a lot of data is shared online. The sensors in Nijmegen are visible on online viewers. When zooming in on the sensors, the addresses of the participants become visible to the public. Privacy is not an issue researched within this study, but it is a topic that needs to be considered in the citizen-sensor-network when it moves on to the next phase. Until now the citizen-sensor-network has been set up as an experiment within which 34 participants were involved. In this period the privacy has been guarded by contracts with project members, invisible data for outsiders, access to data in a safe online environment. When 100 more participants with a sensor become involved a new online system needs to be developed in order to secure the privacy. The the members of the citizen-sensor-network are at the moment

discussing about which measurements need to be taken into the future in order to secure the privacy of all the participants involved.

Furthermore, many questions remain about the responsibility and roles within the citizen-sensor-network. Questions such as: who is responsible for high concentrations of NO₂; who is responsible for high noise concentrations; who will fix the sensor when it is broken; what to do to keep the data updated and reliable, still remain.

An perspective for further research therefore is to find out how to mobilise the citizen-sensor-network when more than 100 participants are involved? Or how to implement the citizen-sensor-network as policy making process in other issues? Furthermore, a remark can be made about the Environmental Policy Partnership framework (EPP). The EPP-framework is a self-developed framework on basis of the DIAD-framework from Innes & Booher (2010) and the VBM-framework from Lawrence (2006) that is not tested before in other research. In order to test the validity of the framework I invite other researchers with pleasure to test out the framework.

7.2 Conclusion

In this research the claim was that the citizen-sensor-network Smart Emission is a policy making process regarding air and noise pollution in the city of Nijmegen. In order to examine this claim, the case of the citizen-sensor-network Smart Emission is analysed from the lens of the Environmental Policy Partnership framework. In the case of Nijmegen, the research topics were air and noise pollution. Therefore the objective of this research was to examine how the citizen-sensor-network Smart Emission contributes to policy making regarding air and noise pollution in Nijmegen.

The main research question is:

How does the citizen-sensor-network Smart Emission contribute to policy making regarding air and noise pollution in Nijmegen?

In order to formulate an answer on the main research question, four sub-research questions are proposed. These sub-research questions are summarised in the following sections. At the end of these sections I will briefly reflect upon the main research question.

1. Who is involved in the citizen-sensor-network and why?

In the citizen-sensor-network four different types of participants are involved: citizens, scientists, experts from industries (software- and hardware developers) and administrators (government). The citizens involved are the citizens living in and around the city of Nijmegen. The

administrators involved are the air and noise quality experts from the municipality of Nijmegen. The scientists involved are the planning scientists from the Radboud University. The experts from industries involved are soft- and hardware developers.

From the 34 participants involved in the citizen-sensor-network, 11 participants have participated in the in-depth interviews and 16 participants have participated in the group discussions. From these 16 participants, 9 participants also participated in the interviews. This means that in total 18 participants have contributed to the research. Therefore in total 11 interviews are conducted and 5 group discussions have taken place.

To provide an answer the question why participants are involved interests of participants are captured by interviewing 11 participants and observing in total 16 participants during 5 group discussions. Within the interests collected, three categories have been found: the personal interests, the background interests and other interests.

Interesting finding is that the background interests have a relation to environmental issues and research. The personal interests are related to an issue a participant experiences in his direct living environment. In total one other interest found. This interest did not fit into the background interests or personal interests. The next sections elaborate on these three groups of interest by describing them more into detail.

Background interests

There are 2 participants that have a 'technical background' P5 and P6 explain for example to be much interested in the technical side of the project because of their backgrounds as metrologist and as teacher in technique. P6 explained that he has, also because of his background, a strong affinity with this type of research and technical methods to measure air and noise. P7 has a political background and explains that his interest in air quality started during his studies and that he wants to invest in this topic in order to put it on the political agenda. He aims for a good air quality because he sees it as an important factor for the quality of life. The participants 10 and 14 do not mention that they have a specific educational background in air and noise. But mention that they have been active in citizens-committees or NGO's concerned with the environment for years.

Personal interests

Participant 14 explains for example that he is worried about the industrial area near his neighbourhood and sees the citizen-sensor-network as an opportunity to find out how this is affecting his living environment. Participants 1 and 6 are involved because of their worries concerned with the CO2 pressures in their garden and their homes. Participant 5 partakes because he is interested in what kind of outcomes a local monitoring network generates, if we

can recognise local sources and differences in values with national monitoring systems. Participant 7 his interest in air quality and noise pollution started already during his studies when he lived in Mexico city. When a project about air and noise started in Nijmegen, he had an direct interest. Participant 19 partakes because he is dealing with a wood heating neighbour. He explains to be asthmatic and that he partakes because the citizen-sensor-network provided him a tool to measure if the wood heating actually is harmful or not. I also asked participants if they had any idea why others would participate in the citizen-sensor-network. The participants mentioned that they think that other participants participate because of a personal issue or something else that bothers them.

