EMPOWERMENT INITIATIVE IN AIR QUALITY

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MEDNARODNA PODIPLOMSKA ŠOLA JOŽEFA STEFANA
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POBUDA ZA OPOLNOMOČENJE KAKOVOSTI ZRAKA

Magistrsko delo

Supervisor: Prof. Dr. Milena Horvat

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"Tell me and I will forget.
Show me and I will remember.
Involve me and I will understand."
Ancient Chinese proverb

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Abstract

Air quality is extremely important for the entire population. Public awareness of the importance of air quality and its negative impacts on human health and other living creatures as well as raising awareness of the individual's role in reducing their own exposure to the hazardous environment is a challenging task. In the framework of the EU-project CITI-SENSE partner cities were set to empower people to take action at a local level. In Ljubljana, a grammar school was engaged. In the early stages of the project it was intended to equip the school with low-cost sensor units, which could enable them to control the air quality in the school premises, indoor and outdoor, and find common solutions to improve air quality. However, because of delays in the supply of sensor units we had to change and adapt the purpose and objectives of the research project. Therefore, the project objectives shifted towards educational potential through co-designing activities. Instead of data gathering and interpretation the focus was shifted to more collaborative two-way approach. Activities related to air pollution were designed together with the school to fill the gap of missing sensor data. These activities led to the process of empowering grammar school students and teachers, which was the primary goal of the CITI-SENSE project. An important result of joint project cooperation project is an application displaying air quality in Ljubljana, which individuals can use on smart phones, which touches the societal needs and reflects a part of Citizens' observatory concept. Another important result of this master thesis is the preparation and organization of an informative street event together with grammar school students. Developing a systematic collaborative approach has led us to action research, in which we gather and analyse data using appropriate tools for assessing the effectiveness of these events in grammar school student groups. A comprehensive approach made important findings on selected tools and represents a good basis for further development and improvements, which we plan to use in other urban population groups.

Povzetek

Kvaliteta zraka je izjemno pomembna za celotno prebivalstvo. Ozaveščanje javnosti o pomenu kvalitete zraka in negativnih vplivov, ki jih ima onesnažen zrak na zdravje ljudi in ostala živa bitja, ter dvigovanje zavedanja o posameznikovi vlogi pri zmanjševanju lastne izpostavljenosti zdravju nevarnim okoljem je zahtevna naloga. V okviru EU projekta CITI-SENSE so partnerska mesta vključila svoje občane v sodelovanje v njihovem lokalnem okolju. V Ljubljani smo učiteljem in dijakom ene od srednjih šol predstavili cilje projekta in jih pridobili za sodelovanje. V začetnih fazah je bil naš namen šolo opremiti z nizkocenovnimi senzorskimi enotami, s katerimi bi lahko sami nadzirali kakovost zraka v šolskih prostorih ter poiskali skupne rešitve za izboljšanje kakovosti zraka. Zaradi zaostankov pri dobavi senzorske enote smo morali spremeniti in prilagoditi namen raziskave ter cilje projekta. Namesto tehnoloških rešitev, zbiranja in interpretacije podatkov smo cilje projekta preusmerili v izobraževanje in sooblikovanje različnih aktivnosti, kar je prispevalo k ozaveščanju lokalnega prebivalstva o pomenu kakovosti zraka in vlogi posameznika pri ohranjanju in izboljšanju njegove kvalitete, torej opolnomočenju dijakov in učiteljev. Pomemben rezultat skupnega sodelovanja na projektu je aplikacija prikazovanja kakovosti zraka v Ljubljani, ki jo posamezniki lahko uporabijo s pametnimi telefoni. S tem smo navezali stik s prebivalstvom, uporaba sledenja kakovosti zraka na pametnih telefonih pa odraža koncept »opazovalnice kakovosti zraka« za prebivalce mest. Drugi pomemben rezultat magistrske naloge je priprava in izvedba informativnega dogodka, ki smo ga organizirali skupaj z dijaki. Razvoj sistematičnega pristopa k raziskovanju družbenih aktivnosti je vodil do akcijskih raziskav, v katerih smo zbirali in analizirali podatke s pomočjo ustreznih orodij za ocenjevanje teh dogodkov pri populaciji srednješolcev. Omenjeni celoviti pristop je podal pomembne ugotovitve o izbranih orodjih in je dobra osnova za njihovo nadaljnjo izgradnjo in izboljšave, ki jih bomo v bodoče lahko uporabili pri študiji drugih populacijskih skupin mestnih prebivalcev.

Abbreviations

ARSO	=	The Slovenian Environment Agency
CO	=	Carbon monoxide
CO_2	=	Carbon dioxide
ICT	=	Information and Communication Technologies
JSI	=	Jožef Stefan Institute
MOL	=	Municipality of Ljubljana
PM	=	Particulate matter
TAG	=	Technical advisory group
WHO	=	World Health Organization

1 Introduction

Poor air quality, caused by gaseous and particulate pollution, is associated with both short and long-term adverse health effects (Air Quality Short Life Working Group, 2014). The World Health Organization (WHO) (2014) has estimated that air pollution causes 7 million pre-mature deaths each year, making air quality issues a public concern. Raising public awareness about air pollution is of key importance and the first step towards empowering people.

Lately there have been several European projects dealing with air quality issues, which have been conducted at schools; Traditionally these studies focus on measuring air quality indoors e.g. SINPHONIE (2014) and Schoemaecker, Verriele, Hanoune, et al. (2014), outdoors, or the relation between the both (Blondeau, Iordache, Poupard, Genin, & Allard, 2005), or even by sampling the people at school for trace elements (Fiddicke, Becker, Schwedler, et al., 2014) etc. Environmental health studies rarely focus on studying the participants themselves, nor the social processes of the development of the project. They focus more on the actual measured air quality than the process leading to it. Action research is a method, with which we can study these processes. It has been previously applied to evaluate for example the work of teachers themselves e.g. as in Clausen, Aquino, & Wideman (2009). In this thesis we are applying it to a European wide empowerment project where we put into practice an empowerment initiative in a case study school. Page and Czuba (1999) define the process of empowerment as "a multi-dimensional social process that helps people gain control over their own lives. It is a process that fosters power (that is, the capacity to implement) in people, for use in their own lives, their communities, and in their society, by acting on issues that they define as important." Empowerment can happen in several levels. In the lowest level of empowerment, people receive one way information as simply communicated to them e.g. awareness raising and risk communication of air quality issues, which might later lead to actions taken by individuals. A higher level of empowerment is a collaborative process where the stakeholders have a say in what to do and how to do it while tackling the problems together. Within this thesis we will see the shift from lower level of empowerment towards higher level of empowerment.

The project, which supplied the framework for this thesis, is an ongoing European citizens' science project CITI-SENSE (citi-sense.eu), which aimed to develop sensor based citizens community for improving quality of life in cities. CITI-SENSE, together with four other projects deals with a concept of Citizens' observatories (www.citizen-obs.eu) - the key part being involving the citizens and understanding their behaviour. In practice, the EU project was to supply case study schools across Europe with novel low cost measuring devices to monitor the indoor air quality in order to act upon it. However, the project experienced substantial delay in providing sensor units to schools, whereas the case study locations had already recruited the case study schools. This thesis discusses how a case study school in Ljubljana acted upon this new situation, which lasted a year and a half through documenting the process, finding help in the action research approach. Different schools across Europe found different ways to cope with the lack of technology, mainly by providing other sensor units at schools. Throughout the process, Ljubljana case study highlighted the activities which are not only sensor-relied e.g. public awareness

raising campaign aiming to establish a sustainable project also beyond the project lifetime. The collective first year case study findings for all the case study schools across Europe are reported in Robinson et al., (2015).

The activities described in this thesis took place during two subsequent school years 2013/2014 to 2014/2015. Many of the activities at the case study school in Ljubljana were designed using the co-design approach, where scientists from the Jožef Stefan Institute, as part of secondary educational science outreach, were collaborating with the students and the teachers from the school, to discover most appropriate solutions when faced with the absence of sensor units. Moreover, to understand the social processes taking place at the school, the participants' motives were considered a crucial piece of information on trying to understand the nature of the processes. Many of the activities were extracurricular in their nature, giving the students the opportunity to learn something valuable not usually taught at schools, also acknowledged by Moura (2014) and Feldman & Matjasko (2012), while some were integrated in the curricula by the teachers.

As a reflective process, the activities were evaluated and adapted constantly. The process was supported by advice from the EU project's expert group, focusing on engagement and empowerment. The collaborative activities, decisions leading to them as well as views of the participants were carefully documented. Feedback was gained through semi-constructed interviews and reflection questionnaire in addition to continuous observation. Through participatory evaluation e.g. Zukoski & Luluquisen (2002) we were able to seek to involve those with a stake in the issue throughout the process, from framing the issues to data collection and dissemination of the results. While studying the behaviour of a small community, we were also able to observe how the school community may be adding to our understanding of the bigger Citizens observatory concept of the EU project. The school case studies can demonstrate this in a miniature scale, as schools have multiple stakeholders all working in different aspects, yet having the same goal. At the same time, when the processes at the school were being monitored and recorded at the local level, the school case study findings were also fed into the CITI-SENSE project learning organization.

Most of the results of the activities at the case study school proved to be useful in a co-designed street campaign to inform the citizens about air pollution in the city. Special attention to the development of this campaign is given as an example of a co-designed activity in this thesis. We were aiming to create more meaningful activities through high user involvement as guided by Reed (2008), ISO DIS 9241-210 (2008), Wilkinson & De Angeli (2014) and Mahmood, Burn, Gemoets & Jacquez (2000). Feedback received after the first campaign can consequently further improve the second campaign and enjoy higher success.

Unlike many other case studies at schools which merely focus on measuring the physical environment, this case study instead emphasises the importance of studying the processes. Important ground work was done to understand the importance of this interdisciplinary boundary work conducted with the help of action research. Such knowledge will be beneficial in the near future as Horizon 2020 project calls (European Commission, 2014a) progressively include stakeholder and citizen involvement. As more and more EU projects will involve schools, the lessons learned from action research method from a project at school can give valuable insights for future projects to come.

1.1 CITI-SENSE Project as a Framework for Urban Air Quality

CITI-SENSE project (citi-sense.eu) is a research project which started in October 2013 and continues until September 2016 and aims to "develop the so-called "Citizens Observatories" to empower citizens to contribute to and participate in environmental governance, and to enable them to support and influence community and societal priorities and associated decision making. CITI-SENSE is developing, testing, demonstrating and validating a community-based environmental monitoring and information system using innovative and novel Earth Observation applications. CITI-SENSE supports scientific research by involving citizens in the processes of gathering, analysing and interpreting data for use to protect and enhance the health and wellbeing of the community and the environment." (CITI-SENSE, 2014) Data collected from CITI-SENSE contributors is further used to study the quality of different urban environments either indoors or outdoors in the nine case study cities of Barcelona, Belgrade, Edinburgh, Haifa, Ljubljana, Oslo, Ostrava, Vienna and Vittoria. The project is based on distributed data collection using innovative low-cost static, portable and personal devices which communicate with data repositories through mobile phones or other devices (CITI-SENSE, 2014). This infrastructure is possible through the collaboration of 29 partner institutions. The project does not merely aim to test the technological tools, but also develop participatory methods, data management strategies, and applications to facilitate the exploitation of the data (CITI-SENSE, 2014). The high and abstract ambitions and concepts of the CITI-SENSE project were operationalized through case studies in the nine cities, this thesis describing a part of the case study taking place in Ljubljana.

The EU project touches societal needs, as air quality poses health risk to humans worldwide. Knowing what the air quality levels are is traditionally left to the scientists and governmental institutions to monitor and report. The regulatory monitoring is usually made in a few selected locations in cities covering only fraction of the city at a time. However, personal exposure to air pollution can significantly vary in different locations in the city. High spatial density air quality information is not currently available, even though many cities are trying to provide this information to the citizens via air quality models.

There are various actors in Ljubljana, who have interest or obligations to monitor the air quality. The national air quality monitoring is done by the Slovenian Environment Agency (ARSO) (www.arso.gov.si). Whereas the local regulatory air quality monitoring is conducted by the municipality of Ljubljana (MOL) (www.ljubljana.si). In addition, other institutions and individuals can be recognised as important contributors to this field. The most significant contributor to the common knowledge is be said to be Anton Planinšek, a former air quality advisor at ARSO, who dedicated his career to these issues. Secondly, there are other institutions that include air quality measurements in Ljubljana through various projects. The main ones being the Milan Vidmar Electric Power Research Institute (www.eimv.si) and the Geography Department from the University of Ljubljana (www.ff.uni-lj.si/en/1/Study/Departments/Department-of-Geography.aspx). The following paragraphs describe the characteristics of air quality monitoring in Ljubljana based on the finding from the abovementioned actors.

Air quality has been already monitored continuously in Ljubljana for the past 46 years. The air is currently being monitored in three locations across the city. Ljubljana had previous problems with sulphur oxides, which have now been completely eliminated. Nitrogen oxides and PM10 have also been declining in the past years. Ozone and benzene do not exceed the number of days per year when the concentrations exceeded the 8-hourly limit values set by the EU. Some of the recent actions the city has taken e.g. closing part

of Slovenska cesta for traffic decreased air pollution (measured as black carbon) by 58 %. Nowadays the main pollutants in the city come from traffic and from individual house heating, particulate matter (PM) being the most persistent and dangerous of them all. During winter time the majority of the pollution comes from wood burning, while in summer the increase in concentration is due to the contribution of the resuspension of particles. Traffic contributions stay the same throughout the year. All of the PM measured in Ljubljana are not generated in the city though. (Fičko et al., 2014, Planinšek, 2014, & Ogrin et al., 2014, and personal communication with Anton Planinšek, 19 November 2014, and with Nataša Jazbinšek Seršen on 19 December 2013 and on 17 March 2015)

The geographical layout of the city in a basin creates additional problems with air quality. Inversion layer being one of them. This is when the air masses do not get mixed normally, but the warm and polluted air gets trapped under a layer of colder air above the city. The condition might last for days concentrating the pollutants and causing respiratory problems for the vulnerable groups. Given Ljubljana's position in a basin, the pollutants also come from the surrounding wider regional catchment area. It is estimated that this impact in PM concentrations might be as high as 25-30%. (Planinšek, 2015 and personal communication with Anton Planinšek on 19 November 2014)

Since the air quality is measured at a few stations only, it is necessary to find other ways to conclude the air quality situation throughout the city. One way is through air quality modelling. A working real time air quality model is not available yet to the citizens of Ljubljana. The municipality has been working with Milan Vidmar Electric Power Research Institute to create models of air quality city-wide (personal communication with Rudi Vončina 7.4.2014 and with Nataša Jazbinšek Seršen on 19.12.2013). CITI-SENSE provides alternative ways of providing similar information.

1.2   Citizen Science and Collaborative Participation

To close the gap of readily available information to the citizens, CITI-SENSE project is developing and testing how a network of low cost fixed and portable air quality sensor units could provide more information to the citizens about the air quality in higher spatial and temporal resolution. This is established by a two-fold approach: data collection by means of citizen observatories (described later) as well as an initiative which aims to empower people to take action.

In a wider case study conducted in Ljubljana within the CITI-SENSE project, private citizens, organizations as well as schools are invited to participate in air quality monitoring by hosting fixed air quality sensor units or carry portable ones to monitor their immediate vicinity outdoors as well as indoors in the case of schools. The emergence of low-cost air quality sensor units is opening new possibilities for individuals and groups to assess their exposure to air pollutants at specific place and time, as well as to share this information with other citizens. In Ljubljana, one can receive outdoor air quality information from only a few governmental air quality stations, whereas indoor air quality is not even regulated. Even though the city has taken steps to improve the local air quality, the citizens themselves still need to understand what their contribution to the wider issue is, and how they can improve the air quality situation through their actions. Thus, air quality awareness raising is becoming more and more important.

New technological solutions make it possible for the citizens to make the invisible visible by visualizing the personalized air quality data in smartphone applications as well as online. Transforming the data gathered by the low-cost sensor units into information that is useful and easy to understand by the general public is the key in increasing the citizens' awareness of their environment, and enhancing their ability to recognize and change their exposure to air pollution, resulting in better quality of life for all. The

currently available air quality data in Ljubljana is only in form of numbers. This might not be inspirational for some citizens, as numbers can be hard to interpret. Many processes in the project can take a participatory approach. For example the visualization of the air quality data can be made in a collaborative manner, which is connected to the other element of the data when people start sharing their observations, analyse and visualise the data, and at the end, collaboratively form evidence-based decisions. Such collaboration has become more and more common (Isenberg et al., 2011).

This leads us to citizen science. In citizen science, the citizens are given the possibility to collect or even process data as part of a scientific enquiry (Silverton, 2009). Cohn (2008) explains further how collaborations between scientists and volunteers collecting data have the potential to broaden the scope of research and explore new ways of collecting scientific data. In addition, the citizens who take on an active role in data collection as insiders may contribute valuable information about the local community.

When a citizen science project is not merely aiming to produce data, but to identify and find solutions to improve something, this collaboration between scientists and the lay people can become very effective. The ones with a stake in the issues are the best ones to judge the applicability of the suggested measures, and should be included in the collaborative problem solving. Citizen science can be of a type of low citizen engagement, where citizens merely provide data, or highly collaborative where they also participate in defining the problems, designing data collection methods, analysing and interpreting data as well as disseminating the findings (Bonney, et al., 2009).

To understand the broader concept we need to introduce what Innes and Booher (2004) refer to as collaborative participation which should "incorporate not only citizens, but also organized interests, profit-making and non-profit organizations, planners and public administrators in a common framework where all are interacting and influencing another". This type of active participation requires management of stakeholders, continuous collaboration, dialogue and interaction, and subsequently creates a community of active citizens. With this in mind, we can finally introduce the term Citizen observatory.

Citizens' observatories are systems that support and promote community-based environmental governance (Liu, et al., 2014). The network of people from various backgrounds including citizens as well as decision makers will work as an access point to information as well as a platform for contributing to collect, share and discuss about environmental data.

