E-waste Race

REPORT FOR FINAL BACHELOR PROJECT SI 0BEPS0

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CONTENTS

At the moment I am following an internship at a company named E-waste race. I wanted to do this internship to gain some practical experience within the multidimensional and exiting world of sustainability. The inventor and founder of the E-waste race, Timmy de Vos, is an Innovation sciences alumni (Vos, 2012). This made it extra interesting for me to intern at his company. By working at the E-waste race I can explore one of the many employment options after studying Sustainable innovation. A brief description of the E-waste race will be described below.

Description E-waste race

The E-waste race organizes competitions between schools in one region in order to collect as much e-waste as possible[1]. This project is designed for elementary students in classes six, seven and eight[1]. The race proceeds in three steps[1].

> ### Definition e-waste
> *the term e-waste is short for Waste Electrical and Electronic Equipment (WEEE) which describes "old, end-of-life or discarded appliances using electricity" so all types of waste containing electrically powered components (Widmar, 2005). Also when talking about e-waste, Small domestic e-waste is meant.*

First, an introduction lecture is given to all participating schools about for example the sustainability issues surrounding e-waste. The second step is that after this lecture all students have four weeks in which they have to collect as many broken and small electronical devices as possible. During the race the company E-waste race works with a website. Here children can upload which e-waste they have collected in order to receive points for them. The scores are registered and shown online to increase the gaming element. In order to receive the points a second child of the group has to check with a second account if the first child really has the amount of e-waste it claims to have. This is done to prevent cheating by letting the children check up on each other themselves. Furthermore, the website can be used by neighbors to upload the e-waste they have at home and to let the children pick them up. By doing so, the children will again get points on the website. During the race the E-waste race also works together with several local qualified garbage disposal firms that will make sure that the collected e-waste is picked up at participating schools. These firms also take care of the fact that the e-waste is being recycled in an appropriate way("Over de E-waste race - E-Waste Race," n.d.). The final step is that, at the end of the race the school that has collected the most e-waste will win a school trip. In this way all schools work together in building a sustainable consciousness in their neighborhood and it is made sure that valuable materials are being brought back into the product lifecycle[1].

1: Information from an interview with Timmy de Vos, 14 November 2016. Interviewed by Anna Lena Gompelmann.

As seen above, the E-waste race is an educational elementary school project on the subject of recycling e-waste. It wants to spread knowledge about recycling e-waste and it wants to change people's behavior towards more e-waste recycling. Therefore the next section will discuss why recycling e-waste is so important. This will be followed by a brief description of the beginning of the e-waste race. The chapter will end with the research assignment provided by the E-waste race which was used as subject for this final bachelor project.

1.1 THE E-WASTE PROBLEM

The E-waste race tries to teach children about the recycling of e-waste and why it is so important to do so. But why is it important to recycle e-waste, what is the problem related with e-waste? This will be discussed within this section. The discussion of the e-waste related problems and the importance of recycling will be divided into four sections; raw materials, e-waste stream, a case study and solutions.

1.1.1 RAW MATERIALS

Within this section five issues surrounding e-waste's raw materials and their recycling will be discussed.

The first issue is that the production of electronic devices requires the use of scarce and expensive raw materials. For example, roughly 10% of the total gold worldwide is used for the production of electronic devices (European Commission, 2016). Taking in mind that the gold global production in 2013 was 5.1% of the 54,000 tones in available reserves, theoretically it would mean that it would take 19.5 years to exhaust the total gold supply(MacDonald, 2014). That compares with 38.5 years for copper and 28 years for iron ore (MacDonald, 2014). This shows that a main issue of e-waste is the depletion of several of its raw materials. These scarce raw materials can be brought back into the industry by recycling the e-waste. This will be explained later on in this section.

The second issue relates to the fact that e-waste contains a large variety of metal, metal-alloys, plastics, glass and other materials (Stengs, Zonneveld, & Groen, 2017). Several of these raw materials are of high value when being recycled. For example, in a report from the United Nations University it is being stated that the 41800 kilotons of total e-waste production in 2014 contained: 16,500 kilotons of iron, 1,900 kilotons of copper, and 300 tons of gold (Baldé, Wang, Kuehr, & Huisman, 2015). Next to that it is stated that it also contains a significant amount of silver, aluminum, palladium, and other potentially reusable resources. The United Nations University calculated that all these raw materials together have a combined estimated value of US$52 billion(Baldé et al., 2015). This shows that the large amount of e-waste that is being produced still has quite a large value to it, but only if it is being recycled appropriately. So the issue is that when e-waste is not being recycled all these valuable raw materials will be lost.

The third issue is related to the processes of recycling and recovery of e-waste. During the processes of recycling and recovery the aim is to liberate, separate and refine these materials. In this case recovery stands for recycling plus the recovery of energy (Stengs, Zonneveld, & Groen, 2017). So as mentioned before, if handled correctly e-waste presents a valuable source of secondary raw materials. The problem is that a large variety of different e-waste treatment technologies are needed in order to recycle and recover materials from all the different types of existing e-waste. This makes e-waste treatment processes advanced and innovative, because they need to adapt to the changing material composition of electronic devices over time (Stengs, Zonneveld, & Groen, 2017). So the third issue is in order to minimize the first two issues e-waste needs to be recycled, but these recycling processes are advanced and innovative which makes the process expensive and difficult.

A fourth issue is that e-waste also contains toxic and cancer causing compounds such as mercury, cadmin, chromium, and ozone-depleting chlorofluorocarbons (Hester & Harrison, 2008). These components require correct handling and treatment to avoid environmental-, safety- and health risks. The process of removing these hazardous components is called depollution, which is not an easy process (Stengs, Zonneveld, & Groen, 2017). These toxic compounds are also related to the fifth issue.

The fifth issue is that health issues and environmental risks due to bad working conditions and hazardous chemicals are common side effects of e-waste productions (Widmer, Oswald-Krapf, Sinha-Khetriwal, Schnellmann, & Böni, 2005). More on this subject will be discussed in the case study below.

Within this section the raw material related issues were discussed. To determine the scale of these issues, the next section will discuss the e-waste stream and its scale.

1.1.2 E-WASTE STREAM

Within this section three problems and fact about the e-waste stream will be discussed.

First of all the e-waste is one of the fastest growing waste streams within the EU, growing with 3-5% per year(Eurostat, 2014). It is reported that in 2005, 9 million tones of e-waste were generated and this is expected to grow to more than 12 million by 2020(European Commission, 2016). In fact in 2014 Europe had with 15.6 kg/inh, compared to all continents, the highest amount of domestic e-waste per inhabitant(Baldé et al., 2015). The problem is that at the moment only one-third of the e-waste in the EU is being managed appropriately (Eurostat, 2014). The remaining two-third can belong to one of the following three different disposal options(Eurostat, 2014). One is that e-waste is collected by unregistered enterprises and properly treated.