Other interests

There was also an participant involved with no interest relate to his background or related to a personal interest. This participant became interested in the project because of his neighbour. This phenomenon occurred when his neighbour started sharing information about his sensor with him. Participant 1 explains that he has been intrigued by the air and noise quality in his living environment for already a long time, but did not show activity around this topic until his neighbour told him about the citizen-sensor-network. Due to the enthusiasm and interesting data analysis of his neighbour he got triggered and signed up for the citizen-sensor-network.

When we take these motivations into the perspective of the EPP-framework the interests of participants should point out if three conditions diversity, interdependency and equality are embedded.

Diversity is embedded in participants their diversity of backgrounds interests, personal interests and other interests. When taking a look at the conditions of interdependency and equality. These two conditions are not clearly pointed out in the research. Participants are involved because they experience some personal issues themselves or have a background which is related to the topic. Reflecting upon Interdependency, the participants do not participate because they are in a certain way dependent to each other. The question if the condition of equality is embedded is also not answered with these outcomes.

2. What are the internal values and external values from the participants involved?

Internal and external values are, as explained in the EPP-framework, the personal learning experiences and the data interpretations from participants involved in the citizen-sensor-network. In order to explain once again the internal values and external values I depicted them underneath.

Internal values: the internal values are the personal learning experiences that participants gain

by conducting an activity which is part of/or related to a planning process on city-level (Lawrence, 2006).

External values: the external values are the data interpretations that come forward from the actual act of data collection by the participants involved. The data is therefore interpreted as useful and shared by participants in the process (Lawrence, 2006).

During the interviews and group discussions several personal learning experiences (internal values) and data interpretations (external values) from participants are collected. These are collected by interviewing 11 participants and observing in total 16 participants during 5 group discussions.

In total 43 internal values are found and 11 external values are found. From the internal values 33 internal values are found for the type of participant 'citizens', 2 internal values are found for the type of participant 'scientists', 6 internal values are found for the type of participant 'administrators' and 2 internal values are found for the participant type 'developers'. In the participant type 'citizens' the most internal values are found. From the external values, 1 external value for the type of participant 'administrator' and 10 external values for the type of participant citizens are found.

Less external values are found than internal values. An explanation for this can be found in the content of the external values. The citizens involved have many difficulties with interpreting and understanding the data. Within the external values collected, the following interrelated external values can be found. From these internal values and external values interrelated personal experiences are derived. These are briefly summarised in the section below.

A brief summary of the interrelated internal values and interrelated external values: participant 1 and 6 are interested in CO₂ concentrations inside their homes and their garden because they experience high values of CO₂ concentrations in their measurements. Participant 12 experiences many difficulties with interpreting data, using software and interpreting the data for analysis. Participant 18 experiences that measuring air quality is more difficult than thought. Participant 17 experiences that there are many questions among citizens among different issues related to air and noise pollution. Participant 20 experiences that questions from citizens are very specific. Participants 6, 7, 15 and 17 have interrelated internal values in the dynamics of the group of participants involved. Participant 16 experiences troubles with low-frequent noise. Participant 12, 21 and 23 are also interested low-frequent noise. Participant 6 is interested in high frequent noise peaks. Participants 20, 19, 16, 6 and 17 would like to start a project group in order to focus on specific neighbourhood related topics. Participant 17 and 19 are interested in wood heating emissions. Participant 10 and 11 learned nothing. Participant 21 learned that measuring noise in

dB does not show high noise peaks. Participant 23 learned that dB shows short noises and wants to measure noise in dB instead of dB(A).

3. How have shared meanings and shared identities developed in the citizen-sensor-network

Shared meanings

The shared meanings in the citizen-sensor-network have developed on basis of the interrelated internal values and the interrelated external values from participants. This resulted into the following shared meanings:

1. CO₂ is experienced as a health problem by participant 6 and participant 1. They both measure high concentrations of CO₂ inside as well as in their garden.
2. The group process is experienced by participants 6, 7, 15 and 17 as informative, fruitful and dynamic with several issues involved and diverse people.
3. That measuring air and noise is complex and that the data is hard to interpret is experienced by participants 18, 19, 12, 7 and 5.
4. Participants 7 and 12 have difficulties with reading and understanding the data.
5. Participants 18 and 19 experience that measuring air and noise is more difficult than thought. Participants 5 and 7 experience that the units of measurement are hard to understand and read.
6. The hour averages in dB(A) are experienced by participant 6, 20, 16 and 12 as not useful to measure short noises or noise peaks. All participants involved tried to measure noise peaks and short noise but this did not work with measurements from an hour average.
7. Participants 20, 19, 6 and 17 propose that the citizen-sensor-network should start with small project groups of citizens. In this context participant 20 suggested to include a council or board with active and passive members.
8. Participants 19 and 17 state that the citizen-sensor-network should focus on neighbourhood related topics, specific topics by citizens their interest, so that citizens are able to research their own issues.
9. Participant 19, 16 and 6 explain that more citizens need to participate in the citizen-sensor-network. Participant 19 suggests in this context to search for a connection with politics. Participant 6 suggests to replace an article in the local newspaper to active more citizens. Participant 19 suggests to install hundred extra sensors to involve more citizens.