Even though only a handful of people would collaborate in such a community project it can still be expected to function normally, as Nielsen's (2006) theory of 1-9-90 rule explains: in most communities the majority, or 90%, do not contribute, although they might find value on the provided information. The next 9% participate in existing discussions, whereas only 1% initiates and actively participates in creating the content. This will also give us guidance in what level to involve stakeholders, as we need to adapt to their different interests levels towards our project and available resources as well as their level of influence they have over the decisions. It is good to recognise different strategies for different categories of stakeholders. Mendelow (1991) has suggested a matrix, as illustrated in Figure 1, to map these categories as part of stakeholder analysis. In his matrix, he suggests to invest little effort for the stakeholders who have low interest and low level of influence. Although stakeholders can be seen as dynamic, and one day these potential stakeholders might upgrade to a higher level. Similarly, those who have high interest and are able to influence should be given constant attention and be kept informed.
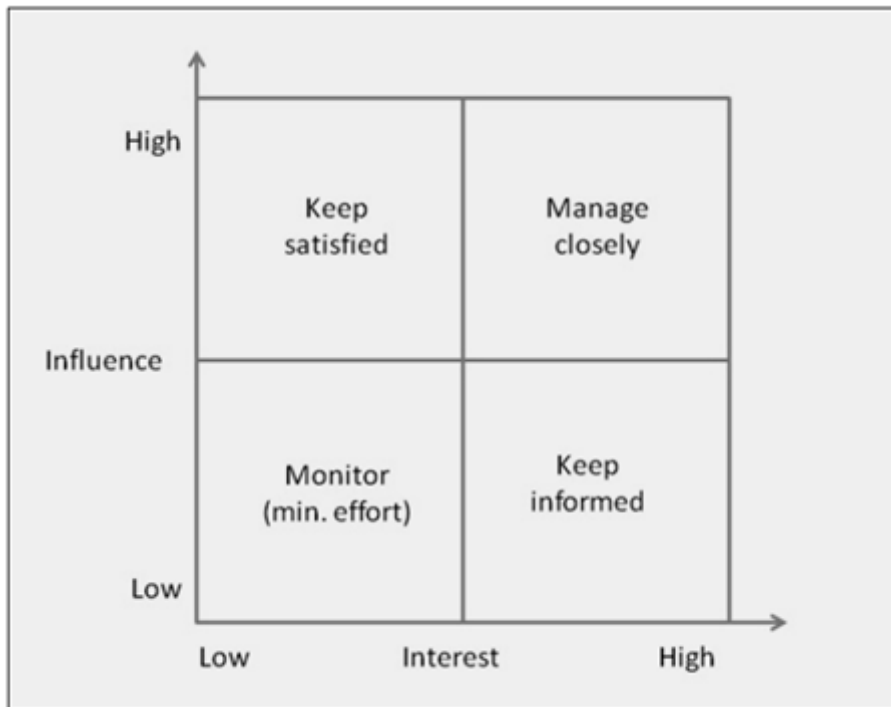
Figure 1: *Grouping of stakeholders according to interest and influence* (Mendelow, 1991).

Citizen science projects are becoming more and more common e.g. Cohn (2008), Silvertown (2009), and Riesch & Potter (2014). The concept of citizen science itself is not new as it has been used for decades e.g. bird watching communities. Citizen science projects vary from observing the nature to gamified online games. General principles on setting up a citizen science project are given below as summarized by Cohn (2008), Silvertown (2009), and Riesch & Potter (2014): (i) the citizen created data needs to be validated, (ii) the data collection procedure must be standardized, well understood and followed by the participants, (iii) there needs to be a purpose for the data collection, (iv) the results of the research need to be disseminated, (v) volunteers should be acknowledged for their participation.

Silverton (2009) summarizes how applying citizen science is still learning by doing, as technology develops so fast, whereas documentation of good practices is lagging behind. This emphasises the importance of this particular work we are conducting at the case study school. First, to learn about our own ways of working, as well as to provide guidelines for other research institutions who want to work with secondary schools. We have been exploring similar questions as many other scientists engaged in these activities. As this project is not merely about producing data, we are not only interested to look for answers to the general questions other scientists are also asking, e.g. what kind of issues arise when shifting the data collection responsibility to the users as stakeholders? Is non-professionally collected data reliable? What kind of instruments can we trust in the hands of citizens? But, as we are also interested in the social processes and practicalities, we might also want to ask how to find a balance of the needs of the scientists and users? What are the costs of shifting the focus from the data collection devices and data quality to the educational potential this project has to offer? We are interested to see how the concept of citizen's observatories evolves naturally, in a secondary school setting, when given the opportunity.

1.3 Notes on Topic Selection Process

To study social processes, it is important to be able to recognize which data is relevant and which not, as is emphasised by Erickson (1986). This intuition to recognize the relevant data was both naturally born in the mind of the author as well as cultured in the EU project through a work package focusing on engagement and empowerment. From early on the author with a Bsc in Environmental engineering took interest in these issues and made efforts to implement the guidance given by the work package in the local case studies in Ljubljana. The high level of various citizen engagement strategies led to the praising of the Ljubljana case study as the shining star by the Technical Advisory Group (TAG) of the project. She actively integrated herself as part of the earlier mentioned work package and took part in their meetings and work activities. This integration between work packages helped her to nurture her capacity building. The main step forward to help other work packages to benefit from this integration was taken during her three month internship in the leading partner institution of the CITI-SENSE project at NILU-Norwegian Institute for Air Research (www.nilu.no) where her main task was to coordinate the input from others as well as to take the lead of the main writing of the deliverable 3.2 *Pilot study evaluation and protocol for phase 2* for the school case studies which in turn was a collaborative project to include the engagement and empowerment perspective of the project to balance with the so far technologically focused project. Her presence in the project improved the communication between work packages given to her triple role in activities of three work packages. The engagement and empowerment aspect was readily integrated in the project with her as the translator between the different scientific fields and subsequent backgrounds of the involved scientist, as well as between science and stakeholders.

Such interdisciplinary bearing liaison officers are needed more and more in research especially on the onset of the new EU calls under Horizon 2020. Inter- and transdisciplinary approaches with respect to complex societal challenges such as environmental issues, are needed both to improve the collaboration between the scientists, as well as to collaborate with the stakeholders (including citizens). This should be done in a well-organized manner based on existing collaborative methodological approaches as well as best practices from already concluded similar projects.

This thesis works both as an example to implement the collaborative point of view into technocracy oriented one-way communicative project. It includes a comprehensive documentation of the activities taking place in the case study school while adapting to the social aspects and practicalities of the collaborative processes which often remain invisible or black boxed in scientific reports, yet often play a very important role in shaping the research process.

Due to technical issues and subsequent delays in the project there was a pressing need to take action to find solutions to continue the work in order to meet the aims. This process is extremely interesting, and worth documenting. Not only does it give insights into the project as a whole, it also helps us understand and improve our ways of work with these new stakeholders. We recognised early on the issues we were facing within the project, the main one not being able to provide sensor units to the schools which we tackled with implementing plan B activities. After realizing the potential of learning from this process, we discovered action research, which provided us the framework to systematically use the existing documentation we had collected throughout the project. Through action research we were able to analyse the processes happening in our case study, which hopefully can inspire others who are struggling with similar issues in future projects. Action research requires innovative approaches but can be risky for the research institution as it is not yet well recognized amongst traditionally conducted university

based research (Anderson & Herr, 2005). Nevertheless, the heart of action research lies on collaboration – the collaboration between the action researcher and the institution under the magnifying glass: by collaborating, we get new insights and knowledge.

In this thesis we first describe what we set up to do, what research methods we used to observe the processes, followed by the activities which actually took place in the case study school, and finally, analysing the activities in order to learn from them. We conclude with recommendations on what needs to be taken into account when working with secondary schools.

1.4   Aims and Hypothesis

Given the originally technocratic nature of the project we might have never ended up using collaborative approach in our case study if the sensor units had been available from the start. The way we worked with participants might have been radically different, us mainly providing help in data interpretation instead of the collaborative activities. The end results would most likely have been about identifying issues in indoor air quality and less on potential solutions and actions individuals can take. Instead of one way communication of air quality information we managed to find other more collaborative and two-way means of awareness raising. Within this thesis we want to understand the shift from the technocratic EU project to a collaborative case study which put into practice the high ambitions of the EU-project.

In order to understand this shift we present the sequence of activities taking place at the case study school. They are described very specifically in order to realize the complexity of the issue and the various actors. The actors themselves playing an active role in the settings instead lead us to study their motivation to participate, which we believe had great impact on the processes. We were motivated to comprehensively analyse the processes at the end of the pilot phase of the project, as the project still continues to a full implementation phase. This analysis can help us improve the way we work with the case study school, and provide a basis for starting to work with new schools later on. We are especially interested in the practical point of view of the processes and want to share them with other scientists working with secondary schools.

The research method used in this study is inductive. Unlike deductive research, which starts with a set of hypotheses, this work is conducted in the spirit of action research, which is inductive in its nature (Blackstone, 2012). However, below are listed preliminary hypotheses. As one can understand, iterative hypothesis will emerge from analysing the qualitative data gathered throughout the project.

Accordingly we developed the following hypotheses which we will use to create a list of recommendations to work with secondary schools:
  – Collaborative approach bears fruit in advanced awareness raising.
  – Participating students have diverse individual motivational factors influencing involvement in extracurricular activities associated with the project.
  – Social pressure plays a role in participants decision to take part (work conducted separately by adapting the theory of planned behaviour).
  – Communication and clear division of roles are key parts in arranging activities in a grammar school.
  – Action research is a useful method to capture and adapt to real life situations.

In the following chapters, we describe the process of recruiting the school and the documentation of the various activities using action research.

2 Methods

2.1 Choosing the Case study School

To justify the chosen research methods; we first need to understand the need for their use. In that light we shortly describe how the case study school and first students were recruited for the study and how we needed to shift what we aimed to study in the first place.

The project aimed at recruiting three schools in each participating city. Most locations used the already established relations to involve schools from previous projects. This was also the case for the selection of a case study school in Ljubljana, which was envisaged to be one primary school. However, due to the lack of technology already during the pilot phase of the project, we were not able to provide the envisaged primary school the promised goods. Around the time when the activities were to start in the case study locations, contacts with a new case study school for Ljubljana was made with Gimnazija Vič grammar school, which is constantly looking for collaboration with institutions acting in science. The age of the students in secondary school was considered more appropriate at this phase of the project, compared to the younger age in primary school. The school was also known for its various merits of its research activities even documented by the popular media e.g. the submarine project Calypso (calypsoproject.com). A teacher from the school told how the school is also committed to sustainability. They have been separating trashes for years, and the leftover food from the cantina for example is sent to homeless shelters. "Our school, even though a grammar school, is more focused on science and technology and sustainable development (especially A and B classes). We constantly need to find activities in these fields for interested students to work on. We have been working with the National Institute of Chemistry and the Faculties of Biotechnology and Electrical engineering for many years, but also with the Jožef Stefan Institute. I like how these scientists know how to adjust to the lay people and simplify the message. These activities put the school subjects in a different perspective. It gives content and examples of real life projects, which are demanding and interdisciplinary, also something which the student will need later in their life."

After an initial discussion, a meeting was arranged together with three representatives from the Jožef Stefan Institute, the teacher from Gimnazija Vič grammar school as well as the head master. An introduction to CITI-SENSE project was given with PowerPoint slides. At the end of the meeting contact persons, both from the school and from the Jožef Stefan Institute, were selected.

Soon after the introductory meeting, students started to get involved. The next chapter discusses how various students were recruited for various activities and campaigns during the pilot phase of the project.

2.2 Recruiting the Students

Throughout the case-study period, both students and teachers were given a chance to participate. The teacher, who took the most active role at the school was the one

recruiting the students and informing the teachers. During an interview at the end of the school year 2014/2015, the teacher explained about her recruitment method: "I introduced the project during my classes and told them that this is a possibility for them to do something, which could have also an international dimension, which works as motivation for some students. Some students like experimental work and research, where others are more into arts or sports for example. Actually only few, at this age, have developed such research minded skills. I appreciate the self-initiative of the students, when they come to tell me what they want to do, e.g. the flood documentation project in Ljubljana, where students were collecting photographs from citizens and mapping the worse flooded places on a map."

"In every class I teach, I offer everyone the possibility to participate. The A class is more science-oriented. I also teach the F class, it being language-oriented, which enables me to adapt my expectations for students, who also sometimes find my teaching method (including encouraging individuals to reason) too different and demanding from what they are used to in Slovenia (where they get instructions to do tasks, rather than thinking by themselves) and are shocked by it in the first year of grammar school. I also have a virtual classroom and encourage students to start their own project portfolio. Students can receive a higher grade if they participate in these projects and prove they have done something besides regular school program."

She continues to explain her selection criteria: "When a student wants to participate in a longer-term project (e.g. when they are planning to participate in international competitions), I test whether they are capable and motivated by giving them a task. After three weeks I will see whether they accomplished something or dropped out. Sort of an entrance test of their commitment."

She also had a plan which classes to target: "The plan was to invite first and second year students to take part in the CITI-SENSE activities, as third was being prepared for the next year's matriculation examination. Some students heard from other students about the project, and wanted to participate (especially the third year ones – who end up participating in the social activities of the project)".

In the 2013/2014 school year, when first activities started to take place at the case study school, a group of technically-oriented first year boys volunteered to participate in the project. We held a presentation to the boys to introduce them to the project and rewarded their early interest with our project T-shirts presented below in Figure 2.

Figure 2: *CITI-SENSE Ljubljana T-shirt.*

To ease the communication with the group, they created an email account, where all of them could be reached at once. Soon after our first meeting, we received and email from the boys telling they had started creating a phone application to visualize the air quality data in Ljubljana (Chapter 3.1.6).

In addition to the boys group, a group of girls from the first year were recruited internally by the teacher, and were going to participate in non-technical activities. We set up a meeting also with the girls to introduce them to the project and started a discussion on possible promotional activities (Chapter 3.1.10 to 3.1.13).

2.3 Case Study

The research described in this thesis was conducted in one grammar school. Case studies are commonly used to study a concept in-depth in specific settings (Boyatzis, 1998). They are usually bound in a particular set of stakeholders, in this case within grammar school settings. To ensure the possibility for emerging theories, as well as to have means to evaluate the project, data is collected in various ways as will be discussed in the following chapters. Qualitative research is considered more relevant than quantitative research, as sampling research in a large scale is not conducted in case studies, since there is already a set of stakeholders who scientists are interested in studying. It is also good to note that the researcher herself is unavoidably part of the dataset, and we need to be aware of the effect of the researchers subjectivity, e.g. the case of double hermeneutics. One of the weaknesses of social sciences compared to natural science is that by analysing humans we introduce additional uncertainty as both the study subjects as well as the scientists are self-interpreting living beings. As scientists try to analyse someone else's views we end up having interpretation of an interpretation, which Giddens (1987) calls double hermeneutics.

We have to understand the limitations of using a case study in our research. The outcomes of this research are very specific, and applicable to our specific circumstances e.g. the Jožef Stefan Institute collaborating with the Gimnazija Vič grammar school, where both of the institutions have their own characteristics and actors. Even though the findings are of particular interest for ourselves, we still hope to draw general conclusions which can be applied for other research institutions working with secondary schools.

2.4 Action Research

Realizing the type of specificity case studies impose led us to action research methods well described by Herr and Anderson (2005), which is commonly used in organizational or even personal development e.g. where the researcher studies her own work practice in order to improve it in terms of personal and professional growth. Action research can lead to better organizational or community empowerment, it creates local knowledge and sometimes the findings can even lead to products. In action research the boundary between the researcher and the participants to be studied is blurred, as the researcher herself is part of the settings. This is also the reason why we describe the process with we-form voice rather than in passive scientific form, us being part of the dataset and to point out the developmental process. In our case study implementing participatory approaches, it is as important to tell who did what, as what was done. This choice of the use of active we-voice is largely discussed in Master (1991).

Action research can be conducted by insiders of institutions, sometimes also outsiders, but it is always a collaborative, reflective process done together with those who have a stake in the process. Action research is especially helpful in settings where improvements of processes are wished to be made, while the changes happen in the settings or in the

researcher themselves. In our case study we apply action research in order to learn from practice how to collaborate with secondary schools in European projects and by learning to improve the ways to act together with them in such occasions as we experienced with emerged problem solving situation e.g. the lack of sensor units in our project. This kind of research is explicitly centred around action e.g. activities at schools. Herr and Anderson (2005) stress that action research itself is not a methodology and it shares some similarities with qualitative, or even quantitative research. The evidence i.e. data collection can be made in several ways. The benefit of action research lies in the fact that the people doing action research, owing to being part of the institution, have inside knowledge of the institution, as well as the processes. Saying this, we also have to acknowledge how site-specific the knowledge gained from this study is going to be. It will help us to improve our ways of working – especially looking towards new projects with the same grammar school, yet we still hope to draw general conclusions on working with secondary schools, which can be transferred beyond our case study.

Herr and Anderson (2005) point out how institutions or communities participating in action research might expect straight forward solutions to problems. The solutions in action research are not that self-evident. It is an ongoing process, where improvements are made throughout the study reflectively. The learning process is iterative. The knowledge creation is a cyclical process, never linear, where we plan, act, observe and adjust our work cycle after cycle. The benefit we get from this is to learn to work with the case study school, while the school benefits on having various extra-curricular activities, with many additional benefits discussed later on this work.

In practice action research is done by critically examining the actions as Herr and Anderson (2005) explain in their guidebook. A good example of this will be given in chapter "*Earth day campaign*". Action research is a never ending puzzle, where the researcher has to re-think her hypothesis every now and then. The researcher faces double burden by testing emerging theories through intervention experiments, where the work is being reflected while conducting it. Action research is a complex and even messy process to use, and it is not that common yet to be known amongst all discipline practitioners, while we should make an effort to make it more known given its variable benefits.

This thesis represents the documentation of the collaborative activities, and introduces a case study not only about the process itself, but as the collaboration being the end product. With this collective knowledge, we can make others aware of the practices. It has been emphasised by Herr and Anderson (2005), how action research theses are an important input for the knowledge base on action research, as quite often, the researcher and practitioners of action research are more keen to do the actual work than to write the reports and publications on them. Researchers that decided to choose the action research over traditional research are commonly described as people who are passionate about their projects; its specifics as settings as well as people involved.

As the researcher will face dilemmas on epistemology, methodology and privacy issues, guidance was given from the EU project's consortium level from the work package dealing with empowerment and engagement. From early on we were guided to reflect on our own work by using the method of plan-act-observe-reflect while paying special attention to iterative and two-way learning between the participants. In addition, we were advised to keep track of our progress during all phases. Further the semi-structured, but flexible approach helped us to continuously evaluate and monitor both the processes and the outcomes. As the knowledge creation can be made in several ways, we chose to use methods described in the following chapters to accomplish the action research work conducted.