The second is that the e-waste is collected by unregistered enterprises and improperly treated or even illegally disposed abroad. The last option is that the e-waste is being disposed as residual waste and burnt. So the

problem is that a lot of e-waste is being produces, but only a small part of this e-waste is being recycled appropriately.

The second problem is that in the Netherlands most of the e-waste disposal options for private persons are quite time consuming and a lot of effort is needed("Waar kan ik oude en gebruikte huishoudelijke apparaten inleveren? | Vraag en antwoord | Rijksoverheid.nl," n.d.). This could be one of the reasons why two-third of the e-waste is not being recycled in the right way.

The last problem is that not only within the EU the e-waste is growing, in all kinds of countries around the world developed or not is e-waste one of the fastest growing waste streams (Baldé et al., 2015). The global growth of e-waste has a large impact on developing countries. Loopholes in e-waste directives allows the export of e-waste from developed to developing countries (United Nations Environment, n.d.). The large amount of e-waste then becomes a problem in these developing countries in terms of environmental risks and health risks, as mentioned in the raw material section.

The two sections above show that there are several issues related to e-waste. These issues have a large impact, because of the large growth of the e-waste stream and the low percentage of e-waste recycled. The next section is a case study from a Greenpeace report which can nicely illustrate the issues related to e-waste.

1.1.3 CASE: SMART PHONE (JARDIM, 2017)

This case of the smartphone is a good example for showing the problems related to e-waste. This year the smartphone exists for nearly 10 years and within this period more than seven billion smartphones were produced (Jardim, 2017). After all these years the product design and supply chain suffer from the same not-so-smart linear manufacturing model and short-term, profit driven perspective that were the problem since the beginning. And these six problems which are spread within all fields of the e-waste sector will be shown below (Jardim, 2017).

The first problem is that several raw materials used in the IT sector are mined under bad conditions. This includes life threatening work that often takes place in fueling-armed conflict areas such as Democratic Republic of Congo.

Second, the workers in IT manufacturing are unknowingly being exposed to hazardous chemicals which cause health risks.

Third, the complexity of the devices increases which means more energy is needed to produce a device which again results in an increased demand for coal.

Fourth, again the insufficient product take-back and reuse of materials further results into a rapidly growing e-waste stream. So besides the material and sustainable impact of the smartphone, it has also a large human impact.

The fifth problem is that Even if the intention of the owner is to repair or recycle the smartphone, smartphones are designed and produced in a way that makes it difficult or impossible to demount the devices (Jardim, 2017). This design makes it harder to repair and recycle the devices. So more smartphones have to be thrown away which means a waste of raw materials.

Table 1.1: earth materials used in advanced electronics and other e-waste (Jardim, 2017)

The sixth problem can be seen when looking at table 1.1 which displays earth materials used in advanced electronics and other e-waste. A large amount of these earth materials are rare earth elements, select substances of concern or conflict minerals. One example is Indium which is used in displays of among other things also smartphones. Indium is estimated to have only 14 years of supply remaining if we continue with current rate of extraction (Jardim, 2017). So the intensive rate of mining these virgin materials damages the earth and leads to the depletion of highly needed substances.

After discussing the 6 problems, the image 1.1 below will present four options that can provide solutions for these problems.
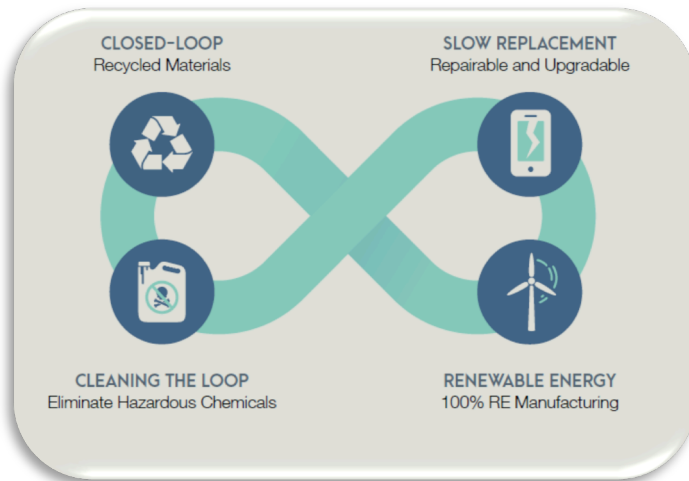
The first solution that is proposed is the closed-loop. Closed-loop means that products should be produced and designed in a way that they can easily be recycled and that it is made sure that all products are being recycled (Jardim, 2017). This means that one day 100% of the materials within a product can be reused. So the long-term ambition for this solution should be for companies to produce products by using recycled materials only. This means no use of finite virgin materials.

The second solution is slow replacement by making products repairable and upgradable. The goal is to make phones that last longer so that the resource and energy drain of each device can be spread over time (Jardim, 2017).

Cleaning the loop is the third solution. It means the elimination of all hazardous chemicals from the product itself and its manufacturing process (Jardim, 2017). This is done in order to protect the health and safety of consumers and workers and to ensure safe recycling.

The last solution is renewable energy. This means that the companies themselves use only energy coming from renewable sources and that they make sure that this also counts for the companies within their supply chain (Jardim, 2017).

These four solutions are presented within a case on smartphones but these solutions are also applicable for the e-waste related issues that were presented in the sections on raw materials and e-waste streams. The solution of renewable energy use for the whole e-waste sector was discussed in the article of Morgan (Morgan, 2015) . The solution of slow replacement for the whole e-waste field was discussed in the article of Ahmed (Ahmed, 2016). The solutions of closed loop and cleaning the loop for the whole e-waste sector was presented in the article of Widmer (Widmer et al., 2005).

1.1.4 SOLUTIONS

As mentioned above, the four solutions of image 1.1 are also applicable for the e-waste problems. Within this section it will be discussed which solution the e-waste race chose.

As mentioned above, the E-waste race is an educational elementary school project on the subject of recycling e-waste. Recycling e-waste belongs to the closed loop approach. The E-waste race makes sure that old electronic waste come back into the loop by being recycled. Next to that they also spread e-waste related knowledge with the aim to change people's behavior and attitude towards e-waste so that more e-waste is treated the appropriate way.

There is much more to the closed loop approach such as there is a whole governing and industry side to the closed loop approach as mentioned during the case study. With focusing on recycling, the e-waste race contributes to what the consumer can do for supporting a closed loop approach. Recycling e-waste is a solution for consumers to help resolve the e-waste problem (Baldé et al., 2015).

So the e-waste race tries to play a role in the solution of the e-waste problems by inducing consumers to recycle more. How the E-waste race started and how they came up with this type of project will be discussed in the next section.