Shared identities

The shared identities found in the framework are related to participants their perceived roles. Participants see themselves as ambassadors, initiators, politician, participants and as non-

participants of the citizen-sensor-network Smart Emission. Interesting to see is that the type of participant 'citizens' perceives diverse roles.

Type of participants: Citizens	
Participants	Perceived role
P12, P10, P1	Participants
P5	Does feels to have a role in the citizen sensor network. Does not mention a specific role.
P6	Initiator
P7	Politician
P13	Participant
P14	Ambassador
P11	No role in the sensor-network
Type of participants: Developer	
Participants	Perceived role
P13	Calibrator

4. How have shared meanings developed into new heuristics?

From the shared meanings that developed, there have been agreements reached. These agreements are seen as the six new heuristics that have developed in the citizen-sensor-network. These new heuristics developed when the participants in the citizen-sensor-network collectively addressed a certain action (a shared meaning) and agreed or made a decision upon this certain action within the group.

1. The first new heuristic that developed is that the citizen-sensor-network needs to be a dynamic, informative and fruitful process.
2. The second new heuristic is that noise will be measured in dB instead of dB(A) because it gives more detailed information about noise pollution; in order to be able to measure noise peaks. The measurements in dB make it able for participants to measure loud noises and noise peaks. In this way new knowledge about the nuisance of noise can be monitored. This provides new knowledge about when noise is peaking in shorter periods of time.
3. The third new heuristic is that project groups of citizens will be created for researching specific issues; The project groups will from now on function as the leaders of the content that will be monitored. Therefore the citizen-sensor-network is able to experiment with which

topics are experienced by the participants as the most interesting. Furthermore, all the active members of the project group will from now on receive his or her own role. With the start of the project groups the dynamics and focus of the citizen-sensor-network changes. Participants are from now on able to act on in their small-project groups within the network, without always sharing their actions with the other participants involved. This gives the participants the ability to conduct their own in-depth analysis, but also the disadvantage that some knowledge will stay at the project groups and will not be reflected upon the whole group of participants. This affects the questions and focus of the citizen-sensor-network.

4. The fourth new heuristic is that there will be a city-wide focus on the issues wood heating and low frequent noise; the topics wood-heating and low-frequent noise will be researched city-wide, is actually narrowly related to the third new heuristic. Wood-heating and low-frequent noise are the first two topics that appear to be the 'specific issues' of research in the continuation of the citizen-sensor-network.
5. The fifth new heuristic is that more citizens will be activated to participate in the citizen-sensor-network by installing 100 more sensors in and around the city of Nijmegen; the municipality promised that they will subsidise more sensors in order to recruit more citizens for the project. By activating more citizens to participate in the project the citizen-sensor-network gets more dense. In the future, the citizen-sensor-network will therefore have more reliable data about air and noise pollution in Nijmegen. The 100 new sensors will provide another view on the data, again changing the personal learning experiences and the data interpretations of the participants involved.
6. The sixth new heuristic is that more expert knowledge from scientists and administrators will be inserted during meetings; more expert knowledge will be inserted during meetings in order to answer questions and explain the complexity of the phenomena air and noise, gives participants more knowledge in order to interpret and understand the data in the future.

With these new heuristics an answer on the main research question: *How does the citizen-sensor-network contribute to policy making regarding air and noise pollution in the city of Nijmegen?* is formulated. The research explains how the citizen-sensor-network transforms as policy making process into a 'new type of citizen-sensor-network'. It depicts how the scientists, administrators, developers and citizens involved in the citizen-sensor-network learn to better understand each other and that collected data got therefore more valuable. The new heuristics, as outcomes of the process, can be seen as the 'new knowledge' constructed. Because of this 'new knowledge' the citizen-sensor-network as policy making process developed in itself. The citizen-sensor-network therefore demonstrates how it contributes as a policy making process regarding air and noise policy.

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Appendix

1 Interview format

2 Coding file motivations

3 Coding file internal values/external values

4 Coding file shared identities

5 Coding file Shared meanings