2.5 Participatory Approach

The approach we took in engaging with the school was highly bottom-up. There were certain elements of needed top-down management e.g. when we introduce the project to the school and tell what we expect from them. But deciding which activities will take place, and how, was left for the school to decide. In traditional top-down strategy, the researchers formulate a vision whereas in the bottom-up approach, the participants develop and try out new approaches to meet the challenges as they see them without necessarily having a vision. (Linhart & Papp, 2010) The original plan of the project was vision led, and we told the school what the expected outcomes of the project were. But given the new circumstances, when those aims were unable to be met any longer, we quickly realized we needed to adapt the aims and objectives to what the school wanted to do and what resources they had. The constant adaptation was also iterative, and no concrete aims were ever pre-set as we acknowledged the dynamic nature of the project.

As the participants had high impact on the course of the project, we also adopted participatory evaluation to gain their feedback on the conducted activities and how they were done. We were already observing the flow of the processes, and documenting it along the way. Apart from the participatory evaluation, we also have our own records of meeting minutes, email discussion and notes from daily note keeping. Having both their views and ours contributed to the knowledge of the big picture. As Jackson and Kassam (1998) emphasize, having both the insiders and outsiders views can be very beneficial, as every perception has its limitations. Outsiders' perception on issues might be limited due to their lack of knowledge and acquaintance with local realities whereas the insiders (the school) views might be limited due to their particularity. We integrated ourselves to be part of the team having both roles of insiders and outsiders. The empirical evidences collected through observation and records further led to the adaptation of the approaches used at the school once we learned how the school worked. This on the other hand helped us to also get more empirical data on methods which work better than others.

As this type of research is not conducted in a laboratory under controlled environment, but describes real life situation of a project taking place in a grammar school, we needed to adapt our method to collect meaningful data throughout the project. As Lewin (1946), one of the original action research theory developers, puts it: "The knowledge is created from real life problem solving situation". Followed by guidance from Zukoski & Luluquisen (2002) on conducting participatory evaluation led us to identify who are the key stakeholders to gain feedback on the process. We identified representatives from all groups and decided about the approach on how to gain their feedback.

We opted to interview the teachers through semi-structured interviews. The in-depth interviews had the advantage of getting more qualified view on the fundamental aspects of the project, focusing on the participatory processes, practicalities and revealing some of the activities which were not reported back to us for one reason or another. Semi structured questions were prepared beforehand, and printed out with extra space for recording the answers in the flow, while keywords were bolded to guarantee fluent discussion. These in-depth interviews had the power to deepen qualitative aspects concerning the evaluation of the project as well as to bring insights. In addition, the interview questions were adapted after some insights were gained from the first person interviewed. This also helped us to ask students specific questions, to confirm our assumptions e.g. whether they saw space for improvements in communication as we did. To gather the views of the participating students, we originally also wanted to interview them in person. However, we recognised the practical limitations of this approach, the biggest one being a possible language barrier, the author not being a native Slovene speaker, and the lack of time as we were getting closer to the summer holiday season. The

decision was not solely made by us. We consulted both the teachers and students to ask which way they preferred. The students found the same arguments as us, while also pointing out that their answers might not be the same if the interview was done in the form of a focus group discussion, as they might be influenced by their peers. The feedback from the students was conceptualized with an online reflection questionnaire written in English and which was first circulated among a volunteer grammar schooler to test the understandability of the questionnaire, which was afterwards modified to its final version.

The student reflection questionnaires were conducted as inductive research, which helped make sense of previously collected data and supplement it with new relevant data. This qualitative dataset further led us to find patterns. This is also along the lines of action research, where the theory emerges from practice. In addition to the participatory evaluation, we wanted to make preliminary hypothesis for further research amongst secondary school students' participation on extracurricular activity through the theory of planned behaviour (see Ajzen, 1991). This was conducted in a form of an online survey sent to the participating grammar school students attached at the end of the reflection questionnaire, while some of the questions were integrated to the reflection questionnaire. Through this preliminary work we were able for example to identify the actors whose opinion matters to these young people when they make a decision to participate or not. This deductive method was also complementary, as we gained insights on the intention of the students to participate during the following school year based on their experience from this year, also indirectly giving feedback on their thoughts about that year's processes. This was done using a 7 point Likert scale.

Thematic analysis of the questionnaire and interviews was conducted to identify patterns of the inductive subjective database. By thematically analysing the data we could encode the qualitative data. Boyatzis (1998) enlightens that the codes emerge from words or sentences which may be themes, indicators of some kind relevant for the theory or study in hand. This thematic analysis can also be grouped with the assertions described by Erickson (1986). He explains his research methods, especially the *analytic induction approach*, applied also in this work, how the process of data analysing is a never ending evolving process. When going through the data, assertions are written down immediately after observation. The assertion is revised when/if disconfirming evidence is found from the data. At the heart of this method lays the concept of data collection and data analysis not being independent and sequential, but instead both are subject to modification as the researcher gains knowledge on the context.

Thematic data analysing can easily get complex. The categorizing was rather simple in our dataset, as the participants reflected very similar, or easy to understand views. We can simply make sense of data through direct interpretation of the individual instances recorded throughout the case study. The meaning of the data, even when interpreted directly, gets more meaningful when the same thought comes repeatedly into prominence and further conclusions can be made accordingly. Similarly, even one instance can act as an indicator of significant meaning. As we will later learn the example from the questionnaire when one girl answered how she is part of the project, we realized we have accomplished our goal to make them feel that way.

When making observations throughout the case study an intuitive approach (as described by Erickson, 1986) was adapted. When dealing with long term participant observation it is best to start with no prior conceptual expectations, which might limit the researcher's openness to the uniqueness of the project at hand, which might consequently also lead to different conclusions regarding observed patterns (e.g. the codes in data analysing by thematic analysis).

2.6 Measuring the Pre-Knowledge

In order to know whether the project had an impact on the students' knowledge, the school was given a one page translated questionnaire from US EPA Teachers Guide to Indoor Air Quality (n.d). Paper copies were given to be filled by the teachers, whereas a Google form document of the same questionnaire was prepared for online distribution to capture larger data sets from the students.

The questionnaire was given to the school, and they were gently reminded several times to fill it in. Despite the efforts, no answer was ever received. Due to the lack of this information, which we were still interested to have, we took another approach by observing and letting the students self-evaluate their gained knowledge.

2.7 Privacy

Due to the sensitivity of some information provided by some of the participants, the participants' names are kept anonymous throughout the thesis. However, as the project is publically promoting co-operation with the school, it would be absurd trying to avoid mentioning the school's name.

In the case of described research assignments, also no names are mentioned. We came to this decision in order not to connect the participants with any views described in the reflection questionnaire. The students have gained public recognition in their accomplishments, but it is unnecessary to connect them to the other processes which took place in the school, where they have expressed their views, and can be easily recognised. Even though all the names are traceable by knowing the school name, we do not want to intentionally expose the individuals' identity in our work. This becomes especially relevant when we have a small sample size of students replying on the reflection questionnaire. To facilitate fluent text, we decided to call some groups of active participants with certain nouns. E.g. boys who developed a phone application are collectively called boys (as there were no other active group of boys). If some other boys are mentioned it is explained so in the text. The most active teacher, whose identity we also want to protect, is simply called the teacher, or the most active teacher, depending on the content. Whereas a trainee who was very active and who we also interviewed is also simply called the trainee. When talking about the opinions and views of both the teacher and the trainee they are collectively called the teachers.

Sometimes when collective feedback on an issue was reported, and everyone from the school e.g. students, trainee and the teacher, gave similar answers, we decided to use the word "school", knowing it is not grammatically correct to have views of an entire institution, as it is not a person.

The interviews as well as the reflection questionnaire answers are not attached to this thesis, as some content might reveal the identity of the participants. All of their answers have been integrated in the text itself to work as a fluent description of processes which took place in the case study school.

The researchers who were running the case study in the grammar school instead are commonly present in the text as active we-form, in practice comprising of the author and her colleague from the JSI.

3 Results and Discussion

As the results are rather a description of the conduct of the project, we decided to group the discussion section in this chapter together with the results. This enabled us to bring up the activities at schools as well as to discuss how they went. We have divided this into two main chapters; "activities at school" and "evaluation of the case study process: crucial factors and actors". In the first chapter we will describe the activities and discuss how we, as well as the students, experienced them, whereas in the following chapter we will analyse what might have affected the success more in depth. The first chapter describes two types of activities; technically oriented as well as socially oriented. We do not draw a clear line between them, as both types of activities interacted with and complemented each other.

3.1 Activities at School

From early on the project took a different turn as the students showed interest in outdoor air quality issues instead of indoor ones. This suited us, as we were able to provide them means to get familiar with the outdoor air quality issues, given that we were running two case studies in Ljubljana within the European project (1) urban air quality outdoors and (2) indoor air quality in schools. Four activities taking place at the case study school relating to outdoor air quality are worth mentioning here: (i) the development of a phone application displaying outdoor air quality from various different sensor units, (ii) outdoor posters to inform the citizens about air quality issues, (iii) informative event on the streets of Ljubljana where citizens were engaged to know more about air quality issues in the city, and (iv) students learning to use portable air quality units.

It was described earlier how some of the students were recruited. During the first year of activities at the case study school a handful of students were involved. Once the second school year started, a new group of people from the first year were recruited. A class of first year grammar school students were given a talk of ideas on what could be done at their school. During the class, tasks were divided between students. Small groups of 2-3 were formed, and individual groups volunteered to take the lead on specific issues discussed. Out of the whole class, four girls stood out as being most engaged, and took active roles in more air quality promotion related activities described in the following chapters.

The circumstances leading to the collaborative approach beyond regular school activities used in the case study produced a wide variety of activities. We shifted from data collection approach to empowerment approach, where students turned into collaborators instead of delivering data or passively receiving information. The process had built capacity, raised awareness and brought up new roles. By creating new collaborative activities the traditional roles between teachers and students, as well as scientists, have gone through changes. The students were taken in as partners and given responsibility and freedom to decide. The image of the school itself as a high-quality educational institution has strengthened. The success of the students in international competitions, and the resulting media attention, connections with the municipality and the visibility of school activities at the neighbourhood level e.g. outdoor posters have helped

to create a positive buzz.

The different activities progressed and developed at a different pace, most of them being linked together in one way or another, supplementing each other. Even though the activities are not sequential linear processes, but rather iterative, reoccurring and constant learning processes, Figure 3 gives an attempt to illustrate the timeline of most of the activities. Some important milestones are marked separately.
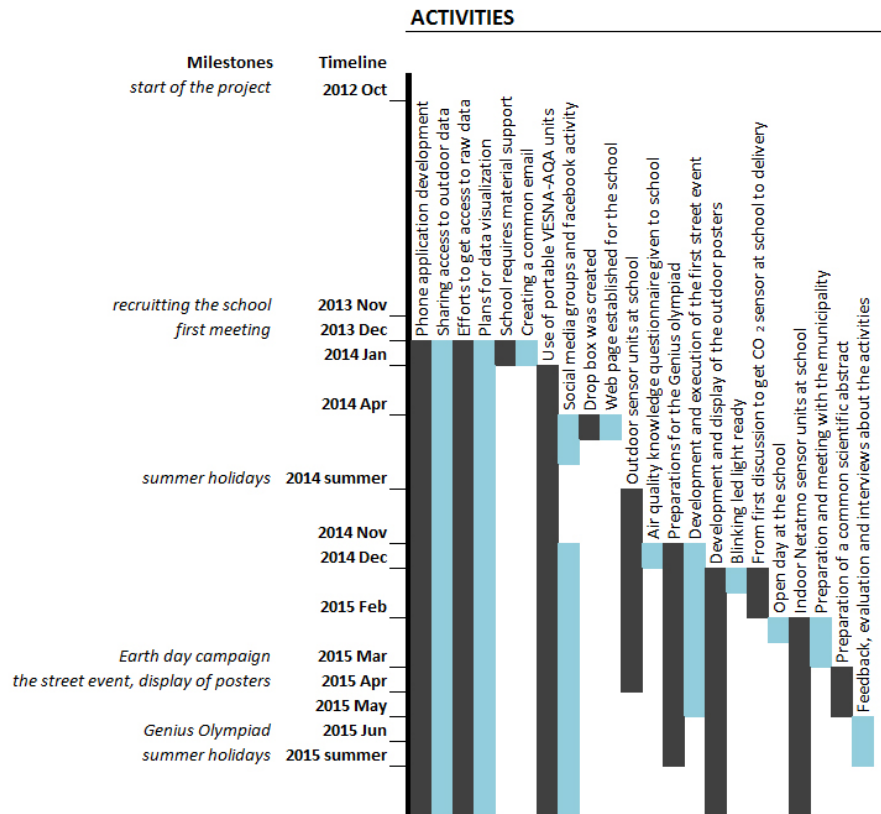

Figure 3: *Timeline of the activities in Gimnazija Vič grammar school.*

In order to systematically receive feedback on the activities, a reflection questionnaire was prepared for the students and interviews took place with teachers. The questionnaire was distributed amongst the most active 22 students. The response rate was 31%. Even though only 7 students answered, the variety of respondents was representative considering the types of activities which the respondents took part in. This gave us enough insights of different views and similar to the reflection questionnaire, had it been conducted amongst a small number of students in a focus group.

3.1.1 Shifts in sensor unit providers

In order to understand the type of activities taking place at the case study school, we need to paint the frame of how they came about. Throughout the first school year the expectations towards receiving indoor sensor units in that school year were lowered. The school never saw indoor sensor units in their first year of participation. To complement the lack of indoor sensor units and to meet the expectations of students eager to get their hands on data, three outdoor sensor units from the same EU project were installed at the school premises. Three different micro locations were selected together with the school; (i) arterial road leading to the city centre (ii) rail road tracks (iii) backyard. The boys

interested in data processing were informed and given access to the data. However they showed no interest in analysing the difference between the three micro locations, but wished to have access to raw data in order to push it to a phone application they had developed, which is further discussed in Chapter 3.1.6.

After the summer, the preliminary indoor sensor unit provider had dropped out of the EU project and a new sensor unit provider was brought in. New types of sensor units were promised to be delivered by October 2014. Unfortunately, the process of bringing a new partner in the project and securing financial agreements delayed this delivery schedule and the start of the main project phase at the case study school. The delay was partially caused by a major order of 10 000 air quality units for the city of London using the same Alphasense electrochemical gas sensors as the new indoor air quality sensor unit provider would have used in their sensor units. Once the sensor units had been assembled, they still needed to go through a testing period, followed by problems with dataflow establishments, resulting also in no sensor units in the second school year 2014/2015 from the CITI-SENSE project. To solve this problem, a decision was made within the EU project level that commercially available off-the-shelf sensor units can be bought for engagement purposes to be used at the schools. Two sensor unit producers were considered to have the desired functionalities within the expected budget. These were IC-meter (http://www.ic-meter.com) and Netatmo (https://www.netatmo.com). The latter one was used in the case study school, as there is already a wide community of Netatmo users in Slovenia. The Netatmo unit has been used in scientific studies for example to estimate the binary occupancy patterns in rooms, in which Wörner et al. (2014) evaluated with machine learning tools that Carbon dioxide (CO_2) measurements qualify for occupancy estimation with 75% accuracy which could be used to optimize for example heating of specific rooms. So far these kinds of approaches still need to be developed further, and the models trained with ground truth occupation information, but eventually such solutions can create smart homes, or even smart schools.

3.1.2 Air quality knowledge

At the beginning of the activities at the case study school, the students and teachers pre-knowledge on air quality issues was envisaged to be tested. We wanted to do this in order to measure whether our project had impact on this, as one of the original goals of the project was to increase the knowledge about air quality issues. However, the school never returned a single answer to the distributed pre-test. When asked for possible reasons for not providing any responses, the school indicated possible explanations to this. The reason given by the school varied from having trouble organising time and space in a computer room, to personnel changes. They did not see it reasonable to simply distribute such questionnaire amongst students and teachers, but recognised the need for an introduction lecture, which they did not manage to arrange due to the above-mentioned reasons. On the other hand, the questionnaire was also freely available online (also on the project website) and it was sent a few times via email to the responsible contact person at the school, as well as distributed as a paper version. As the time passed, and we still had not received anything, we asked again. This time the response was simply: "We do not like questionnaires here at the school."

As we were interested in having this information, we changed our approach, and found other ways to get answers to these questions. Instead of trying to test their knowledge in topical issues, we observed discussions in various occasions and, at the end of the school year, learned what they reported in self-reflected evaluation of their increased knowledge. We included this question to the reflection questionnaire sent to the students. Their answers were as follows (Figure 4):

Please evaluate how much has this project improved your understanding of air quality issues?
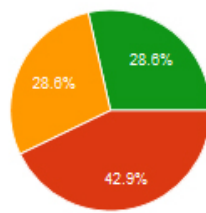
Extremely	0	0%
Very	3	42.9%
Moderately	2	28.6%
Slightly	2	28.6%
Not at all	0	0%
I don't know	0	0%

Figure 4: *Student answers on self-evaluation of their understanding of air quality issues.*

Some students explained later in a different question about whether they have changed their behaviour due to this project that they have not, since they are already behaving in an environmentally friendly way. For the same reason, we might consider the legitimacy of these responses and ask why some of the answers are not that highly ranked as could be expected. This might be simply because people already knew much, and that is why they chose, for example, the option "slightly". Such question should be rather asked face to face which encourages a discussion, and can reveal the real reason for the answers. We gained some insights of the learning process from the four active girls after the meeting with the municipality (Chapter 3.1.11) on our way to a bus stop. The students described how they have learned a lot during the past months by absorbing the information in readily digestible amounts. In the meeting they were able to explain with confidence, and having the facts straight, about the specific air pollutants. They seemed to be proud of their achievements.

We asked the active teachers a similar question. The trainee told that his attitude is almost the same as before as he is, as a geographer, already very well aware of these issues. In terms of behaviour he noticed how he has started to pay more attention to which commuting path to take. Now he avoids heavy traffic sites.

The most active teacher reported how she has been integrating the air quality issues to her teaching throughout the school year, so that the students can get familiar with the topic. Similarly the trainee was appraising how that teacher has a way to awaken the student's curiosity and how at some lectures the students might realize that they have heard about a specific topic already, and can now understand it from a practical point of view. Similarly the teacher pointed out how especially first year students, to whom chemistry can be really abstract, this projects makes them realize how chemistry is not that complicated after all and overcome their fear of the topic.