1.2 THE E-WASTE RACE

The journey of the E-waste race idea started several years ago in Utrecht. More precisely at an event organized by the Utrecht Sustainability Institute (USI), UtrechtINC and Wecycle called the E-waste 2.0 challenge("Circular Economy Lab 1: E-waste 2.0 challenge," 2013). This particular challenge was related to the closed-loop solution mentioned before. The event was organized to find new and creative solutions to solve a recycling related challenge; "How can the e-waste collecting percentage be increased by using a new creative collecting method that works on district level and that uses ICT-applications?" ("Circular Economy Lab 1: E-waste 2.0 challenge," 2013). Two winners were chosen who each received a check worth of 10.000 euro (provided by Wecycle) and a 3 month long professional guidance to realize their concept (provided by UtrechtINC)("Circular Economy Lab 1: E-waste 2.0 challenge," 2013). Timmy de Vos was one of the contestants that won with his idea of the E-waste race.

Image 1.2: Timmy de Vos (second from the right) winning the e-waste 2.0 challenge ("Circular Economy Lab 1: E-waste 2.0 challenge," 2013).

After winning the price Timmy de Vos decided to organize a pilot in the Netherlands. This pilot took place in the 5 week period of 17 March till 18 April 2014. Nine schools participated during this pilot and they collected a total amount of 14,230 kilogram during this race("resultaten @ www.ewasterace.nl," n.d.). This was such a successful result that Timmy de Vos decided to make a company out of his concept.

After discussing what the E-waste race is, which problem it is trying to solve and how the e-waste race developed. The next section will describe the assignment given by the E-waste race on which this final bachelor report is based.

1.3 ASSIGNMENT

The E-waste race wanted a research done on the effects of e-waste race. They wanted a report with the effects the e-waste race had on the neighborhood, so a presentation of the results of an e-waste race. The E-waste race wants to have a positive influence on peoples recycling behavior, by letting students collect e-waste and by providing them with e-waste related knowledge.

So in more detail, the E-waste race provides a way to make sure that e-waste is being collected and recycled. Next to that it also tries to increases the awareness of the participating children by giving them knowledge about the E-waste problem and letting them collect e-waste. Not only are the children being reached during the project, several other people can be reached as well. The children campaign and talk to a large amount of people when trying to collect as much e-waste as possible. By doing this the children spread knowledge and increase awareness on the e-waste topic, which can lead to a change of peoples recycling behavior.

The amount of e-waste collected during a race is known. The level of awareness created and the long-term effect of the race in terms of changing people recycling behavior is not known. The E-waste race would like to know their effect in categories like these. They want this so that these results can then be used to show their potential clients the range of effects of an e-waste race.

How this assignment will be translated into a research question with sub research questions for this final bachelor project will be discussed in the next chapter. First a short description of the theory, which will be used within this report, will follow in the next section. This is done because some concepts from this theory will be used within the description of the research question.

The theory used to answer the research questions will be the social practice theory. It is a theory that tries to analyze a certain practice, how practices change and stay the same(Shove, Pantzar, & Watson, 2012). In this situation the practice is the e-waste recycling behavior. As described by i.e. Elizabeth shove in the book "The Dynamics of Social Practice"; practices consist of the interdependencies between three main elements of practice(Shove et al., 2012). These three elements are: materials, competence and meaning. In order for a practice to exist materials, competence and meaning need to be integrated in the society and these three elements need to be linked. So when wanting to totally change the e-waste recycling practice all three elements need to be changed and linked. How this theory was chosen and a more elaborate explanation will be provided in the chapter on theory.

Within this chapter the assignment given by the E-waste race will be translated into research questions and sub-research question.

The E-waste race wants to know what the effects are from an E-waste race. The E-waste race wants to have a positive influence on peoples recycling behavior, by letting students collect e-waste and by providing them with e-waste related knowledge. So the main research question will be:

"Does the E-waste race help changing people's e-waste recycling practice?"

As mentioned in the previous 1.3 assignment section, a practice exists thanks to the linkages of the three elements; material, competence and meaning. So when wanting to change a practice the three elements and their linkages need to be changed. When wanting to know what the effect of the E-waste race is, the state before the e-waste race needs to be known. Also the changes the E-waste race makes during the race need to be known and if these changes sustain after the race took place. As the E-waste race is interested in a change of practice and a practice contains of the linkages between the three elements, the following three questions will be the sub-research questions.

"Are there existing linkages between the elements of practice before the race took place?"

"Does the E-waste race create new linkages between the elements of practice during the race?"

"Do these new linkages sustain after the race took place?"

When analyzing the three elements of practice things like amount of e-waste collected or level of awareness created will also be discussed. So when answering the (sub-) research questions, the effect of the e-waste race on all three elements will be discussed together with its effects on the overall recycling practice. An overview of all the (sub-) research questions is shown in image 2.1. How these (sub-) research questions will be answered will be discussed in the chapter on methods, but first theory that will be used to answer the (sub-) research questions will be explained. This will be done in the next chapter.

Main research question
"Does the E-waste race help changing people's e-waste recycling practice?"

Before
"Are there existing linkages between the elements of practice before the race took place?"

During
"Does the E-waste race create new linkages between the elements of practice during the race?"

After
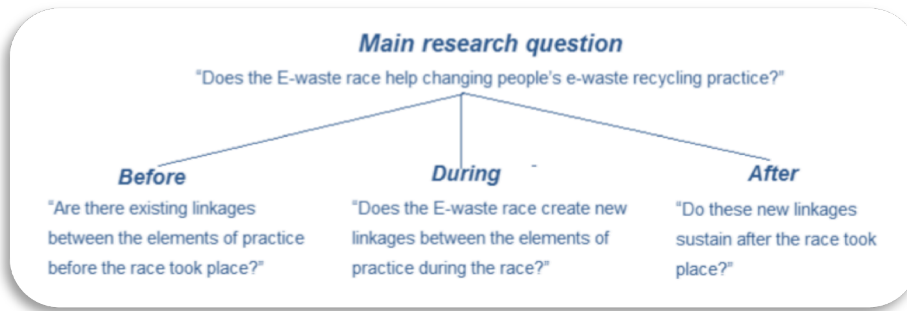"Do these new linkages sustain after the race took place?"

Image 2.1: Overview (sub-) research questions

CHAPTER 3: THEORY

Within this chapter the theory will be explained that will be used to analyze the results. This chapter will be divided into two sections. The first section will explain what theory was chosen and why. The second section will explain the theory chosen in more detail.

3.1 THE DECISION OF WHICH THEORY TO USE

There are two theories that could be used to analyze the results and answer the research questions. The first one is Social practice theory and the second one is Social network theory. Both theories are suitable for analyzing the gathered data, but within this research the decision was made to work with only one theory. This was done because due to the time limitation of this research, applying two theories would be too time consuming.

The decision of which theory to use did depend on two criteria. The first criterion was the results of the fieldwork. The second criterion was the type and amount of data that was managed to be collected. During this research a lot of interviews and questionnaires within schools were being taken. The type and amount of data that could have been collected depended strongly on to which extent the schools were willing to cooperate. On the basis of these two criteria it was decided to use the social practice theory to analyze the data.

In order to explain this choice the next section will give a brief description of the Social network theory and the 3 reasons why this theory was seen as inferior.

The Social network theory analyzes networks and social relationships by looking at nodes and ties. Within a network the nodes are the actors within this network and the ties are the relationships between the actors within this network (Haythornthwaite, 1996). Social network theory could be used to analyze how the awareness and knowledge from the E-waste race spread within the neighborhoods. This could be done by analyzing the network of the neighborhood and looking at which ties were used for information spreading during the race and how this information spreading worked.

The first reason not to have chosen the Social Network theory was that the social network had to be studied in great detail which would require an extensive research. Also the spreading of information could not have been followed in real time but would have been reconstructed one year after it happened. This means that this research would have been too time consuming for this final bachelor project.

The second reason was that in the results of the fieldwork gave no detailed insides on through which ties the e-waste related knowledge had spread.

The third reason was in order to apply the social network theory very detailed data on how the e-waste related knowledge spread was needed. The schools were not willing to cooperate to the extent that this kind of data was available. This would have made it very difficult to use the social network theory. After discussing why the social network theory would have not been suitable for this research, the following section will explain the social practice theory and how it will be used for analyzing the data.

3.2 SOCIAL PRACTICE THEORY

Social practice theory will be used to see if there was a change in e-waste recycling practice due to the E-waste race. This means a change in the recycling behavior of people and not only a change in awareness and knowledge. As mentioned in the chapter on introduction, the E-waste race tries to solve e-waste related problems by bringing raw materials back into the loop though recycling. They want to do this by spreading e-waste related knowledge with the aim to change people's behavior and attitude towards e-waste so that more e-waste is treated the appropriate way. So the E-waste race is to not only to collect e-waste during the race, they also want to induce a change of practice when dealing with e-waste by i.e. spreading knowledge and thereby raising awareness.

3.2.1 DEFINITION

Social practice theory provides a framework to analyze the data collected during this research to see if the E–waste race results in a change of practice. As described by i.e. Elizabeth shove in the book "The Dynamics of Social Practice"; practices consist of the interdependencies between three main elements of practice(Shove et al., 2012). These three elements are: materials, competence and meaning(Shove et al., 2012).

In this theory materials are the 'things' we need to perform a practice. These are things like infrastructures, tools, hardware, encompassing objects and the body itself. Competence means having the knowledge to being able to evaluate a performance and having the skills required to perform the practice. The term meaning stands for the social and symbolic significance of performing a practice. So it can be described as the mental activities, emotions and motivational knowledge used to decide whether or not to perform the practice. This all means that practices exist if materials, competence and meaning are integrated, so when they are linked.

The concept of linkage is very important. The image 3.1 below shows the elements of practice in three different stages of linkage(Shove et al., 2012).
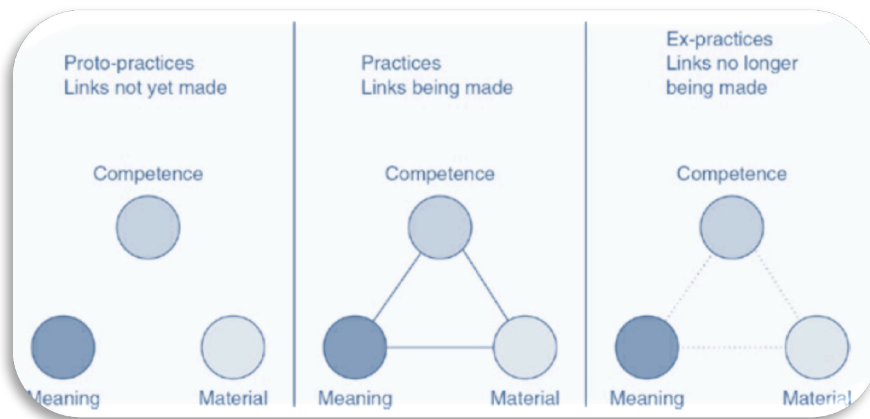
Image 3.1: The three different stages of linkages between elements of practice (Shove et al., 2012)

The first stage is the Proto-practices phase where the elements exist, but the links are not made yet. The second stage is the practices phase where all elements are linked and the practice is practiced. And at last the third stage, the ex-practices phase, where the links are no longer being made and the practice fades away. This shows that the elements have to be linked in order for a practice to exist.

The image 3.2 below shows an overview of the social practice theory.
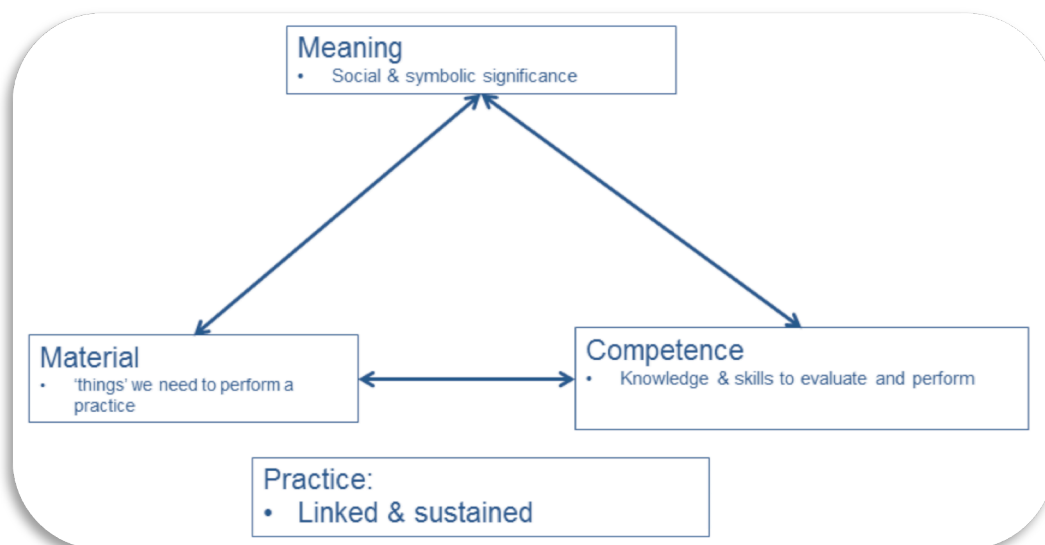
Image 3.2: overview social practice theory

Now that the social practice theory has been discussed, the next section will discuss examples of similar research that also used the social practice theory.

3.2.2 EXAMPLES RELATED RESEARCH

In order to substantiate the choice of theory, several similar researches that also used the social practice theory will be discussed. Within this section five similar researches will be discussed shortly.