The various benefits of participation from a student's point of view are further discussed in Chapter 3.2.1, where some of the answers highly relate to the knowledge they receive. Here we point out instead the broader benefit which the participation brings to the students, as was reported by the mentoring teachers.

Participation in the project and in the lectures where the topic is discussed will start the unconscious research minded thinking process. The teacher emphasized how the project gives the students the opportunity to do research: they will learn how to define a problem and start solving it. This involves choosing the experimental methods, carrying out the research and at the end present their work. The real benefit is seen in the learning process and how the knowledge is transferable to life. The teacher always finds broader social background in projects she brings, manages and integrates at the school, linking the meaning of science to everyday life. The teachers are able to shift the minds of students towards more environmentally friendly behaviour with these projects. The students also get to practice group work, and when done together with teachers, feel as equal partners.

Even though in many situations teachers are supervising them, it is done in a subtle way.

3.1.3 Actual AQ measurements

The original plan in the EU project was to provide each school with three indoor sensor units and one outdoor sensor unit to monitor the indoor air quality and find collaborative solutions for improving the indoor air quality at schools. However, as described earlier, we did not receive the project sensor units in time, which greatly affected the activities which were foreseen to take place at the case study schools in various European cities. The different case study schools adapted to the situation in best manageable way. After struggling with the delivery of planned sensor units, a decision was made in the EU project level to provide the schools with already commercially available off-the-shelf sensor units in order to start the foreseen activities rather than postponing them for another year.

In Ljubljana, a low-cost sensor unit package called Netatmo was bought for the case study school. The package included two indoor air quality sensor units measuring CO_2, temperature, humidity, air pressure and sound, whereas the outdoor sensor unit was measuring air temperature and humidity. The package was delivered to the school, giving them the freedom to plan further activities with the sensor units. Preliminary concrete plans of using them in specific classrooms as well as research questions were already discussed in various meetings with the school during the previous school year.

Before the decision to provide indoor sensor units was made, efforts were made to provide the school sensor units of any kind. When the lack of the sensor units was first realized, the school was offered to host three outdoor air quality units Geotech AQMesh used in the wider Ljubljana case study. The units were placed in three different locations around the school. The locations were suggested by the school, and they were given access to the data.

In the early months of co-operation with the school an outdoor portable air quality unit called VESNA-AQA was introduced to the school as one way of coping with the lack of promised instruments. The teacher did not see the relevance of the instrument to be used indoors, as it was lacking the CO_2 sensor, although it provided great comfort for the technically oriented boys to get access to raw data straight away. The boys were given a few units for long term use. Later on the school saw value to use the outdoor portable instruments in another activity at the school discussed in the following chapter. The school showed interest to have a methane sensor, as they are conducting experiments with algae, and are interested in measuring the gases produced as well as the breathing activity. So far we do not have the means to answer this need. In the meantime, a new version of VESNA based unit was developed named VESNA-PAQ. Even though it provides good technical means for the boys to access the data, it includes some non-relevant sensors for schools, such as H_2S, to which the school does not find any use. Figure 5 presents all the different types of sensor units used at the school so far.

Figure 5: *Sensor units used at the case study school.*

It was constantly emphasized, from the school side, how CO_2 is the most important parameter to measure in the classrooms. Finally, on February 2015, the school was lent a CO_2 instrument TSI IAQ-Calc 7545, which was available at the institute. Two boys from the first year conducted a research assignment named Temperatura in CO_2 v prostorih Gimnazije Vič // Temperature and CO_2 in classrooms of Gimnazija Vič grammar school. The structure of the assignment is given below in Figure 6.

Figure 6: *The structure of a first year student's research assignment to measure CO_2 in a classroom.*

Boys from the second year, who already had technical experience with measuring air quality, had helped these two other boys on performing the measurements. In addition to the above mentioned research assignment, the CO_2 sensor unit was used to perform a calibration exercise together with the recently bought Netatmo unit. The project enabled the students to learn not just about air quality, but also about measuring techniques, data gathering and data processing, introducing them to the science of metrology through practical experiences.

3.1.4 The Earth day campaign

On the 2015 Earth Day, the school planned to organize environmentally-oriented activities. Two classes of second year students were organized to learn using the portable air quality units during the school hours. We were informed about their plans, and how the boys, who had already been working with the units, were to hold a tutorial for the rest of the class. We were invited to join the session, and replied how we can come to observe this activity as well as to document it by photographing. They urged us to deliver as many units as possible a week before. We expected that the ten instruments we delivered to the school would be prepared for the new users by the Earth Day campaign.

However, when we arrived to this session, no pre-preparation had taken place. Some of the instruments were not charged, had not been labelled nor was there a prepared tutorial. The class started with an introduction about what the units are used for, and how the students will learn to use them in order to make further investigations later on outside of school hours. As there was no ready-made presentation how to use the devices, the class started to systematically write down steps on the blackboard – a co-design protocol lead by one teacher. As we were there to observe, we only interfered when we noticed they had forgotten an important step i.e. to set up a server address for sending the data. We also circulated in the class to help out groups of students who did not succeed to connect sensor units to their smartphones. We were not there to lead this activity, as it was part of their own initiative, and tried to interfere only when really necessary. It was a great opportunity for us to see how the school works in this kind of situation. On the other hand, there are lots of lessons to be learned from the importance of communication, expectations, pre-preparation and the outcome of this activity.

Our expectations from the session were based on what was told to us: Second year students and three teachers will learn to use the devices in a session organized by the boys who were already familiar with the device. The units were explicitly asked to be delivered to the school a week before, during which time we expected, they will charge the units, label them and the teachers will get familiar with them in order to help during the session. Unfortunately, due to unforeseen private circumstances one of the principal researchers was not able to take part in the pre-preparations, which had a big effect on the rest of the event. We learned later the reason why the boys had not prepared the session. They were expecting the newer versions of the VESNA-PAQ unit (at the time only one prototype existed) resulting that no-one had touched the bag where the sensor units were delivered during the week the sensor units were at the school. The boys responsible for the session arrangements showed us their gratitude for our presence at the class and help we were giving throughout the session.

A short co-designed protocol how to use the units was drafted during the session. During a break, one girl wrote down the protocol from the blackboard to paper, which was copied for everyone in both classes, shortening the time it took for the next class to figure out the steps. Figure 7 shows the printed protocol and the VESNA-AQA units. We think that this emerging co-designed protocol was a good response to the rather chaotic session providing user view on the most relevant steps similar to a user manual, which is

otherwise 18 pages long.

Figure 7: *Protocol for using VESNA-AQA.*

At the end of the session a discussion was held about what kind of research can be made with the units, where each group got to speak out their ideas. At the time many of the ideas were very similar, so after the session, students were informed in an extensive email describing the capabilities of the device as well as some additional ideas for research. Some common technical problems which some students seemed to have had during the session were pointed out, which later on led to an online FAQ type of page, where the students could report or choose from a list of technical problems they had encountered, as Figure 8 summarizes. Possible solutions were also provided. The following chapter discusses this further.

Figure 8: *Commonly occurring issues with VESNA-AQA portable air quality unit.*

Since the beginning, the decision of the school to involve entire classes was of our concern as the students did not have an option to decide whether to participate or not. Both of the classes were ordered to participate, which was against our principles which we had set in our case study and was also not in favour of the students. This was an example of a top-down approach rather than co-designed where each individual has a say. This issue was also highlighted in the students' answers in the reflection questionnaire.

After a few weeks the teachers sent a list of conducted research assignments and the student PowerPoint presentations. Compared to the amount of participating students

(around 40), the list was not long, as most of the students had technical problems they were not able to overcome and because the students decided to work in groups instead of working individually. The following research assignments were conducted:

- Air quality in occupied and non-occupied room,
- Measuring with the VESNA-AQA instrument,
- Changes in air quality parameter concentrations of CO, NO_2 and O_3 by opening a window,
- Comparison of air quality at home and at the seaside,
- The chemistry of the air,
- NETATMO - measurements in a room with open and closed windows.

After reading the students research assignments and talking with the teacher, we realised that the students had naively expected they can set up a hypothesis, they were not motivated, and they had several technical problems. That is why for example one of the groups decided to work with the easily used indoor sensor units instead. Only two groups critically considered the capabilities of the units "Measuring with the VESNA-AQA instrument" and "The chemistry of the air".

3.1.5 Feedback on technical problems with the portable VESNA-AQA air quality unit

The 2a and 2b classes got ten VESNA-AQA units to take home for two weeks during the 2014/2015 school year, one week for each class. During that period the developers of the units, being part of the CITI-SENSE project requested us to collect feedback for the units in order to develop the product further. We created an online google form to gather this information. https://docs.google.com/forms/d/1jAdMUoRlT38A0jEp0OqjKyP4ECjrcVK3_ocg0LAv9Vk/viewform. The students were asked to report which phone they are using, what version of Android operating system they had, what version of the phone application they were using and what problems they experienced during the measuring period. A list of frequently occurring problems was provided as well as a space to write down any new problems. At the end of the form solutions for the frequently occurring problems were provided. Students could also write any other feedback on the product.

Since the students were working in groups, only seven entries of different phone types were registered. Many more might have used it as a help for identifying and overcoming technical problems. Due to technical problems, six units were returned after students claimed they did not work. In reality two of them needed to have rechargeable batteries replaced and the other ones were just not used correctly. Even though the students were given the user manual and the tutorial during the classes, many of them did not know in what switch position the unit is turned on. Our recommendation to the developers was to urgently consider this issue when units are being maintained or updated and suggested to add a simple green sticker on the ON-side.

3.1.6 Phone application to visualize outdoor air quality

During the first year of activities at the case study school a group of first year boys were recruited to participate in the project. After only a few weeks since the preliminary contact, the boys approached us with a phone application they had developed to display outdoor air quality data. Their project was not short lived. They developed the app further to be more advanced during the course of the next school year as well, and they have real

plans on developing it even further in the forthcoming years.

Unfortunately CITI-SENSE was unable to provide the boys data access for the first two years of the project at the case study school. The CITI-SENSE sensor units for monitoring outdoor air quality had a data transfer through a subcontracted third party server, where it was not possible to obtain freely accessible dataflow without logging in to their online system. The boys were given access to view and download the data from the sensor units, but data flow was never possible to establish.

The second attempt was tried with portable air quality units. JSI had developed portable VESNA based air quality units for CITI-SENSE project. The developers were in close contact with the boys to help them establish the dataflow. The next generation VESNA-PAQ was more suitable for this purpose, as it has low energy Bluetooth connection, which does not interfere with the Wi-Fi as the first one does.

In a later phase of the project, the data flow should be possible through the CITI-SENSE WFS server, where all raw data from various sensor units should go through before they are visualised. We forwarded the request from the boys to have the data in JSON format. The phone app itself was developed to fill the missing gap of data to the citizens. The boys recognized how there is a lack of easily understandable data for the average citizen, thus they designed a concept for an app for simplified air pollution visualization. The app displays pollution heat maps as well as provides a solution for displaying measurements from portable stations according to their location. It is designed to easily adapt to any source of data, so it can be used with a wide range of different stations. They envisage the popularity of low-cost sensor platforms, which could be added to their cloud server. It works as a centralized open source platform for mobile phones/tablets and PCs aimed for the average citizen. The air quality parameters are visualized by effective colour schemes displayed as layers over Google maps. Application will also provide interpretations of the measurements in accordance to the air quality index (AQI).

When reading through their research report on the phone application, we noticed how they have high expectations of the quality of the data: they want to produce highly accurate maps, which is not possible with the currently used air quality sensors. They later wrote more realistically how: "Server will predict the transitions between the sensor units on the map using spline interpolation, therefore creating the overlay image. Map accuracy depends on the density of measuring stations". They are also ambitious with societal benefits: "With this application, we want to minimize harmful effects of pollution on our health by raising public awareness". They explain further, how this public awareness raising is integrated in the phone app: "Every time the pollution level exceeds safe limits, app notifies the user and shows guidelines how to minimize harmful effects. Notification is triggered by our server using Google Messaging API." In addition they will give news and articles on air quality, where the articles will be collected from different scientific and professional sources as well as newspapers and magazines. They consider the different types of end users by, for example, also planning to have an iOS in addition to the current Android version. They have also created a simple way to download measurements of an individual unit in JSON or XML format for more advanced users. Those who are really interested can also opt in for email or SMS alerts about air pollution at chosen locations. And finally, they also describe what we are calling in the EU project the Citizens' observatory by enabling the users who will own air quality stations (compatible with their phone app) the possibility to choose, if they want, to share their measurements with other users, which will also help in forming a better community.

Although the project was unable to support this advanced phone application by providing data, and to have it actually running, the boys are already thinking of other solutions to gain data. At the end of the second school year, they participated in Genius

Olympiad high school competition (described further in the following chapter) where they were also establishing future contacts. They already met a person from MIT who is developing sensors and who is eager to work with them. They also have plans beyond the CITI-SENSE project, and wanted to know whether they have any restrictions regarding the phone app, or are they allowed to develop it further under other projects. They also already talked about setting up a start-up company. They shared some of their ideas for future work with us. They also already recognised how they would like to be part of the problem solving of underdeveloped and fast developing countries with serious air quality problems, which also comes with adapting the application to the local circumstances. The latest version (as of June 2015) of the phone app can be observed in Figure 9.
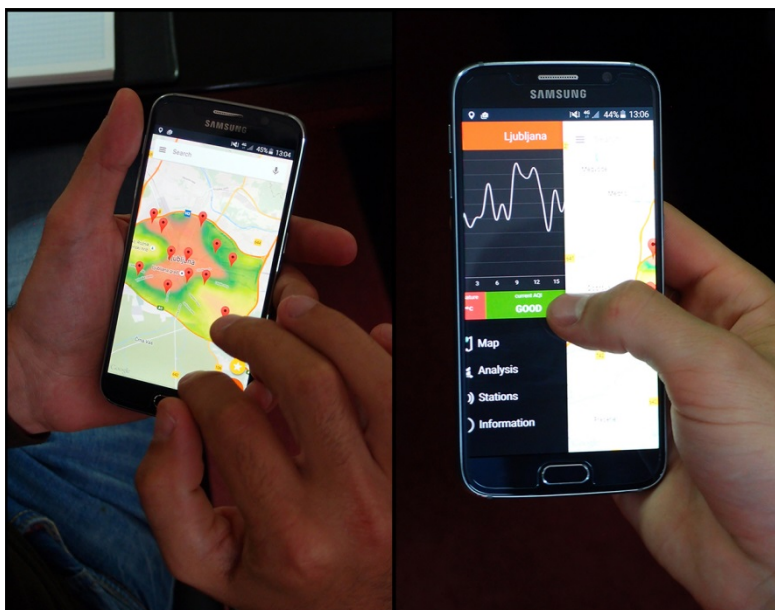

Figure 9: *Phone application developed by boys from the case study school.*

The boys' professional capabilities have been remarkable. An interviewed teacher enlightens how many of the students who come to study at that school are really skilled in Information and Communication Technology (ICT). How the school tries to adjust to this is by finding projects for those students where they will get a lot of data to play with. The boys have done most of the work by themselves developing the phone application. At the beginning they were given instructions from their ICT teacher, and later on also from JSI Department of Communication Systems.

3.1.7 National and international student competitions

The students from the technical group attended both national and international student competitions. In Slovenia, they attended the 28th Annual meeting of young researchers, presenting their work. Later in the same year they attended the international high school competition, Genius Olympiad at the State University of New York, USA.

The case study school was announced the second most successful school among those opting to prepare for and attend the Genius Olympiad competition. Seven students from the case study school participated in the competitions and reached the finals. They were working on four projects, one of them being the previously described phone app. Altogether there were 1197 submitted projects from all around the world. The students from the case study school received a grand award, gold, bronze and two silver medals. We were told how the judges especially appreciated projects which have commercial

value. The teacher told us how the success of Slovenians is already well known, and it was noted during the competition how in Slovenia, there seems to be a better connection of external mentors who are prepared to work with young people. Whereas in USA, for example, support is rarely offered outside the family.

In addition to the phone app, one student had made a short film with CITI-SENSE acknowledgement, describing the importance of environmental awareness. The video is called Diary of the future and available on YouTube: https://www.youtube.com/watch?v=NUdw7bYN69w.

After receiving the award, the school's achievements got the attention of the media. A press conference was arranged on 24 June 2015, which resulted in multiple local and national news outlets to report about their success. The list of media mentions is given below. We met with the winning team the day before to discuss about their experiences. Earlier that day, a boy who had developed the phone app, was invited to a ceremony in his honour by Toni Dragar, the mayor of the neighbouring municipality of Domžale. The co-mentor of the research project from the institute was also invited.

- http://www.delo.si/novice/okolje/viski-dijaki-dejavno-prispevajo-k-trajnostni-rasti.html
- http://4d.rtvslo.si/arhiv/prispevki-in-izjave-odmevi/174343342
- http://www.planet.si/novice/slovenija/slovenski-dijaki-izjemno-uspesni-na-mednarodni-olimpijadi-genius-2015.html
- http://www.startaj.si/8824223/Vi%C5%A1ki-gimnazijci-z-olimpijade-v-ZDA-domov-pri%C5%A1li-kot-drugi-najbolj%C5%A1i-na-svetu
- https://www.sta.si/2149635/viski-gimnazijci-v-svetovnem-vrhu-na-letosnji-olimpijadi-genius
- http://www.domzale.si/s1a6019/medijsko-sredisce/izjemna-dosezka-jureta-miklavcica-in-vida-klopcica-na-mednarodni-srednjesolski-olimpijadi-genijev-v-zda.html

3.1.8 Visualizing the AQ data

In addition to the previously described phone application, the boys from the technical group had other ideas on visualising the indoor air quality data. One was to make a blinking LED light attached to the sensor units to show the air quality in a classroom. The technical execution was made with the help of Raspberry Pi, as documented in Figure 10 below. However, the project has not yet (to date) provided such sensor units to schools, with which the students could have access to the raw data to visualize the air quality in the classroom. This installation was supposed to help make such decision as for example when to decide when to open a window in a classroom.
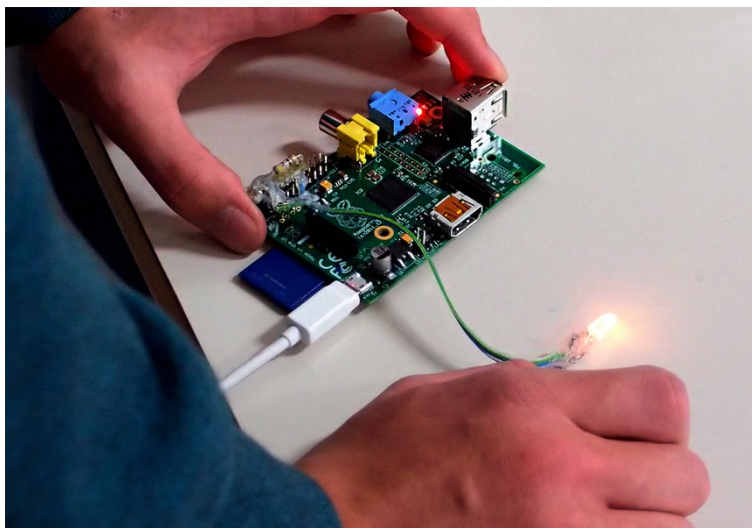
Figure 10: *A blinking LED light attached to a Raspberry Pi.*

3.1.9 Web portal

Each CITI-SENSE school was envisaged to have their own CITI-SENSE domain web portal. Originally the web portal was supposed to be a copy of the main CITI-SENSE school portal and translated to a local language. However, when the web page was created for the school it was not made as a copy of the main portal, but as an empty template. This might have been because the main portal was never developed far enough to work as a portal to be copied. In the end the case study school was left with an empty template to work on, without content or pre-set design. Later we learned to see the benefits and restrictions of this situation and turned it into our advantage.