The first similar research is from the book "De betekenis van groene burgerinitiatieven"(Mattijssen, Buijs, Elands, & Dam, 2015). This is a research done on sustainable citizen initiatives as agencies that focus mainly on sustainable awareness-raising and education. The social practice theory is used within the analysis of these initiatives. This project is similar to the e-waste race, because the e-waste race also spreads knowledge and awareness about a sustainability issue.

A second similar research is discussed in the article "Practice-ing behaviour change: Applying social practice theory to pro-environmental behaviour change"(Hargreaves, 2011). Within this article the insights of social practice theory are applied to the study of pro-environmental behavior change. Which is the same is will be done within this research. The e-waste race also tries to change people's behavior (practice) towards a more sustainable e-waste recycling practice.

This research is also done by conducting case studies and semi-structured interviews. As will be discussed in the next chapter on methods, these are some of the same methods as were used within this research.

The third research that substantiates the choice of theory in this research is the article "Governing transitions in the sustainability of everyday life"(Shove & Walker, 2010). Within this article it is stated that the themes of social practice theory are key themes for any understanding of a sustainable innovation, let alone transition in practice. As this research is about analyzing a change in practice due to an innovative sustainability project, this is also suitable for this research.

The fourth research that is similar to this one is within the report "Addressing consumption patterns through meaning in social practices – findings from a mixed methods analysis of... "(Paper, Liedtke, & Hasselku, 2014). Within this report an analysis was conducted on survey data on environmental awareness in Germany by using the social practice theory. As mentioned above, this project is similar to the e-waste race, because the e-waste race also spreads knowledge and awareness about a sustainability issue.

The fifth and last research that substantiates the choice of theory in this research is the report "Elektronisch unterstützte Einbindung von BürgerInnen in den Klimaschutz"(Aichholzer, 2013). Within this report it is stated that the social practice theory approach recognizes the complexity of social change involved in transitions towards sustainability and that it therefore is a recommendable theory to use for a research on behavioral change towards more sustainable lifestyles. As it is analyzed within this reserahc if the E-waste race changes people's e-waste recycling behavior toward a more sustainable lifestyle, this is also applicable for the e-waste race.

The five examples above show that the social practice theory is a suitable theory for the research done within this report. The next section will discuss how this theory is applied to this research on the E-waste race.

When applying this theory on the E-waste race an interesting division appears. This research is interested in the effect of the e-waste race on e-waste recycling practice. As will be explained during chapter 5 on results, the results will be analyzed in a division from before the race, during the race and after the race. This will be done because the e-waste recycling practice from during the race is different than the e-waste recycling practice in Eindhoven before the race. The thing that is interesting is to see if these changes made in recycling practice during the race if they also sustained after the race took place. So basically there were three different practices. There was one practice before the race, one during the race and one after the race. As explained in the previous chapter on research question, the analyzing of these three practices will be divided into the three element of practice. Each of the three elements within the context of this research will be discussed within the next section.

Three elements of e-waste recycling practice

The first element of practice is the material element. Within the e-waste recycling practice, the "things" belonging to the material element are the "things" needed to perform the e-waste recycling practice. Hereby are meant the things that are needed to recycle. This is for example the recycling infrastructure. In order for people being able to recycle e-waste, the infrastructure has to exist. One example of an infrastructure can be that the e-waste has to be brought to a dumping grounds("Cure afvalbeheer | Inzameling afval en milieustraat Eindhoven Geldrop-Mierlo Valkenswaard," n.d.). Hereby belongs also for example a way of transportation that is needed to bring the e-waste to the dumping ground. These all are material elements related to the e-waste recycling practice.

The second element of practice is the competence element. Within the e-waste recycling practice, this is the knowledge to being able to evaluate the recycling of e-waste performance and having the skills required to perform the e-waste recycling practice. This means that belonging to the element of competence are the knowledge of what e-waste is and the knowledge and skills of how to recycle e-waste.

The third element of practice is the meaning element. Within the e-waste recycling practice, this stands for the social and symbolic significance of performing the e-waste recycling practice. So the knowledge of why it is important to recycle e-waste. There can be more than one reason of why recycling e-waste is important and these all belong to the meaning element of practice.

In this chapter the theory that will be used to analyze the results was discussed. The next chapter will be about the methods used to get these results.

CHAPTER 4: METHODS

Within this research, data was gathered that was used to answer the (sub-) research questions. What kind of data was gathered and how, will be discussed within this chapter. This chapter will be divided into four Sections. The first section will discuss the scale of this research. The second will be about the questionnaires and interviews done during this research. The third section will discuss the questions asked during the questionnaires and interviews. The last section will be about who participated during the research. This chapter will start with discussing the scale of this research.

4.1 SCALE

The timeframe of doing this final bachelor project was provided with a limitation. This had as result that this research could only focus on one race region. The E-waste race has taken place in several regions within The Netherlands("Resultaten - E-Waste Race," n.d.). The company is located in Eindhoven so the traveling when doing the fieldwork will be less time consuming. Because of the proximity to Eindhoven it was decided to focus the research on this region. The E-waste race takes place annually in Eindhoven since its start in 2015("Resultaten - E-Waste Race," n.d.). This means that this research had to be conducted before the next years' race started, because the new race would interfere with the results. The E-waste race was interested in long-term effects. This means that the research needed a large period of time between the race and the fieldwork. The largest period of time between two races is one year. So the research was conducted one year after the last E-waste race had taken place. The research was conducted in 2017, so the race which was investigated was the E-waste race in Eindhoven in 2016. In order to answer the research questions fieldwork needed to be done. The type of fieldwork that was done will be discussed within the next section.

4.2 QUESTIONNAIRES AND INTERVIEWS

To find out if the E-waste race helped changing people's e-waste recycling practice the three elements will be analyzed before, during and after the race as mentioned in the chapter about the research question. This section will discuss what kind of research was done to answer these research questions. This section will be divided into three different sub-sections. The first section will discuss the three different types of schools that participated during this research. The second section will discuss the different groups of people that participated during the research. The third section will discuss the different ways of research that was used within the different schools. The fourth section will explain the different types of methods that were used within this research and why they were used.

Three case studies

In order to do this, three schools were analyzed. This means that three case studies were done.

The first one is a school that collected a lot of e-waste during the race last year. The second one is a school that collected a little amount of e-waste during the race and the last and third one is a school that did not

participated at the E-waste race. What is meant with high scoring school is a school that collected a lot of e-waste during the race for which the school received a lot of points. These points were then again divided by the number of participating students in that group, which was the score of that group. This is done so that a group with a little amount of students will have the same chance of winning the race as a group with a lot of students.

The first two schools were chosen to get insides on what changes were made during the race thanks to the e-waste race and if these changes sustained. A high and a low scoring school were chosen for this, just to see if there is a relation between the amount of e-waste collected and the amount of effects that sustained after the race. The last school, that did not participated at a race, was chosen in order to give some more inside on the e-waste recycling practice before an E-waste race took place. This was done so that the effects of the e-waste race could really be seen by comparing the situation before a race with a situation after a race.

When choosing elementary schools for the high and the lows coring schools it was important to look at schools where the students that did the e-waste race last year still go to the same elementary school. So looking for schools where children from group 6 and 7 participated one year ago. When looking for an elementary school that did not participated it was important to look for schools where the students did not know what the e-waste race was. So that that these students did not have a lot of prior knowledge about e-waste thanks to the E-waste race.

After defining at what kind of schools the research will be done, in the next section it will be discussed what kind of research will be done at these school.

Three layers

As mentioned in the chapter about the research question, when the students collect e-waste during the race they can also spread the knowledge that was provided by the E-waste race onto other people. This means that the E-waste race could also influence the recycling behavior form these other people. This means that different kinds of people can be influences by the e-waste race. Within this report these different kinds of people are being divided into three main layers; School, home and Neighborhood. The school layer consists of the students that participated in the previous race, other students from the school that did not took part within the project and the teachers. The home layer consists of the parents and siblings of the children that participated in the previous project. The neighborhood layer consists of the people living in the neighborhood of the schools.

In order to analyze the level of influence that the E-waste race had on the different types of layers, methods were used for each layer. The next section will discuss the different types of methods used at each layer discussed per case study.

Research done per case study

First the methods used for the high and low scoring school will be discussed per layer. This will be followed by methods used for the school that did not participate during a race.

High and low scoring school

For the high and low scoring schools that participated during the previous E-waste race, the school layer's information was collected by organizing quizzes (questionnaires) and interviews. Within this research the school layer will again be divided into three sub categories. The first category is the group of children that participated during last year's E-waste race. The second category is the teachers that supervise the children during the previous E-waste race. The last category is the other children within the participating school that never participated at an E-waste race.

The quizzes for the first category (the students) were about the information provided during the standard E-waste race lecture to test how much standard knowledge was still present after one year. In addition to the standard knowledge questions this quiz also asked questions about how they dealt with e-waste at home at that moment, questions about how they campaigned during the previous race and about what these children thought about the impact of the E-waste race. Interviews on first category were done with two students on similar questions to receive more elaborate insights.

Quizzes about the standard knowledge could have also been held in the third category (students that did not participated) to test how much the knowledge about e-waste had spread within the school and how much knowledge had also remained. The quizzes could have been combined with a little lecture in order to have made it more interesting for these classes to participate within this research. If a classical quiz would have taken up too much time for the teachers there was also a second way to gain knowledge on the third category. A second option would have been to hand out questionnaires or to do interviews on the schoolyard during a break. The children could have participated voluntarily and it was not time consuming for the teachers. Unfortunately due to time limitations it was not possible to do the research on the third category. This came due to slow response from the school. In the end it would have been possible to do interviews on the schoolyard, but because the date was set at such a late time in the research process, there was no time left to do this research. The questionnaires that would have been done with these students are shown in Appendix Fieldwork.

The second category, the teachers that supervised the children during the previous E-waste race, was also interviewed. The interviews with the teachers were about how their classes campaigned during the race, how many people they thought where reached during the race and what the teachers though about the impact of the E-waste race.

The research conducted within the home layer depended on the extent to which the school was willing to cooperate with respect to contacting the parents. Such as meeting them at parent night or handing out personal data such as address and telephone numbers. The schools did not give away this kind of information, but it was possible to formulate a letter and give it to the children to bring home. This letter consisted of a questionnaire together with contact information for if they were willing to do an interview. The questionnaires covered questions about what the impact of the e-waste race was on them to see if it resulted in a change of thinking and acting by the parents and questions about if they saw changes in the thinking and behavior of their children due to the E-waste race. If contact with the siblings would have been possible they could have been asked to participate at the standard information quiz to see if the information from the e-waste race project had spread to them as well. Unfortunately this was not the case.

The information from the neighborhood layer was tried to be gathered by randomly handing out questionnaires to people in the neighborhood. This was done at crowded places such as the supermarket and by going from door to door. Questionnaires were more convenient compared to interviews because it took less time for the researcher and people can do it simultaneously. The plan was that interviews could have been done with people that were reached by the E-waste race. They would have been about if they knew what the e-waste race is. If yes, where did they hear from it and did it change their practices. If they did not hear of it they could be asked what they know about e-waste already. In both cases standard knowledge questions could have been asked and it would have been good to know were these people live to see how far from the school the information had spread and if there was some kind of pattern. Unfortunately there were no neighbor found that did hear from the E-waste race and almost no people were willing to participate. The questionnaires that would have been done with the neighbors are shown in Appendix Fieldwork.

School that did not participate at a race

A quiz with the standard knowledge questions was also done at the group of students where no class at that school ever participated at the E-waste race. This was done to create an inside of the level of e-waste related knowledge before a race took place. The quiz also included questions about their current e-waste recycling behavior. The quiz was combined with a lecture on e-waste in order to make it more interesting for a group to participate.

It was chosen because of three reasons to only do questionnaires with the students and not with the parents or the rest of the neighborhood. The first reason was the time limitations. It took a very long time before the questionnaire meeting with the students was definitely scheduled. After this there was very little time left in the research process. Next to that the second reason was that it was already very difficult to contact the parents from students that did participate at the race. It would have been even more difficult to contact parents from children that did not participate at the race. The third and last reason was the school that participated as school for this case study. As will be mentioned in section 4.4 on schools chosen, this was a very different school which made the results not very representative. The risk was that the results from the

other layers would have also been not very representative. So the decision was made to only do questionnaires with the students.

After having discussed all the different types of fieldwork, the two tables displayed below show an overview of the different types of filed work mentioned in the two sections above. Table 4.2 shows which types of methods were used at the different schools and layers. Table 4.1 shows the content of the methods used at the different schools and layers. The content of the questionnaires will be discussed in more detail in the section 4.3 on questions.

After having discussed the different types of methods used, the next section will discuss why these types of methods were chosen.

layers	Case-study high Group that collected a high amount of e-waste during last year's race	Case-study low Group that collected a low amount of e-waste during last year's race	Baseline case A class 6, 7 or 8 that did not participate at the E-waste race and neither has another class within their school.
School layer			
students	Knowledge remaining+ behavior during the race+ impact	Knowledge remaining+ behavior during the race+ impact	Baseline knowledge+ e-waste recycling practice know
teachers	Behavior during the race+ impact	Behavior during the race+ impact	
Other students within the school	Knowledge remaining+ impact	Knowledge remaining+ impact	
Home (parents)	Knowledge remaining+ behavior during the race+ impact	Knowledge remaining+ behavior during the race+ impact	
neighborhood	Knowledge remaining+ impact	Knowledge remaining+ impact	

Table 4.1: content of the methods used per school and layer

layers	Case-study high Group that collected a high amount of e-waste during last year's race	Case-study low Group that collected a low amount of e-waste during last year's race	Baseline case A class 6, 7 or 8 that did not participate at the E-waste race and neither has another class within their school.
School layer			
students	All questionnaires+ 2 interviews	All questionnaires+ 2 interviews	questionnaires
teachers	interview	interview	
Other students within the school	Interviews	Interviews	
Home (parents)	questionnaires	questionnaires	
neighborhood	questionnaires+ interviews for people who know the E-waste race	questionnaires+ interviews for people who know the E-waste race	

Table 4.2: types of methods used per school and layer

Previous research

During the fieldwork within this research, amongst others, four different kinds of methods were used, so a mixed method approach was used (Greene, Caracelli, & Graham, 2016).