The case study school was originally given editorial rights to edit the web page. As guided by the EU project's special group focusing on empowerment and engagement, we kept the administration rights. However, as time passed and we learned more about the skills and responsibility of the boys, we decided to grant them also administration rights. This was the right move, because ever since the web page experienced a rapid phase of development. Beforehand, some content was added with co-design approach. The first step was to provide them with a list of available modules in DotNetNuke content management system (CMS). The boys would reply and tell which module they want in which page, as the editorial rights are limited only to editing existing modules, but do not allow adding them. However, this way of working was rather slow, especially since the boys seemed to want to edit the web page outside of normal working/school hours, and replying might take more than a few minutes, which can greatly affect the motivation to continue editing at a specific time.

After the boys were given editorial rights to add content on the website they started to work on the content. They also showed interest to view near real time data from the sensor measurements, but as was discussed, the CITI-SENSE sensor units never (yet) arrived to the school, nor was there any data to be displayed. Instead, a pair of boys used a text they had prepared for a research assignment providing content to the web page, which we will learn later, also became useful in other activities at school. Looking back, the fate of the web portal might have benefitted from the lack of the EU project support. This way the students were able to modify the content more freely as they felt it should be.

The teachers also played a role in getting the content up and running. The boys were

encouraged to have the content ready for the upcoming street event. One teacher edited the pages by shortening and summarizing the content.

An analytical tracking tool from Google was installed at the web portal during the spring 2015. This enabled us to monitor the traffic on the website. However, up to this point, this never became of interest of the school.

A major problem which was encountered with the web portal was frequent server maintenance, which caused interruptions in the availability of the webpage from time to time. It happened to be down exactly in the most crucial moments. We can count three such examples. The first one was when we had a meeting with the school and wanted to introduce them to the website for the first time. This was not possible, because the server was down, which was a first occasion of such kind, and came as a surprise for us. Later we took print screens of the web pages and presented those offline, instead of online, to avoid this problem in similar occasions. The next incident happened during the street event. Access to the web page through small business cards with a link and a QR-code was prepared. Unfortunately the server was going through maintenance, and was not available to anyone engaged on the streets that day. This also affected the statistics of the web page for that day. As there was no access to the web page, no visitors were recorded, and the amount of people reached was not possible to track down. The third crucial time this happened was at the Genius Olympiad competition. The boys wanted to demonstrate how the citizens' initiative would work in real life, but could not as the servers were down. Ever since the first time and repeatedly after the web page was not available, the school strongly pointed out how it is not acceptable, and would rather have the content in their own website and server.

Later discussion with the students revealed that they do not find the web page useful at all, and do not think it has future after the CITI-SENSE project will cease. The boys who have access to the web page do not find it attractive to work with. They would like it to have Javascript support and more options to modify how the pages look like. Saying this and the above mentioned technical problems and disappointments, school specific project web sites does not seem to be an initiative which should be supported further in such projects. It also takes a lot of resources to maintain them as well as to figure out what kind of content to put there. The students did not have any suggestions about the content either.

Further investigation through the questionnaire to learn about the students view on the web page from also those who were not involved in the editing revealed that the situation is not as bad as we first thought. Some students, who were not involved in the editing this school year, are interested to be part of it next year. On the other hand, those who do not have the technical skills rather stay out of the way. Studies e.g. Hargittai & Walejko (2008) have confirmed that boys are more likely to post content online, but computer skills overrule the gender difference. E.g. if a girl has good computer skills she is more likely to contribute. This can however later become a collaborative project, where some students would suggest content, and others, who are capable, would implement it online. This was also reflected in teachers answers, where an idea to collaborate and network with other schools was introduced. There are already plans how and with whom to do this. But for that purpose they want to use a more reliable server in Slovenia.

3.1.10   Facebook

During the first year's activities a Facebook page (https://www.facebook.com/CitiSenseGimVic) was created by a group of girls, who were classmates of the technical boys. This group was named *Social media group* in the EU project documentation. The Facebook page was created quite late in the school year, which might have affected the interest rate to start actively posting anything together with

the fact that the project failed to provide any sensor units to the school in time, which was one of the main topics to be communicated through social media. Later we learned that a lack of committed teachers to run this task probably had its tolls on the success of the Facebook page.

However, the Facebook page was revitalized by a new group of first year students almost a year later from its establishment, and consequently a new social media group was formed. This time, the group was actively posting about their CITI-SENSE activities at school, as there were actually activities to post about. This was led by a teacher and a trainee. We were actively posting similar posts and sharing pictures with our own CITI-SENSE local Facebook page: https://www.facebook.com/CitiSenseLjubljana

For the following school year 2015/2016 they need to find another responsible person to take over the administration of the Facebook page, as the teacher does not foresee having enough time, and the trainee has finished his training period. A possibility to have the students as administrators is not ruled out. The teacher sees this as a manageable option, as the students are active on Facebook anyway. The students did not take that active role on suggesting posts or managing the page so far. We asked the students what kind of content they would like to see, but did not receive many concrete suggestions. The trainee suggested having more up to date posts from the action sites. Below you can see the students' answers:

- Different posts with small facts about air quality around the world - small because they would be quick to read and so they would be more memorable and more people would actually read and understand them.
- The content that is on now is good.
- At this point I have no ideas.
- I do not use Facebook, so I do not really care.
- I do not know.
- I do not really have an opinion about that. I think those who organised it are doing a good job on their own.

3.1.11 Connecting with the local authorities

The school decided to organize a meeting with the municipality of Ljubljana (MOL). The students were given the task of writing an email to the mayor, who has regular citizen contact hours. This was good practice for the students, as they got experience of writing to someone important, which is not that common at their age. The students were asked to send us a draft version of the email before sending it out, but for some reason or another, they did not. This led to change of plans, as they actually sent the email to the general municipality contact email address rather than the mayor. The email they sent was received at the environmental protection department, and from there a meeting with the head of the department was arranged.

The purpose of the meeting was three-fold: 1) to inform the municipality what the school is doing, 2) to discuss possible joint activities during Ljubljana being the European Green capital (European commission, 2014b), and 3) to gain support for the upcoming promotional street event, in case the municipality could arrange for the school to use the city bicycles BicikeLJ. They were also expecting the municipality to be interested in the activities and see the benefit of their co-operation. This expectation was reported both from students and by teachers.

The first goal was partially met, as the head of the department invited the school to come again during the next school year to give a presentation to a wider set of colleagues

from the environmental protection department. The second goal was discussed further during the meeting, and it was clarified, how there will not be any extra budget for additional activities, but how the city rather tries to merge with other already planned activities, and to have them under the umbrella of the European Green Capital. An invitation letter was sent to all the schools in Ljubljana soon after the meeting, to inform them about the possibility for joint activities.

The third goal was not met, as the municipality is not the owner of the bicycles, but they are managed through a company with whom we were advised to make contact with. The company gets several such suggestions regularly, yet are unable to fulfil the requests, so the head of the department knew to lower our expectations.

The school's expectations were high regarding the collaboration. The meeting on 31 March 2015 remained as the only one in that school year. The school also received an invitation letter, but is not that enthusiastic in taking part in proposed activities, as the proposed budget is not high enough to cover the efforts of the schools. The school was also disappointed, how the municipality does not see the benefit of the collaboration and the value of the project, which has the potential to promote the city. One teacher pointed out how every opinion of a citizen should count. She was disappointed how the municipality has not taken an active role in this EU project.

A few months later, the school informed the municipality about their success in the international high school competition. The school was expecting them to react somehow. The municipality reacted to this news only after a delay of 11 days. This was dramatically slower than what the mayor of the municipality of Domžale did, inviting the boy, who has a residence in the municipality, to a ceremony in order to congratulate the young man's success. The municipality of Domžale even got interested in this kind of project and is now trying to find some funding for such an initiative.

Regardless of the previously mentioned negative sides, we would like to emphasise, how the girls who took part in the meeting were really positive about it. They had prepared for the meeting by studying about air pollution, and by finishing drawing posters, which they took with them to the meeting. The girls presented their ideas about the informative posters, which were later displayed in front of their school. They were also talking about air quality problems in Ljubljana. The head of the department filled in insights of the accumulation of pollutants in Ljubljana and how the municipality is trying to reduce the problem. She also expressed her concernes about us going to the streets spreading out word of bad air pollution in the city, and how this might result in them receiving many phone calls from the concerned citizens. The girls pointed out that they are not only going to inform about the current problems, but also solutions, and explained how the school had prepared information on their webpage, and how we are going to give out small business cards with QR codes to access the website about this information. The head of the department wished them luck with the upcoming event.

3.1.12   The street event

On April 4th a street event to inform the citizens about air quality issues was organized. The concept was developed together with the students, and this event ended up being the most co-designed example. This event also connects most of the previous activities described earlier, demonstrating how separate groups working at the school can collaborate to create something new, educational and unforgettable. This event enabled the students to experience talking with people on streets, who were not expecting to hear about air quality, e.g. people on their way to the market place. In practice the final activity was executed by a group of students walking in pairs or group of three, stopping people on the streets and giving them cookies, small informative cards and balloons, while

spreading the word of current air quality situation in Ljubljana.

3.1.12.1 Initial idea

The street event was planned to be a low cost re-occurring event to inform the citizens about air pollution issues. The original idea was contextualized on an A4 sized concept description, after which the idea was introduced to the whole class of first year students on 1.12.2014. Brainstorming took place during the introductory class. Soon after, a group of four girls showed their interest to take active part in organizing the event. A meeting was organised to talk through the ideas, where the concept was fine tuned to include both the original idea and the students' ideas. Figure 11 illustrates the summary vision of how a first year student saw the event could look like.
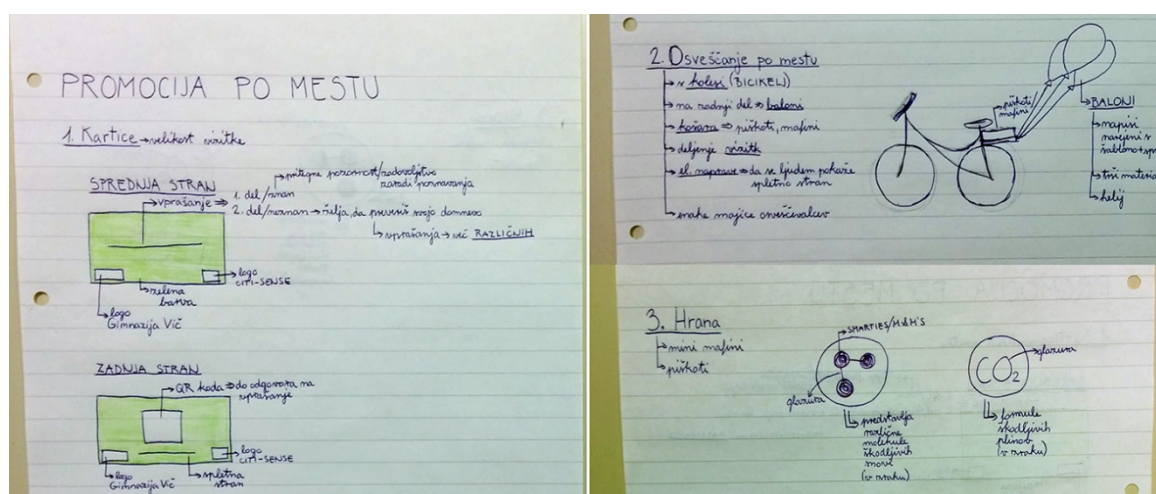

Figure 11: *Student vision of the street event.*

The original idea included cycling around the city with different coloured balloons attached to the bicycles. The students initiated arrangements to use the city bicycles, BicikeLJ, but later on, once the arrangement fell through, we opted to walk. This decision was also a rational one, as engaging with citizens on the streets would have been rather difficult on bikes.

In the following subchapters we discuss further the different elements and ideas of the event. The student's ideas were coordinated by the trainee who greatly helped to realise the activity, while the final approval of all different elements was left to the teacher, who participated in this kind of activity open minded.

3.1.12.2 Business cards

The idea for the business cards came from the students. Originally the students were inspired to make a small leaflet on air pollutants, and resources for preparing this information were provided. The idea developed further into small business cards, which would inspire people to find more information about questions asked in the business cards. Access was provided via QR codes, which was also students' idea. Out of the 20 suggestions made by students, four were picked and reviewed. (1) Can ozone damage your health? (2) Do you exercise near busy roads? (3) Is heating with wood really environmentally friendly? (4) The greenhouse effect – a beneficial or harmful phenomenon?

The initial design of the cards was proposed by the students, as is visible from Figure

11. The design was developed further, and documents were exchanged amongst us and the students. Figure 12 illustrates two other versions together with the final one. The design was fine tuned to meet technical limitations of printing e.g. green logo does not look good on green paper. Once the final design was agreed upon by both sides, the printing took place in the premises of the JSI (Figure 13) .

Figure 12: *Co-designed business cards.*

Figure 13: *The business cards were printed in the office.*

The feedback on the business cards after the event was related to the design, paper quality and the access to information. For such a public action, it is not enough to draft non-professional looking business cards. Now all the business cards looked too plain and similar, even though all of them carried a different message. The thickness of the paper was also problematic. Even though we used thicker than regular office paper, at $120g/m^2$, it was not thick enough to feel professional. Originally we had prepared even thicker paper, which we used for the printing at the institute, but later found a mistake in the cards, and needed to print all of them again, but we ran out of paper. The printing was also done too close to the actual event, not leaving enough time for fixing the occurring

mistakes. In the future, we recommend using both a graphic designer and a printing house. The last problem with the cards was that the CITI-SENSE server was down that day, so no one could actually access the information. Everyone was really disappointed, and once again the school said they want to have this information in a trustworthy server.

3.1.12.3 Cookies and balloons

The students came up with a friendly way to approach the people. They suggested to bake some cookies, which were decorated with chemical formulas of common air pollutants. The cookie baking event took place a few days before the street event. A word was spread out at the school and anyone interested could participate in the cookie bake. It turned out to be an inter-class group of students from first, second and third year. This half a day event brought together students, teachers and the kitchen staff. Everyone was co-operating. The kitchen staff had prepared the cookie dough the previous day. The cook instructed the students about hygiene before we started. We also grouped some tables together to have enough space for working in smaller groups. After moulding the cookies and baking them, each table was assigned one air pollutant and one colour to draw with a food gel decorative agent. We explained that since particulate matter (PM) is such a variable pollutant, everyone was given the chance to draw "PM" with their assigned colour. Soon after we decided to start improvising with drawing also our logos and the project name, ending up with very colourful and beautiful set of cookies. Figure 14 is a collage of the cookie baking day. Students commented that the cookie baking was very well organized, the cookies were "cute" and tasted good.

Figure 14: *Cookie baking (middle photo credit, Gimnazija Vič).*

Cookies were delivered to the people in willow baskets together with balloons (Figure 15). Balloons were part of the original idea. Ideas for the text in the balloons were brainstormed together with the students, and for example one boy, who did not end up participating in the event itself, came up with the idea "-50% ozone". This was adapted to the rest of the balloons as well. Just like in the cookie bake, we eventually also improvised with balloons by writing our institute name, logos and contact information. This was done at the site in front of the city hall after delivering the balloons to the city centre from the balloon shop.

Figure 15: *Balloons and cookies.*

We were using three different coloured balloons; red, yellow and green to reflect the different status of air, similarly as in Air quality index (AQI). Originally an idea to show the air quality with a measuring instrument communicating with a Raspberry Pi connected to an LED light inserted in a balloon was introduced. The technical feasibility was already presented in Chapter 3.1.7, but at that point in April it was not mature enough to implement due to sensor unit issues. The balloons were filled with helium. We were told by a balloon company, to whom we outsourced the task to fill the balloons, how the helium can easily escape from these types of balloons, so the filling was recommended to be done the same day as the action was planned. Similarly we were told how rain will negatively affect the balloons, and they will be dragged to the ground soon after the rain would start. That is why the final decision to have the action was postponed until the evening before, to know with higher certainty the chance of rain. The day of the action the weather forecast did not promise rain in the morning, so we decided to go for it. Unfortunately the day ended up being really cold, and we were not fully able to enjoy the pleasure of talking to people.

Despite the fairly bad weather, we were able to engage with several people on the streets. Some of them had rather limited knowledge about the air quality, while with others the discussion developed on a higher level. We observed that it was rather difficult to engage with the local people. One student reported how she "learned a lot about how Slovenians do not want anyone they do not know near them and are always in a hurry". Most of them seemed to be reluctant to enter a discussion. The approach used at the beginning might have been wrong as well, as the students mostly used opening words like "Would you have a minute?" These resulted in more repulsive behaviour amongst the citizens. We believe this approach is too similar to the approach used by organizations collecting voluntary charity money on the streets. Later the students were suggested to change their approach to something more encouraging, such as "please have a cookie". Which, on the other hand made some citizens offer money, which we did not accept of course. Other new sentences students used were: "We are from Gimnazija Vič grammar school which has been participating with the Jožef Stefan Institute and have been measuring and researching air pollution in Ljubljana. So now we would like to inform people about it and let them know what the current situation is" and "What do you really know about air quality in Ljubljana?" We are still to discover the best way for an

introductory sentence. So far the following were suggested by the teacher after the event: "There is a cookie for you", "Can I make your day brighter". Many times instead of getting to talk with the locals, tourists stopped.