First, a set of semi-structured interviews were done. In this case this means that a set of questions or themes are determined beforehand, but the structure can change due to new ideas brought up by what the interviewer says (Longhurst, 2003). The semi-structured approach was done, because some structured questions were needed in order to compare the different schools, but in order to explore the differences between the schools it was important to let the interviewee speak freely.

Second, also face-to-face and paper-pencil surveys or questionnaires were used as a method (De Vaus, 2013). During the quizzes the face-to-face method was used and for the neighborhood paper-pencil surveys were planned to be used.

A third method used was the one of comparative case studies (George & Bennett, 2005). Within this report 3 schools were analyzed so these are the three case studies. The three schools were compared which made this a comparative case study.

Among all these methods also questionnaires and interviews were used. That Interviews and questionnaires were used within this type of research is quite common.

An example of a similar kind of research is the report "Communicating the Greenhouse Effect to the Public" written by i.e. H. J. Staats (Staats, Wit, & Midden, 1996). Doing that research Staats and colleagues examined the effects of a nationwide media campaign in the Netherlands. The aim of this campaign was to raise awareness of climate change by increasing knowledge about climate change, with the underlying assumption that increased knowledge and awareness would encourage people to change behavior(Staats et al., 1996). To research the effectiveness of the campaign they let about 900 Dutch residents fill out a survey and conducted some interviews before the campaign was launched. After the campaign again 700 Dutch residents filled out the same survey and conducted some interviews.

Within this research we also wanted to determine the effects of a sustainability awareness project. Instead of conducting interviews and surveys before the E-waste race we compared the results with a school that did not participate during the race. The research is quite similar and also uses interviews and surveys just like within this research.

Before choosing the types of methods that were used within this fieldwork, research on a variety of different methods was done. The quick notes made during this research are added in the Appendix fieldwork.

After having discussed the types of methods used, the next section will go in more detail on the content of these methods.

4.3 QUESTIONS

Within this section the content of the questionnaires will be discussed in more detail. Only the questionnaires that were used within this research are going to be discussed in this section. So the questionnaires for the neighborhood or other students at the same school, will not be discussed within this section.

The different questions will be divided into the three elements of practice and the practice itself. So the answer of these questions provides information on knowledge of behavior related to which kind of element or if it relates to the overall practice. This is done so that in the chapter of results, the results of the questionnaires can be analyzed more easily.

Table 4.3 and 4.4 show the questions used in the questionnaires. The first thirteen questions that are presented in table 4.3 are the same for all questionnaires so the same for the students from all case studies and the parents for the high and low scoring school. Table 4.4 shows the rest of the questions from the

questionnaires from the students and the parents from the high and low scoring school. The questionnaire, for the students form the school that did not participate at the e-waste race, only has the thirteen questions displayed in table 4.3.

The questions of these questionnaires are color coded. The questions that are marked blue are related to the competence element of the recycling practice. The questions that are marked red are related to the meaning element of the recycling practice and the questions that are marked green are related to the implementation of the e-waste recycling practice.

Questions 2, 3, 4, 5, 6, 7, 9, 10 and 11 are all related to the competence element of the practice. This is because all questions relate to the knowledge of what e-waste is or is not or they relate to how and when to recycle e-waste. Question 7 about what recycling is also relates to the competence element of the e-waste recycling practice. This is the case because in order to being able to recycle e-waste the understanding of what recycling is needs to be present. So all these question relate to the knowledge and skills required to perform the e-waste recycling practice.

Questions 8, 12 and 13 are all related to the meaning element of the practice.   This is because all questions relate to knowledge, about the sustainability reasons and health risks, of why to recycle e-waste.

Questions 1, 14 (from the parents), 16, 17 and 18 (from the parents) are all related to the extent to which the e-waste recycling practice is implemented. Questions 16, 17 and 18(from the parents) are related to effect of the e-waste race that sustained after the race took place. Although questions 16 and 17 are not directly about recycling behavior, they are about the effect of the e-waste race which strongly relates to the extent of which the implementation of the recycling practice improved thanks to the e-waste race. The participants also included information, of the extent to which the recycling practice improved, into their answers.

After having discussed the questions of the questionnaires used, the next section will discussed which schools agreed to participate at these questionnaires and the whole research.

Standard knowledge questions	
Question 1	What do you do with this waste at home?
	vegetables and fruit waste
	Electronic waste (right answer: Bring it to the dumping ground)
	residual waste
Question 2	What is electronic waste? **A**. Only everything that has/had a plug or had batteries inside. B. Only everything that has computer chips inside such as for example phones, computers and TV's
Question 3	What is no e-waste? A. The computer case (so not the monitor) **B**. Ink cartridges
Question 4	What is no e-waste? **A**. Batteries B. Milk frother
Question 5	What is no E-waste A. Kable **B**. Light bulb
Question 6	What is no E-waste A. Toy car with remote control **B**. CD's
Question 7	What is recycling?
Question 8	Why is recycling Important?
Question 9	What should you do with your electronics if they are broken? A. Keep them at home in a closet B. Place it outside on the street and the garbage men will collect it then C. Throw it away together with the residual waste at home **D**. Bring it to the dumping ground
Question 10	What should you always check before you throw away e-waste? A. If it is switched of **B**. If it is really broken
Question 11	What can you do best if devices still work, but you do not want them anymore? A. Throw them away, because you do not need them anymore B. Leave them laying around at home **C**. Give it to someone would use that device or bring it to a thrift shop
Question 12	In countries where a lot of electronic devices are used (such as the Netherlands) are important raw materials that are needed to produce these devices often not available. These raw materials then have to be received from other countries. Often this happens by unsustainable transportation. Why is this not good?
Question 13	What happens with e-waste in developing countries when It is not recycled in a proper way?