As the event was planned as something which can be repeated on a low budget, this gave us the opportunity to explore what might work well. So far we tried the balloons, the cookies, and the small business cards. In all of them we discovered ways to improve. We also wanted to test out one of the original ideas, where we would ask the citizens how they can influence the air quality in their city. The author and one student tested this by preparing some empty paper and marker pens. We walked around the city centre and asked people to draw their answer to this question. We also took a portrait image of each participant and received permission to publish it. In order for them to find the photograph later on, we left them with our local EU project contact info. This activity ended up being a resounding success, as the collage image shown in Figure 16, posted on Facebook, received over 1040 views.

Figure 16: *Interacting with the members of the public.*

The balloons were considered a success as well. They worked as a good entry to start a discussion with young families, as the youngest ones were interested in the balloons, whereas discussion could take place with the adults. The only few remarks we got was that the marker pens could have been more colourful and thicker and how the text in the balloons was not really suitable for the youngest ones to understand. Next time we might decide to use some child-friendly mascots and understandable text. The teacher also

pointed out that we should perhaps write the text on the balloons already at the balloon shop, while the balloons are filling. This might save some time, and be more comfortable considering the dexterity needed for the delicate writing in cold weather we experienced. On the other hand doing these preparations at the site resulted in many people coming to talk to us, and tourists taking pictures while we still had all 75 balloons grouped together.

The cookies also turned out to be a really good interaction ice-breaker. At the same time, cookies brought joy for the students participating in the cookie bake as well as the kitchen staff. All the comments related to the cookies were only positive. The teachers from Gimnazija Vič grammar school, who had nothing to do with the event, could also enjoy the fruits of the labour, as the less pretty cookies were delivered to the teachers' lounge room. They were also shown the pictures of the event later on. The only observed negative side with the cookies was the misunderstanding by some people who tried to offer us money and some parents who did not let their children take a cookie.

3.1.12.4   Feedback of the event

The feedback from the event was collected from a few participants' right after the event as part of informal discussion. This guided us to ask specific questions in the reflection questionnaire as well as on the teachers' interviews after identifying what might be the issues to improve.

Before we started to walk around the city, the teacher held a short introductory speech to the participating students. In her speech, she emphasized what message the girls should deliver to the people. The girls had been provided with information based on the boy's research assignment, which was also online in their web page to study beforehand. The teacher had also integrated these issues to her teaching throughout the school year. The overall message to be delivered to the citizens was quite negative in terms of air quality situation in the city. We asked the teacher later why the approach was to highlight the air quality problems in Ljubljana, whereas we could also have taken a positive approach. She explained that the timing of our action was close to the spring cleaning, when Slovenians have the tendency to burn items from their home in a bonfire. Also the recent economic recession has influenced the choices people make, such as choosing less environmentally friendly heating fuel for their houses. So the main message was adjusted to serve to reduce the environmental impact in these issues.

The students recognized how it would be good to have someone around who is really good at talking to people. Or to generally learn about how to approach and talk to people. They also suggested to promote the event more in the general public.

From practical point of view, it was mentioned how we should perhaps consider specific routes to cover, rather than walk randomly. The students could also come up with more ideas to engage with the citizens. Cookies and balloons might not be enough to engage in real conversations, as they are just easily given away. The unforeseen success of 1040 views in Facebook after posting the collage image speaks on behalf of more active two-way engagement, as it encourages the participants to think solutions for improving air quality right at the action place.

Some suggestions for further activities already exist. The trainee suggested how it would be great to have the phone application developed by the boys working in order to actually have something real to show to people. According to the feedback of the event, the students would like to involve the boys to take part and demonstrate air quality with a LED light inserted inside a balloon, which changes according to the measured air quality. Such technical elements might also encourage some boys to take part in the activity as, so far, only girls were present. Overall the teachers highlighted the benefits of this kind of

activity in the minds of the students. The teachers were only taking care of the absolute necessities, while it was the girls' initiative leading the activity as they imagined it. No one had experienced this kind of activity before, and the teacher stepped outside of her comfort zone. "It was different, and fun, and a new situation for me. As a science teacher I am really rational. I took part in it open minded." She explained how we created a new dimension of promoting air quality in Ljubljana and how this kind of creative activity empowers students to be active and motivate them to be more involved in social issues.

In terms of the success of the event quantitative aspects were considered less important than qualitative; no one considered the number of people engaged important. The feeling of the students was highlighted instead. This is an example of the qualitative research data overruling the quantitative one, which should be integrated more in the EU project level. It would have been possible to estimate it from the amount of business cards printed, or cookies vs. how many were left by the end of the day, or by the traffic on the website, which was not possible anyway, due to the CITI-SENSE servers being down. Even then we would not have come to real numbers, as for example some people took more than one cookie, some did not take a balloon, some took both cookies, balloons and business cards.

The approach to design the activity together made a big difference. The following was described by the trainee: "I think it is important that the kids feel they were part of it, and to bring their ideas to the project. It makes them more motivated to participate and they work easier. They can also learn more. This way they are not forced to do something." Similarly the best description of the success and benefits was reported by the teacher: "I think that since everyone involved actually wants to repeat this campaign, speaks for its success. All students and even the kitchen staff have expressed their willingness to do it again. What the students felt is much more important than any number estimating reach, since this is something which affects the children's lifetime orientation."

The street event was a great example of a co-designed event. All the aspects were designed together with the school stakeholders. Even though the entire initial class, to whom the idea was presented, did not take part in the event itself, it still gave the possibility for everyone to participate in the brainstorming. The charm of the event attracted students from higher grades to take part, and the associated cookie baking, as well as the street event itself, were executed with participants of all ages. The fact that everyone wanted to repeat the event speaks for its success, as was summarized by the teacher. Nevertheless, what is more important, the teachers emphasized how the experience of the students to express themselves through designing this kind of activity, and to talk about important issues while growing up, to respect the world we live in, are non-measurable. Yet the most valuable.

3.1.13 Posters

The initial idea of informative outdoor posters was presented to the entire first year class. Soon after, a group of girls took on an active role in several activities, including the poster making. In order to make sure the idea is doable, from all perspectives, we drafted an image for the headmaster to explain her the idea of the installation as illustrated in Figure 17.
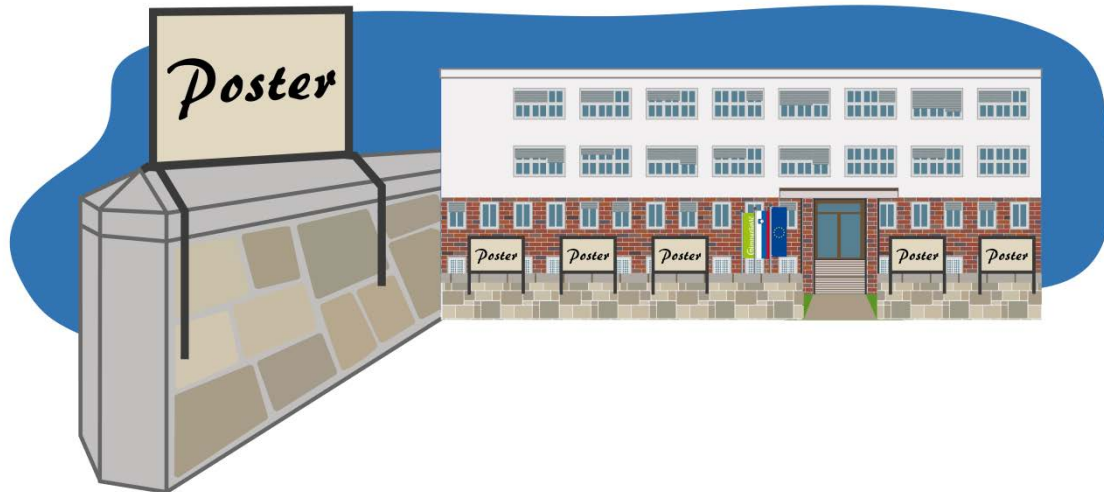
Figure 17: *Idea of the poster installation sent to the headmaster.*

We were also in contact with a printing company, as we needed to print the posters on a material which can handle severe weather. Similarly, we discussed the best solution for the installation, with the school, the printing house and with JSI workshop staff, which could help with the realization. The original plan of metallic frames over the stone fence of the school was eventually switched to wooden frames on the lawn behind the fence. The frame hosts two posters at a time on both sides of the frame. The final type of the poster frames is visible in Figure 18. The participating girls drew the posters, after which they were scanned at the printing house and printed on 5mm forex with UV protection. The school decided to have B2 size (500 x 707 mm) landscape posters. The size and layout was discussed several times. Altogether eight posters were printed.

Figure 18: *Poster installation.*

Poster content was discussed already at the preliminary meeting for the entire class. Soon after, a smaller group meeting was organized with the girls. One of them already had

sketched a draft version of one poster. We sent the girls inspirational ideas what to include in the posters via a photo collection on a PowerPoint. A few weeks later, a meeting with the head of the environmental protection department was organized where girls presented their paper versions of the posters. They were all drawn, painted and sketched on a green cardboard.

The school wanted the poster to be of a size suitable for both indoor and outdoor use. It was also a matter of financial resources to opt for the B2 size, as a bigger one would have cost relatively much more. Looking back, when the posters were already set up, they regretted not making them bigger. The green colour was chosen as it represents the EU project colour. In order to have some variety, some posters drawn later were yellow.

The girls were given free hands to express the message as they wanted. Guidance was given about the size, orientation and colour of the posters, as well as what key words to use. Other than that it was left for the creativity of the girls to spread the message. The trainee at the school was helping with the organizational necessities from the school side.

The girls wanted to promote the street event through the posters as well, so one of them drew a cyclist with balloons attached to the bike, as we imagined the event to look like before we changed the concept to be a walking event. Other posters vary in content, as can be seen in Figure 19.

Figure 19: *Outdoor informative posters.*

Later on, when we asked the girls what they think posters communicate, they answered: "That we should pay attention to the air and how we affect it as well." "They make people curious, because they only communicate the main problems, but not the answers. They are making people aware of the problems."

The final location of the posters and their angle to the street was decided by the headmaster. She gave instructions between which trees the posters should be placed, and she told how it is not desirable to have empty backsides of the posters facing to the school. That is why the posters were placed, not facing the street, but 90° to the street. In addition, the idea to make frames to host two posters at the time was facilitated. During the poster installation we already came across problems of the trees blocking some of the view of the posters. We also had to adjust the distance between the posters in a way that one can see all of them while walking by.

Later on we got feedback from the students as well as from teachers. More or less all of them reported how the posters angle was perhaps not the best choice. One suggested to place them in 45°. Some of the posters are hard to see in their current positions, and some people might find it difficult to read them sideways. The size was also considered too small.

Regardless of the inconvenient size and position of the posters, the school has plans to make more of them. They would like to rotate a selection of several posters. Some more artistic ones might be seen as well. Since the morning after the poster installation the students and teachers as well as passing by people have been creating a positive buzz around them.

3.1.14   Next school year

The school has plans for the next school year 2015/2016. Apart from expecting the sensor units to finally arrive and to start with the actual indoor air quality measurements, we asked the students what they would like to do within the CITI-SENSE project. Unfortunately, many of the students did not have any suggestions. Promotion was mentioned as well as making the project more known in the school itself (something we suggested for the first year students during the first year of CITI-SENSE activities). They also want to do more awareness raising of the general public. Whereas the boys are expecting to do some more coding.

Since some of the students told that they would like to meet with us face-to-face more often, we asked the teacher whether this could be possible. She told they have a slot on every Tuesday for project meetings and similar activities at 1:30-3PM. This will also facilitate the arrangements for the next outdoor event, which everyone wants to repeat. For this the school needs additional committed teachers to help with the realization, as the teacher participating this year pointed out. The idea with the blinking LED lights should also be possible to adopt for the next event. The boys are collaborating with the Jožef Stefan Institute's Department of Communication Systems to solve some technical issues with sensor unit communication. It looks like they will need to develop a new application to solve this. The school also hopes to get the municipality to show interest in their activities.

The teacher has many plans for the next school year. She explained how the teachers will be getting familiar with the VESNA-AQA units over the summer, and expects some more activities to take place with those portable units. Just before the start of the next school year, they will participate in a science teacher's conference in Slovenia, presenting some of their activities this year.

They are really looking forward to obtain the sensor units. The motivation to start indoor measurements is summarized by the teacher: "The students are exposed to different environmental conditions in every classroom, as it is up to the teacher to open the window. I open the windows all the time, but quite many Slovenes still follow the saying: "No-one died of stinky air yet, but of cold". To solve these problems, students will identify them and make measurements in different classrooms. The teacher explained further their eagerness to get more indoor air quality data: "The preliminary measurements we made so far indicated how CO_2 concentration at the end of the classes makes a big difference in the classrooms whether we have opened the window during the classes or not."

Apart from the above, the teacher was thinking of perhaps introducing the idea of making a short film. So far she is already successfully using the short film form, one of which also won a prize at the Genius Olympiad. "They really get motivated differently when they see that it was done by their peers".

Debate competitions amongst secondary schools were also brought up by the teacher pointing out how educational it is. In addition, the teacher participated with some students in a "science on the streets" event, which she finds worth exploring also in the domain of air quality. It is easy to agree with her argument: "It popularizes the science in a new way,

easy to understand by the public."

3.2 Evaluation of the Case Study Process: Crucial Factors and Actors

As Erickson (1986) has pointed out, the complexity of the actions or stakeholder perspectives in the project can be hard to observe and thus, record and understand. Yet, in order to avoid repeating the same mistakes, it is important to document and analyse the current ways of working. Cuel & Manfredi (2006) at their paper: Toward a Project Learning Organization: a Multifaceted View emphasizes the intra- as well as inter-project wide reflective learning amongst participants. Throughout this work we have been reflecting our work, identifying factors affecting the project and will discuss how we can use this information to our benefit in the future. The inductive findings support the discussion.

As the research was made within a case-study, we need to acknowledge its particularity. The findings mostly apply to secondary schools. We for example also have activities within the same project in a primary school, and we have noticed the approaches we need to adapt are totally different to those used in secondary school. That's why not all the findings can be generalized to school settings, but only to secondary schools. We should also mention that this specific grammar school seems to be populated with highly motivated and capable children, which was also emphasized with the success of the school nominated as the second best high school amongst the competing schools in international Genius Olympiad high school competition.

Throughout this chapter we try to understand the complexity of the process by highlighting crucial factors and actors.

3.2.1 From failure to success

The local case studies in the EU project were highly dependent on the development of the EU project's technical infrastructure; mainly the sensor units as well as ICT support. This greatly affected the school's possibilities to conduct their planned research in indoor air quality, especially when there were no sensor units to measure the indoor air quality. To avoid the possible failure of the empowerment initiative from a technical point of view, a decision was made in the EU project level that while we were waiting for the actual CITI-SENSE sensor units to arrive, we could buy off-the-shelf sensor units to measure the most important parameters, e.g. CO_2, humidity, temperature and noise. The period before that decision was made, consisting of little over a year, some schools, e.g. Gimnazija Vič grammar school in Ljubljana was provided with outdoor sensor units, which might have greatly affected the students' interest to rather focus on urban air quality outdoors, rather than the original indoor air quality. Almost no indoor measurements were made during the first two years of activities, even though the tools were provided in the second school year. Their arrival might have been too late to re-integrate into the activities which eventually took place. This shift in focus could has been seen as a failure to meet the original research plans set in the EU project.

However, the lack of sensor units and ICT infrastructure did not damage the success of the project as much as we were afraid it would. Early on we made a plan B, and were working with our stakeholders closely to ensure engagement activities were taking place at the school. It was much more important to have engaged, motivated and empowered students than endlessly wait for indoor sensor units to arrive in a distant future.

Even though the original plan failed, everyone who was asked reported that the project

has been a success, at least to certain level. The teachers measure success differently than scientists. For them it is important what the students learn, and how these projects shape them as individuals. The trainee reported as follows: "Yes, it has been. Because the children have learned something. And not something you can measure outside. Even though the first goal was never accomplished (sensor units at schools) we did great. The learning of the children is more important. It would have been nice though to experience how the sensor unit scenario would have looked like." He continues by listing the benefits of this project: "How the kids respond varies, as they are all different. The students can get to express their ideas. They also get to learn about the topic which is not totally covered by the school curriculum. You can sure find bits here and there in different subjects, but through these projects the kids see that what they learn at school can be applied in real life. The normal school system does not allow students to participate that much. Our grammar school is special in a way. The freedom to do these things is really important."

The students also mentioned the educational potential of the project, but more of them were discussing the amount of peers participating as a measure of success. They do not seem to have developed a consensus about higher level success indicators, which also opens up the question why scientists do it that way?

Some students were also critically evaluating this year's activities e.g. "We could have brought the project much further, however that was not possible due to issues with the data-flow and misunderstandings that I mentioned before. We still achieved a lot in this past year and I think we all did our best to help out." Some would increase the success by making a bigger buzz about it at the school and involving more students. However, arguments against involving as many students as possible can be found. It is much more important to involve students who are motivated to participate. We saw that by expecting every student to take an active role in a class does not work if the students are told to participate. They will experience not just a lack of motivation but technical problems, which also lead to further frustration. One participant pointed this out: "some of my classmates were forced in some activities, like using VESNA-AQA and they did not really like it." The general negative atmosphere was present during the Earth day campaign. This gives us confirmation in our belief that collaborative approach bears fruit in advanced awareness raising. By adapting participatory evaluation throughout the case study activities we have created a positive atmosphere and made some students believe they were behind some of the ideas which, in actuality, we originally introduced to the entire class. When we asked the students how they heard about the balloon event, the students who were the four active girls reported back "I was part of it" and "We came up with the idea for it."

Some students reported the initiative being successful in their school simply because "it was fun". From their answers we get a notion that they are expecting to participate also during the next school year.

The teacher took the most critical role. Even though she still thinks it was a success, especially given the success of the students participating in the international high school competition, she pointed out the shortage of promised goods: "I was a bit disappointed with many of the CITI-SENSE partners in other countries, who were not able to have the technicalities running. This was exemplified with the web page server not working at crucial times e.g. at the balloon event and during the competition in USA, when we wanted to demonstrate the citizens' initiative, but could not since the server was down- again."

To have confirmation on the success of the case study, we can also see the reflection of the scientific community in the EU projects consortium and beyond. The Ljubljana case study was always perceived to be well advanced in the plan B activities shifting from

sensor units focus to social processes and empowering people. In addition, the technical advisory group used expression "shining star". The story of the case study school has been also told in international conferences, where the approach is taken as novel, and where discussion usually led to us sharing our empowerment strategies. We have not been alone in sharing these activities, we also prepared a scientific abstract with the most active school stakeholders reflecting their views and giving them credits for their work.

The project has been multifaceted, which is characterized by having iterative phases. There have been many other aspects in addition to the technical ones which have influenced the project success. These are more socially oriented parts of the processes, which we learned to be more important. These are discussed further in the following paragraphs and further chapters.

The benefits of co-design were highlighted in individual activities. It was clear that the school was not willing to be taking orders. They wanted to have a high level of control, which supported the bottom-up approach. The teacher emphasized the benefits this freedom we gave them brought to them: "For students this was a great way of being involved and taking responsibility." She continued with: "And most of this affects their inner orientation of environmental behaviour, and intrinsic values and effects." Followed by the example of the street event: "It was a good experience for the girls to practice public speaking, to establish contact with people passing by, to present their ideas". The trainee reflected also similar views when we asked about his opinion of a scenario where we would have had full control: "It would have made a big difference. I think it is important that the kids feel they were part of it, and to bring their ideas to the project. It makes them more motivated to participate and they work easier. They can also learn more. This way they are not forced to do something."

We wanted to know whether the students felt they were given the opportunity to influence the course of activities throughout the project:

− Yes, it felt okay, but I am not used to such a responsibility that comes with it from before. But it was exciting and fun too. And we were able to use our creativity.

− Yes.

− Yes but only in our school. We did not really have much part in decisions made on JSI or NILU, which is certainly understandable.

− Yes, to some point.

− Yes, I've taken part in almost all of the activities. I've helped designing posters, baking cookies and took part in Saturday's "making people aware" action. I've enjoyed a lot.

− Not really, but I've never really thought about it, I let the teachers do their work.

The last response was from a student who only participated in cookie baking. An insider view on how things were run at the school was provided by the trainee: "The teacher decided mostly what will be done, whereas I and the students were deciding how things will be done. We had brainstorming with the students to discuss how to do things."

We asked what the boys have liked about the project so far. Their answers were: "All the experiences I got."; "The general idea behind it."; "We were allowed to do almost whatever we wanted." —All being very positive. On the other hand, as we knew the boys were interested in technicalities, we asked what kind of issues they have had to overcome during their participation. They mainly wrote about the sensor unit issues and the lack of dataflow, but also how they had other technical problems such as with the school network setup. What worried us at the beginning, some students also mentioned issues with their mentors. Later our investigation, as well as our own experiences, led us to understand the different views the participants were experiencing. In order to solve any issues, first we

needed to identify them and assess how much we would be able to influence the settings, by so far deciding to rather adapt to the situation than to suggest any dramatic changes.

During the first year of activities at the case study school we had unfortunate experience with the first year's group of girls, ceasing their activities. We asked the teacher whether she has any possible explanations for this: "Definitely because I did not teach them. I think this has to do with the commitment of the teacher, and the relation what he/she has with his/her students. Personal interaction of the teacher-student is important. If I promise something I will also carry it out."

At the end of the school year 2014/2015 we realized how we have most likely also inspired some students with the science experience we have been able to provide for them. This belongs to the concept of science identity (Carlone, & Johnson, 2007), which is the psychological process by which people become inspired by science and through learning construct and integrate their experiences into their identity.

3.2.2 Views on CITI-SENSE project and empowerment

As the project took a new direction since the very early phase, also the school's perception of what the project is about highly demonstrates that they think it is an urban air quality empowerment initiative rather than an indoor one.

All the actors from Gimnazija Vič grammar school had several opportunities to communicate about the project to the outside world. It was interesting to observe what they think the project is about. Here are some examples.

From an email to Europlakat, the company they asked for support in using the city bikes:

- "This project is based on establishing an air quality monitoring network and raising public awareness about options of increasing the quality of air."

In an email, written by the students, to the head of the municipal Department for Environmental Protection, Nataša Jazbinšek Seršen, the following was written:

- "This project is mostly about raising public awareness on the quality of air that we breath and the impact it has on our health." Whereas during the meeting, they emphasised how: "It is a citizen initiative …"

Similarly, in an email to the municipal Department of Economic Activity and Transportation, to gain a free pass for delivering balloons and cookies to the city centre they wrote:

- "Gimnazija Vič grammar school, together with the Jožef Stefan Institute, are partners in a European CITI-SENSE project, which is about citizen initiatives on air quality monitoring and pollution awareness"

On the street posters:

- "Gimnazija Vič, together with JSI, is working on a European project about urban air quality." Together with: "we raise awareness on (1) the quality of air that we breath, (2) reasons for quality decline and (3) the options we have to do something about it ourselves".

The latter one partially refers to their extensive online content on the vic.citi-sense.eu web portal which the four boys first recruited are editing.

We also asked the teachers and the students to describe what the project is about in a sentence or two at the end of the school year once they have had hands on experience. Below are the answers both from the students, and later from the interviewed teachers.

- "It is about caring for air quality, especially in the cities. It educates people about how important it is to know what the quality of the air around them is

like and how it can affect us. It is also developing as simple as possible possibilities for people to get to know those facts."

- "It is about caring about the environment and trying to explain to other citizens why is it important to reduce pollution."
- "About measuring and analysing air quality."
- "It is about raising awareness about air quality among the citizens of each city."
- "Reminding citizens about air quality."
- "Firstly, it is about researching air quality in Ljubljana and then secondly, it is about making people aware of the danger of polluted air and possible solutions to this problem."
- "It is about raising awareness of pollution, especially air pollution and it is connected to chemistry (because of all the toxic gases and exhausts)."

Whereas the teachers told the following:

- "Participating in environmental monitoring and educating others about potential dangers. Kids can participate to spread the word as non-professionals, which is great."
- "Empowerment of citizens in environmental issues connected with air quality issues. It gives them the opportunity of active citizen role. It reaches towards citizens with several activities and media e.g. Facebook and web pages and it has an international dimension. People will learn that in different countries, similar problems can occur. The project is a bridge between experts and citizens."

In addition we asked the teachers what they think *empowerment* means:

- "That you get sense of being part of your surroundings, be it natural or social. Not being a passive observer, but passing these observations to others by sharing what's wrong with the environment."
- "That students and citizens are able to get reliable information to make decisions based on real knowledge. To not be fooled by politicians. It is important that they learn to look at evidence by themselves and make a distinction between what is a reliable source and what is not."

3.2.3 Supportive atmosphere

The students were asked about their reason for participation. It was envisaged that there might be peer pressure, which is common amongst adolescents of the interest groups (Sumter et al., 2009). We thought that through the theory of planned behaviour (e.g. Ajzen, 1991) we would be able to study whether the decision to participate was affected by social pressure, their attitude and their perception of the participants' level of perceived control over the ability to engage in the activity.

The theory of planned behaviour has been used earlier in secondary school, for example to study the pro-environmental behaviour (de Leeuw, et al., 2015). To see how others have modified the original model, see "Application of the Theory of Planned Behaviour to predict Iranian students' intention to purchase organic food" by Yazdanpanah & Forouzani (2015) and Botetzagiasa, Dima & Malesios, (2015). Unfortunately, we did not receive enough data to analyse which of the factors suggested in the Theory of planned behaviour plays the biggest role, neither to update the model to fit similar research. This exercise turned out to be rather useful in identifying whether the students are going to participate in the activities next year or not and to identify the other factors affecting their participation. We tested the questionnaire with one student during

the preparation of the questionnaire, but failed to notice how we had constructed the 7 point Likert scale without keeping consistency of the polarity of the scale, which led to the misunderstanding and dubious results.

We gained answers to these same questions through other means as well. We asked the students to tell whether there were some groups of people who did not support their participation. Most of the students reported that they had their teachers, closest friends and family's support, whereas only one participant reported how she had to convince her grandmother about the bad air quality situation in Ljubljana. On the other hand we had one participant reporting how the constant issues in the EU project led his parents to advise him to quit or at least lower his activity. There were even students reporting how being able to participate together with their peers was the main reason for them to take part in the first place. Or one whose parents were surprised to hear how the student had dedicated to participate in yet another extracurricular activity. Overall, there do not seem to be obstacles from the point of view of social pressure, but the atmosphere is rather supportive.

This is also supported by the comment from the trainee where he described that the atmosphere in this specific grammar school is special compared to other Slovenian secondary schools; In Gimnazija Vič grammar school, students actually wish to participate in extracurricular activities related to environmental issues, whereas in most other secondary schools such students are rare, and easily stigmatized with negative image. The opposite seems to happen in Gimnazija Vič grammar school, where those who wish to participate actually might need to fight for their position.

According to the Theory of planned behaviour, attitude plays a role. So we asked whether their attitude has changed during their participation. We had two types of answers. Some students reported how they were already well aware of these issues, so they have not, as they are already doing what they see can be done, whereas the other ones reported how now, when they know, they have learned to realize the problems and how to affect them. This was nicely summarized by one participant "I realised that every action counts. That if we do not take care of our planet even by tiny changes, nobody is going to do it for us."

3.2.4 Motivation

People have the right to participate or not to participate. E.g. both the Aarhus convention by the United Nations Economic Commission for Europe (UNECE) (1998) as well as the United Nations (UN) Convention on the Rights of the Child (1989) exemplify the right of the individual to decide. Earlier we mentioned how motivation should be criteria for participation, and no-one should be forced to participate in any activities. As we described in the case study of the Earth day, students' motivation plays an important role also in the success of the project. It was already clear during the classes that some students had no interest in participating, but yet, they were forced to do so. This was also highlighted in the reflection questionnaire. Instead those students who participated in activities of their own volition reported various positive feedback.

"Motivations to contribute can be internal (feeling of competence, joy and fulfilment from contributing, altruism) or external (monetary rewards, peer recognition, self-marketing, personal need and self-interest)." (Hars & Ou, 2002). We asked the reason for their participation as well as how they think they can benefit from being a part, and the answers were various. In general they appreciate the experience they are gaining, how they get to learn to work in a team, to communicate, to introduce their ideas to others, being responsible for something for the first time, or how they get to co-operate with real

scientists for example. In addition we can also observe a pattern how the girls commonly described how they want to make the world a better place, whereas the boys are interested in the cutting edge technology, big data and coding. We observed throughout the project how the boys, who were given various data in various stages of the project e.g. from outdoor sensor units placed in their schoolyard in three different microclimatic locations, were not interested in the data itself, but merely about visualizing it. Speaking of different motivational drivers, girls had stronger community values whereas boys were motivated by exploring and improving their professional knowledge. Some student also reported how they gained useful information and tips for pro-environmental behaviour they have otherwise not encountered yet. They want to know for example how air quality can affect you and why, make this world a nicer, cleaner and healthier place. One even mentioned how the knowledge she gained was not accessible through the schools educational system, where the participation gave additional value for her. Or simply, how they get to hang around with their friends.

Practicing English was also listed as one benefit. This will hopefully be taken to a new dimension during the following school year 2015/2016. The students participating in international competitions already gained extensive experience on explaining their concepts related to air quality issues for the general public as well as to the scientific community. Whereas the students who participated in the street event, reported positively about their experiences, when they encountered tourists on the streets and got to speak to them.

We were also interested to know why some students did not participate. We did not have the capacity to ask all students from the school, so we approached this through the participating students and asked them why they think some students did not participate. The main reason was time, and how simply some students are not interested to do these kinds of extracurricular activities as it would be too much work for them. Some also mentioned how they are probably not ready to take on such responsibility. What we also found is that some students were avoiding participation because they did not feel comfortable working with the mentor from school, who has more demanding teaching methods than what the students are used to. However, her teaching methods are highly appreciated amongst educators. For example the trainee was praising her teaching methods: "She has a way to awaken the students' curiosity".

Similarly, the reasons why they think some people did not participate, they were also listing possible disadvantages of their participation. Only few actually even wrote anything, as most did not see any disadvantages. Time was considered the most common disadvantage. One mentioned how it can be stressful and another one pointed out the misunderstandings in communication (when receiving conflicting instructions from the mentors), which highlights the problem we already identified earlier and will discuss in the following chapter.

Interviews with the teachers provided more insights about the reasons for students to participate: the trainee reported the following: "A big part is their personality. They are curious, and they aim to get things done once they start something. One of the girls for example had a really tight time schedule. She had ballet and jazz, but she still managed to draw posters in the evening on time… The student motivation might be partially that it affects their image of themselves and in the eyes of others (in a positive way)." The teacher pointed out how the knowledge is something transferable in life and how the international competitions provide good background for the students.

One explanation for the motivation could be found from the participating students perhaps being more active to participate than the non-participating ones. We only went as far as to ask the students what other extra-curricular activity they have taken part in this school year. The students reported acting, filming school news, micro capsulation

research, the submarine project, cultural activities like literature events, writing for the school newspaper Vičwatch, healthy school and English promoting group. Only one student out of 7 had not participated in any extra-curricular activity before CITI-SENSE, but wrote how she would be interested for example taking part in the submarine project.

The participating students have interest and intentions to participate also during the next school year, but they do not see likely that their classmates would participate, which remains an open question to study further.

We have learned that in order to keep the students motivated, it is important to keep them updated on the processes of the project, and to be honest on the issues we are facing in the EU project level and explain how this affects their school activities. The technical issues we faced in the project highly affected the phone application development, whereas the activities which the girls were involved in, similar issues were not faced. The students also reported that they would like to receive more emails from us, also reflecting that the idea of single contact person does not fit the needs of the students. We actually asked the students' opinion how to improve the communication, and we received various suggestions, mainly about sending emails and using online platforms meant to communicate in project work, such as asana (https://asana.com)

We rewarded the students' interest in participation already when they first showed their interest. We gave all the participants our project T-shirts. At the end of the school year 2014/2015 we also rewarded their participation by preparing them a diploma as illustrated in Figure 20. The school uses an online CV, collecting records of extracurricular activities. This diploma can be beneficial for their future.
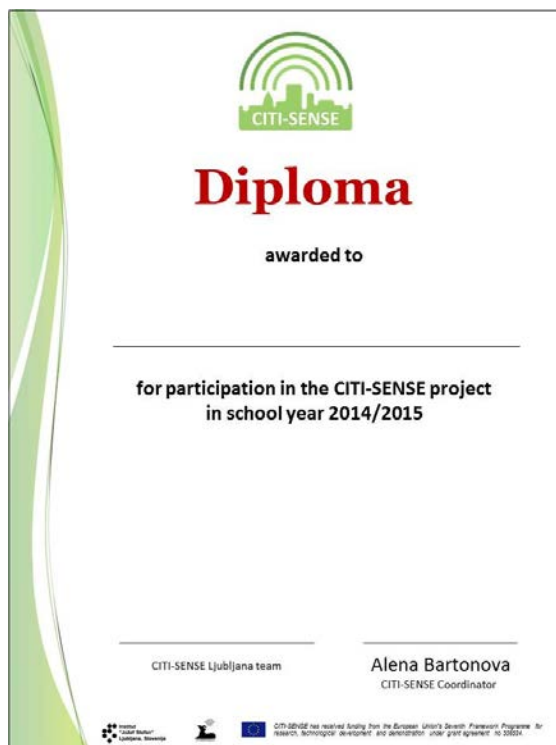

Figure 20: *Diploma for the students.*

Students are not the only ones, whose motivation matters. Actually this kind of projects would not function without the commitment of teachers. Not many teachers took active roles in the activities. The only other active participant was a trainee at the school, who described his motivation to participate as bringing him insights from the organizational point of view, how these kinds of projects work at schools. In a later

chapter we will look more into details the problems which the lack of commitment or proper reward can result in.

The trainee reported his motivation to be the experience in this kind of program. He learned that behind every project there is a lot of organization, a lot of communication, especially through emails. He also got to know more about air quality issues in Ljubljana, and appreciated the visit at the municipality, which he was organizing together with the girls. Unlike some students and teachers, he did not have issues with time, as he "had lots of time during the school working hours to take care of the practicalities. I never had to invest my personal free time (excluding the bike event held on a Saturday)."

We also have to acknowledge that without the main force at the school there would not be any project at this grammar school. This force was the teacher who has been working in the field for 15 years. Even after reaching the top of her career, she still finds motivation to take part in this kind of activities and is constantly looking for new scientific partners to provide the scientific content on the activities.

3.2.5 Communication arrangements

Organizational support is an important aspect of a successful project, especially in terms of communication. Since the preliminary meeting with the school, where also the headmaster and the head of the Department of Environmental Sciences responsible for the local project were present, it was decided that the contact between the school and the Department of Environmental Sciences would be kept between representatives from both institutions to keep it fluent. However, this contact person from JSI was not the main person to coordinate practical activities at the school, and it took a while until a fluent way of communication was established between the two institutions. Second issue arose with having multiple different groups of students e.g. few boys from second year, four girls from first year, whole class of second year etc., depending on the activity. Sometimes it was necessary to contact the students themselves, rather than to send the information through the contact teacher. This was not always possible, as the individual contact information was not known, or when speaking about a whole class, it was expected that an email address for the whole class would exist, which was not always the case (some preferred Facebook group over common email group). Various methods were used to reach the students. Email was considered the most appropriate method, as it also leaves an electronic trace. When needing to contact two parallel classes, the other class, which was using a group email, promised to post the emails we sent to the other class's Facebook wall. When there were only a handful of students to be contacted, and their email addresses were known, they were all contacted via email and the teacher was CC'd. The boys from the technical group, on the other hand, preferred to have a specific email address created for them in a google account, where they were all reached at once. This was an efficient way of contacting them all at once. As a negative side, it has to be said that it was not always clear which one of the boys replied to an email, as they were rarely signed.

As this was one of the main issues we were struggling with and trying to adapt throughout the project, we asked what types of communication tools the participants found effective. According to the teacher, the communication worked fine, and no recommendation was given. The trainee suggested creating an open Facebook group, which might encourage the students to also talk amongst themselves, connecting students from different classes. However, they pointed out that the students most likely expected the communication to go through the teachers as we, the outsiders, are not an authority for them, which can explain why we never received any replies to emails we sent out.

We rephrased this question for the students, as we were reaching many types of

students with the reflection questionnaire. We were trying to explain the issue we were constantly facing and asking how they would solve it: "What do you think would be the best way to communicate with everyone involved, and why? Think also how would this work in practice in different situations e.g. if you have a group of students from different classes participating in group activity once or twice, compared to a group of 4 students who are actively involved throughout the school year" And in the following question "In general, how would you improve the communication between us (either JSI or the teachers informing you about CITI-SENSE project) from what it has been so far?"

- I do not know, because some people check their emails regularly, some do not. some have Facebook and some do not. Some do not want to go to meetings at school (most of my classmates- they rather stay in class and eat a snack) because they do not feel like it or are lazy. There is nothing I could think of at the moment that would be more effective. Maybe the email and meetings before school or between breaks is the best (if it is after school most students do not feel like staying late in school so they would not come).

- Through group emails and maybe some group meetings, if there is some important information.

- Asana, it was made for it.

- We should work over diaries or web applications, which were developed for a large number of people to easily work on it.

- Face-to-face and mail/hangouts (some sort of texting service).

- I think communication via e-mail would be the optimal option because I think we're old enough to check our mail fairly regularly and this is how you could reach a single student or a bunch of them at the same time.

For possible solutions the students suggest more face-to face meetings, Asana, and emailing. The face-to-face option was argued to be good as: "it takes more time to explain an idea through mail than it is to show or tell it." Someone was also thinking beyond the everyday communication, and was thinking of outreach by flyers handed out at school. One student pointed out how we should see and report to one another more often, which is along the lines what we hope to reach. There were also students who did not recognise problems with the communication.

As one of the earlier responses reflects, the school stakeholders sometimes met during the classes. We also participated in these quick meetings multiple times. Many times we found them confusing as the agenda was not always executed as we expected. The trainee described how the communication during the most active time of the project took place with the most active girls: to those 4 active girls, we actually communicated also through text message, which worked nicely. In general we used email, but it did not reach everyone at the right time. I, for example, had to run from class to class to find the students to come to our meetings, and arrange this with the teachers. In retrospect, it must have been confusing for the students as well.

We also need to point out that some of the communication was made in English, while other times in Slovene as the author of this thesis is not a native speaker of Slovene. Generally, face-to-face communication with students was conducted in Slovene, whereas information and guidance was distributed mostly, but not always, in English via email.

As part of communication we recognised, by being aware of Mendelows (1991) matrix, that some of the students or teachers needed more attention than others, and needed to be updated more frequently. On the other hand we wanted to avoid a situation where we would have been unnecessarily overloading some students, who might end up

being on a mailing list receiving our updates.

3.2.6 Financial support

It was emphasised from the teacher's side, how this kind of project takes a lot of their time, and most commonly, it is taken from their free-time. There is a need to reward the extra work the teachers are conducting. This was also listed as a possible obstacle for some younger teachers to participate as mentors. "Given the current economic situation, on top of early career woes, teachers with young children, time is precious, and if the teachers invest their personal time to these activities, it should be shown in their pay-check. This is also a general problem in public sector as teachers are limited to certain payment levels, where no-one pays for their extra effort. And during the time of the recession, they are not allowed to be promoted." It is rewarding to see, though, that even those who have reached the top of their careers (in terms of payment) they still find the energy and willpower to participate in various activities.

The solution for the above-mentioned problem could simply be that it would be best to involve schools as real partners in the projects, in order to concretely reward the extra work and time the teachers are investing.

One way to ease the situation is to support the school activities with the resources they need to conduct the planned activities. Schools have limited financial capabilities to provide additional tools for themselves. The participating school had a vision to be part of the CITI-SENSE project as a case study school, and knew from the beginning there will be some small investments that needed to be made in order to have the case study running the way they envisaged it. These investments were provided by the local partner in the project, JSI. Most of the costs of the street event were also covered by the JSI (e.g. the business cards and balloons) whereas the school paid for the cookie dough and the delivery to the city centre. The paper for posters was bought by the school, while the poster printing and frames were ordered by the JSI. In a further phase of the project, the school is interested in having a display in the main hallway, where the current air quality could be displayed. The only problem is that they have had such display also in the past, twice, and on both times it got stolen.

3.2.7 Feedback on the role of the researchers

As the school was not an official partner in the project, we wanted to know how they see our (the scientists) role in this equation of activities taking place in the school. We asked this both students and teachers. The students saw our role as coordinators and support for their activities, as well as providing instruments and helping interpret the data, but also as mentors. One student is also expecting guidelines later on.

The teachers' answers were more advanced. They reported how we gave great support and how we set the basic outline for the project. We worked as a bridge between researchers, teachers and students and provided expert professional knowledge. They also gave feedback how it has been really easy working with us. How we were helping with the ideas and in realizing them. How we were very skilled in adapting to the needs of different aged children. And at the end, how our attitude was not superior but collaborative.

The feedback from the school reflects the process we were going through while trying to adapt to the new circumstances not being able to provide preliminary envisaged sensor units to the school. If the EU project had gone as planned, we might have never adapted the collaborative approach and become a part of their team. As part of the feedback from the teacher, she told how commonly the researchers they work with keep a distance to the

case study school working from top-down and using jargon, whereas our presence has been rather different. We believe that the guidance given by the EU-projects working group on empowerment and engagements and close contact with them helped us to achieve this. We gave the school the freedom to decide, yet we took part in every activity, either as collaborators, mentors, organisers or observers but never as an authority setting rules on what to do. Our goal was to get the ball rolling to guide the school to sustain the project also after the official end-date in September 2016. We firmly believe the school has means and motivation to continue with their activities.

3.2.8 Transparency

The CITI-SENSE project is an experimental one, where prototypes of new technology are introduced. Therefore we cannot and should not offer the participants a ready-made toolkit, but rather introduce it as an opportunity to collaborate having an influence on the final products the EU project is to report. As the aim in the EU project is to test the technological tools, but also the participation mechanisms, we must be rigorous managing expectations all the time. Dealing with low-cost sensor technology it was necessary to openly communicate about the state of the technology and data uncertainty. By not emphasising the developmental state of the sensor units, the stakeholders might have had false expectations on the capabilities of the units, and expect them to work as any commercially available off the shelf products. Transparency and good communication are a key element on handling problems even before they occur. It was important that we managed the expectations from early on to avoid disappointment and losing mutual trust between participants. Early expectations affect how the project is perceived in a later phase as Luoma-aho, Olkkonen and Lähteenmäki (2013) emphasizes. We communicated frequently and openly with our stakeholders about the newest updates in the project and whenever we delivered products we discussed in what kind of experiments they can be used for. Adjustments of expectations were made along the way when new circumstances arose. We also needed to remind some students what the portable outdoor air quality units were capable of before they started their own experiments. However, many of the students did not either understand it or otherwise ignored the instructions. Nevertheless, the school is still eager to continue the project and are looking forward to receive and start working with the new sensor units in the school year 2015/2016.

3.2.9 Sustainability of the project beyond CITI-SENSE

It is greatly emphasized in the EU project level how important it is to make further efforts beyond the project itself - a continuum - speaking for the sustainability of the project. Gimnazija Vič grammar school has a history of high level of participation in research projects given that the students from the school are also competing nationally and internationally every year in addition to their various other research projects. We believe that there is a high chance the project is going to stay alive in some form with the help of these stakeholders. The preliminary proof for this though is discussed.

Ljubljana will be the European green capital in 2016 (European Commission, 2014b). The city has set a sustainable development vision for 2025 already back in 2007, which might have influenced how the city started to systematically improve in various environmental sectors. Each month will have its own theme, air quality issues being addressed in the late 2016, already when the CITI-SENSE project will have ceased.

During the meeting at the Department for Environmental Protection at the Municipality of Ljubljana, the group from Gimnazija Vič grammar school was discussing the connection to activities during 2016. They wrote about their plan also in the email to a

company providing city-bicycles to the citizens: "The project has also been presented to Mrs. Jazbišek Seršen at the Department for Environmental Protection at the City of Ljubljana. Next year, our activities will also be included in the project Ljubljana – European Green Capital." Similarly they wrote to the mayor: "CITI-SENSE project was presented to the City of Ljubljana where they invited us to join the efforts within the Ljubljana – European Green Capital 2016 project." In order to start the collaboration, the municipality needs to show stronger interest and assume an active role to do so. The co-operation has the potential to sustain the initiative also beyond the timeline of the project.

In addition to possible co-operation with the municipality in 2016, the phone application which the group of boys developed will live beyond CITI-SENSE. Since the start it was aimed at a wider audience. When the data will be available and the application is up and running, we envisage how the concept of the phone application (described in chapter 3.1.6) illustrates its wider implication to the community and how it fits to the concept we call citizens' observatory. Sharing environmental information through citizens observatories contributes to the empowerment initiative to empower people. The boys plan to continue to develop the phone application beyond the official time frame of the CITI-SENSE project. They even have interest to expand the phone application to cover other cities as well, especially in China and India, where air pollution is a big problem. We will keep supporting and encouraging their plans. The boys believe that the phone app has the potential to influence decision making in a higher level by saying that once the system is running, the media attention it will eventually receive will lead the government to take action to improve the air quality.

4 Conclusions

Starting up an empowerment initiative in a grammar school to monitor indoor air quality turned out to be a challenge. From early on the EU project CITI-SENSE, which provided the framework for the case study, experienced several technical delays greatly affecting the established case studies in various European cities. This led us to re-evaluate what was important in the case study in Ljubljana. We shifted from postponing activities with the early developmental indoor air quality sensor units to co-developing various activities with the school which also made the stakeholders to be more prepared to enter the main study. This thesis has documented the processes taking place at the case study grammar school at Gimnazija Vič describing what happened and how we constantly adapted to emerging situations. Considering that the time from when the school was recruited until present, a year and a half passed. We hope to draw lessons from this experience also beyond the case study which may be beneficial to similar cases given the new direction EU- projects are set to take by encouraging the use of participatory approaches involving people.

The originally highly technocratic project was focusing on produce data. Citizen participation and empowerment was a rather abstract aim for natural scientists running the case studies. The onset of issues raised the importance of collaborative activities, as the technical ones were not available. Had the sensor units been delivered and produced reliable data we might have ended up with a completely different case study. Through these collaborative activities in Ljubljana case study, we were able to put into practice the abstract issues described by the EU project expert group on citizen engagement and empowerment showing the way to other case study cities.

The project was twofold (i) citizens observatories which were to create environmental data, and (ii) empowerment initiatives conceptualizing the citizen's observatories empowering the people. Even though we never managed to provide a functional dataflow to the school case study, which was especially expected by boys developing a phone application, we managed to adapt well to the empowerment perspective of the initiative. The path was not straightforward. We needed to constantly manage the expectations as well as to adapt to new circumstances and decisions made at a higher level. We tried to build towards a self-sufficient local case study in order not to be influenced too much by issues the EU project was still solving. This built the potential of the case study to live beyond the official timeframe of the EU project. We believe that the students from this case studyschool have the potential to become empowered active citizens by showing pro-environmental behaviour and being a part of citizen's observatories having the potential to change the way society generates and uses environmental information.

Through the case study we learned to see how schools are complex institutions. The schools have wide social responsibility and vision. The project is only a short lived phase in their never ending educational activities. We need to understand not to take over the way they function, but to adapt and respect the special way each school works. Being aware of the way the school functions and its dynamics is crucial. Action research provided good framework to systematically trace this down. We need to respect the resources the schools have available, and which can be limited. The time the teachers invest in this kind of projects can be much more than originally initended. Their efforts

should be rewarded. There is a lack of motivated and committed teachers, which also increases the tasks to those who decide to lead the activities in their schools. In order to ease this we need to adapt to the school dynamics, especially regarding the timing of activities and not to overload them just before their exam periods or holidays. In order to find a balanced and fluent way of working, it is necessary to talk to the stakeholders both about practicalities as well as expectations. Every new situation might need a different approach, so the ways of working should be adapted constantly.

A year and a half is enough time to experience staff changes or some students to graduate from secondary school. As in many phases of the project, the leading teacher's decision to mainly recruit first year students was beneficial. It does not only give them more time to adapt and learn about the topic at hand, it also reaches out to a generation which is yet to establish a routine and set an image of what grammar school studying is. There is room for them to explore the extracurricular activities and take the most out of it in years to come.

It is necessary to recruit students who are motivated to participate. People have the right to participate and the right not to. The students which are motivated want to make a difference. Many students expressed positive attitude towards participation and volunteered to several activities. The students' interests to participate vary which has to be taken into account when designing activities. This also helped us to understand the division of work we noticed amongst the students, where the students picked up tasks and activities that best suited their interest and did not try to interfere with something they are not good at e.g. girls not picking up any roles on editing web pages. On the other hand everyone was ready to face new challenges, the street event being the biggest one. Even the teacher reported this kind of activity being completely new to her and out of her comfort zone. The street event was also a great example of a co-designed activity.

We were closely following instructions from the EU-project's expert group on engagement and empowerment and adapted the co-design approach, which enabled a high level participation and decision making by the students. For a change, their role shifted from obeying an authority to bringing them on the same level with their teachers. The teachers, as well as the scientists, had collaborative rather than superior attitude towards the students. The students were given the role of deciding how the whole event would look like and it was executed with such a great success that everyone wants to repeat it.

The case study school is well known for its active participation in science projects. It is a privilege for the students to take part in this kind of projects. Their peers do not stigmatize them negatively; instead the atmosphere is rather supportive and motivating. Many of the students are already active in taking part in extra-curricular activities, and manage to find time to do so, time being one of the possible reasons why their classmates did not participate, together with being ready to be responsible for something for the first time in their lives.

Giving the school too much freedom might look under outsider's objective as a chaotic process. Yet, it pays dividends. We needed to blend in to see what happens at schools in order to understand that everything is under control. We became part of the dataset by being present and being insiders, sometimes influencing the processes, sometimes just observing them. This enabled us to receive valuable insight information on their views and how they execute activities. In order to get comparable data with other participating schools in the EU-project, some level of top-down management is yet necessary to comprehend the bottom up one. The role of the JSI in this case study represented a bridge between researchers, teachers and students and a source of expert professional knowledge to the school facilitating the case study.

It was necessary to constantly adjust to the project. The iterative nature of the project is

typical for action research, which we conclude to be beneficial in terms of learning from our own ways of working. By planning, acting, monitoring, evaluating and acting again, we tried to improve our ways of working while doing. Students were involved in the feedback loop through a reflection questionnaire. In order to make sure the questions were understandable; a draft version was sent to one of the students for feedback. The open ended questions provided substantial insights in the project process from a students' point of view and revealed much more relevant data than a short quantitative part of the questionnaire which we tried, and unfortunately failed, to implement.

Through the reflection questionnaire, as well as through questionnaires to the teachers, feedback on practical issues was gained. Communication was recognised as one of the main areas to improve in our case study as we were constantly trying to find ways to reach everyone involved and get them informed in time. The solution a teacher suggests is to have communication only through the teachers. Whereas students reported they would like us to write them more emails and have face-to face meetings. Yet our experiences so far are that we cannot expect to have viral email communication with students, as they do not perceive us as an authority. New technological ways to keep contact in project work was also suggested i.e. Asana. In addition to finding an appropriate way of communication, we need to make sure the message which is being communicated is not conflicting with instructions from the teachers.

We can draw further lessons from our specific case study which others can find inspirational for their case studies. Participatory evaluation of the first street event has helped us to create an image how even better co-designed event could look like. Feedback was gained after the first event, where the participants were asked how they would improve the event. The charm of the event attracted students from all grades. Everyone involved in the first event wants to repeat it, speaking for its success.

When preparing any sort of information material for the general public, we recommend using both a graphic designer and a printing house. This will not only save resources, but also end up producing a higher quality product. The content though should still be left open for co-design approach.

When engaging with random people on the streets, it is important what kind of opening sentence is used. Some wording might result in repulsive behaviour of the citizens such as "Do you have a minute?"

Activities on the street should be made into active two-way interactions. Passively giving goods to passers-by does not lead to active engagement. Instead, engaging them in some activity, e.g. drawing, can lead to higher success.

In the case of the web page, the school was left with too much responsibility in creating their own content, which first seemed overwhelming. They had to start from scratch. Even though it was a right move to give them the administration rights, we would suggest in similar project, who wish to have school specific websites to provide some general preliminary content. Looking back, the fate of the web portals might have benefitted from the lack of the EU project support. This way the students were able to modify the content more freely as they felt it should be. The school specific web portals have to be hosted on reliable servers, where maintenance is managed and adapted to user needs. In our case, a temporary solution was to inform the server maintenance staff every time there was an important event coming.

Decisions on long term installations should be made together with all stakeholders. This was emphasised with the poster installation. Even though the initial plans were made together, the final decision changed the plans without consulting others involved. The installation and opening could also be made as an event itself, and could potentially lead to some media success.

It was necessary to adapt the aims to fit reality. The original aim to supply the school with sensor units to monitor their indoor air quality, in order to find collaborative solutions to improve the indoor air quality, was not feasible and the focus was changed to outdoor air quality. The school had some specific problem areas it wanted to investigate once the sensor units would arrive, which became less and less important. What was more important was the involvement of students in the educational process. The shift in their way of thinking is much more valuable than single measurements made in some classroom. That is why we also changed our activities to be more informative, collaborative and with high educational impact. The inner orientation of environmental behaviour of the students is non-measurable, yet the most valuable.

We have most likely positively affected the students' science identity. It was not measured in this work, as its importance was only revealed towards the end. The work in similar projects should be continuously evaluated and well documented, both in terms of processes and outcomes. We need to develop different ways to measure success. Simply reporting the number of students involved or assignments made is superficial. The real value lies in the individual development. This also cannot be measured by knowledge tests. Some kind of self-reported development diary of participants could give us a good start to see how they grow as individuals. Teachers can see this process as they observe the students on a daily basis, but how to develop a method, in which scientists can easily get access to still remain open. This information gathering still needs to be established by finding guidance from participatory methods, not forgetting that the teachers have extremely valuable information about the social processes, the capabilities and learning processes of the students. This knowledge should not be overlooked, but used in its full potential.

5 Acknowledgements

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