Table 4.3: Questions 1-13 for the questionnaires for the students from all case studies and the parents for the high and low scoring school.

parents		students	
Question 14	Do you have e-waste lying at home at the moment?	Question 14	Which way collecting e-waste shown below have you used? - Flyers - Radio - Made a Youtube clip - from door to door collecting - a different option namely:..
Question 15	With who have you talked about the e-waste race? (number of people per parent) - My partner : How much - My parents and stepparents How much: - My brothers and sisters How much: - My neighbors How much - other relatives How much -colleagues How much: - Acquaintances How much: - People on the streets that I do not knew How much:	Question 15	With who have you talked about the e-waste race? - My parents and stepparents How much: - My brothers and sisters How much: - My neighbors How much: - Friends of mine that are not in my class How much: - My grandparents How much: - My uncles and aunts How much: - My nieces and nephews How much: - Acquaintances How much: - People on the streets that I do not knew How much:
Question 16	Do you think that you have learned a lot about e-waste and sustainability during the e-waste race? And why? Give an example.	Question 16	Do you think that you have learned a lot about e-waste and sustainability during the e-waste race? And why? Give an example.
Question 17	Do you think that your family, neighbors and other neighborhood members will recycle in a better way thanks to your child's participation at the e-waste race? And why? Give an example.	Question 17	Do you think that your family, neighbors and other neighborhood members will recycle in a better way thanks to your participation at the e-waste race? And why? Give an example.
Question 18	Do you think that your child has learned a lot about e-waste and sustainability due to its participation at the e-waste race? And why? Give an example.		
Question 19	Are there questions or remarks you would like to make about the e-waste race?		
Question 20	Did you gave e-waste to your child to bring to school during the race?		

Table 4.4: Rest of the questions from the students and the parents from the high and low scoring school

4.4 SCHOOLS CHOSEN

Three schools have been found that agreed to participate at this research. The first school was the Theresia elementary school in Eindhoven which won during last year's E-waste race. This is school collected the most e-waste during last year's race. The second school is the elementary school de Schakel in Eindhoven which collected almost the least amount of e-waste during last year's E-waste race. The results of last year's race are shown in the table 4.5 displayed below.

Name	students	items	points	Score
Theresia	48	2800	49240	1026
Hasselbraam	28	910	16820	601
de Kameleon	42	1409	24880	592
de Hanevoet	87	2380	41670	479
Slingertouw	75	1793	35220	470
Reigerlaan	52	915	17980	346
Driestam	49	685	13870	283
Klimboom	47	429	8430	179
de Schakel	23	243	3790	165
Floralaan	86	97	2370	28

Table 4.5: Results E-waste race Eindhoven 07.03.2016-08.04.2016 ("resultaten @ www.ewasterace.nl," n.d.)

The third school that agreed to participate within this research is the school named 'democratisch Onderwijs Eindhoven' or also called 'doe040'. This is the school that did not participated at the E-waste race and it is a very special school. This school was founded by Jacqueline de Theije-van Ewijk with the teaching philosophy that the students are responsible for their own development("Visie en missie – DOE040," n.d.). Although this school works in totally different way than regular elementary schools in Eindhoven, this school is certified as official elementary school by the Dutch government("FAQ – DOE040," n.d.). Also this school has students from all ages working together. For this research only the questionnaires of students from years 8 till 12 were used. This is done because the e-waste race normally takes place in years 6, 7 and 8 of the elementary schools and these students are between 8 and 12 years of age("Hoe zijn de groepen op de basisschool georganiseerd? — Anababa," n.d.). This school was chosen for this case study, because this was also the only elementary school that did not participate at the E-waste race that agreed to participate within the research.

Because the school for the not participated case study is such a special school the material properties from this school were analyzed. When doing this it was found out that the results of this school are not very representative due to three material properties. These will be discussed in the section below and they will be taking into account when analyzing the results.

Material property case study doe 040

The results of this school are not very representative, due to 3 material property reasons.

The first reason is that this school is a very special school which means that these children are form very specific households.

The Second reason is that they children did not work separately on their own tables. Within this school they do not work with the classical classroom concept. This means that the children sat down on chairs that were placed in a half circle. In order to write properly almost all children lay down on the ground. This means that the children did talk to each other a lot and even the teacher walked around and helped some children. The effect of this can be seen in the results of these questionnaires. Several results are very similar in a way that the students phrased their answers in a similar way.

The third reason is that some children had problems writing so they only answered the multiple-choice question. This could also mean that some children had difficulties reading either and so they did not fully understand the questions, which could result into wrong answers.

Within this chapter the methods used within this research were discussed. The results that came out of these methods will be discussed an analyzed. This will be done within the next chapter.

CHAPTER 5: RESULTS

The results will be presented in a structure that will follow the three elements of the social practice theory. This is done in order to show in a clear way how the theory is useful in analyzing the results. As discussed in the chapter 4 on methods, the fieldwork was divided into three case studies. The results from these three case studies are presented within this chapter. These results are also divided into before the race, during the race and after the race. This is done so that the changes that were made by the e-waste race can be shown in a clear way.

5.1 BEFORE

This section is about the situation of recycling e-waste in Eindhoven before the E-waste race took place. The questionnaire results used in this section are from the school that did not participate at the e-waste race (doe040). The results of the questionnaires done at this school are presented in table 5.1 and they are being discussed throughout this section.

Number of students	10	answers right	% right
Question 1	What do you do with this waste at home?		
	vegetables an fruit waste		
	Electronic waste (right answer: Bring it to the dumping ground)	1	10
	residual waste		
Question 2	What is electronic waste? **A**. Only everything that has/had a plug or had batteries inside. B. Only everything that has computer chips inside such as for example phones, computers and TV's	4	40
Question 3	What is no e-waste? A. The computer case (so not the monitor) **B**. Ink cartridges	8	80
Question 4	What is no e-waste? **A**. Batteries B. Milk frother	6	60
Question 5	What is no E-waste A. Kable **B**. Light bulb	4	40
Question 6	What is no E-waste A. Toy car with remote controle **B**. CD's	7	70
Question 7	What is recycling?	8	80
Question 8	Why is recycling Important?	4	40
Question 9	What should you do with your electronics if they are broken? A. Keep them at home in a closet B. Place it outside on the street and the garbage men will collect it then C. Throw it away together with the residual waste at home **D**. Bring it to the dumping ground	7	70
Question 10	What should you always check before you throw away e-waste? A. If it is switched of **B**. If it is really broken	6	60
Question 11	What can you do best if devices still work, but you do not want them anymore? A. Throw them away, because you do not need them anymore B. Leave them laying around at home **C**. Give it to someone would use that device or bring it to a thrift shop	10	100
Question 12	In countries where a lot of electronic devices are used (such as the Netherlands) are important raw materials that are needed to produce these devices often not available. These raw materials then have to be received from other countries. Often this happens by unsustainable transportation. Why is this not good?	2	20

| Question 13 | What happens with e-waste in developing countries when It is not recycled in a proper way? | 0 | 0 |

Table 5.1: results questionnaire students case study doe040, x=competence x=meaning x=practice

Within this section the states of the three elements of practice before the race will be discussed, followed by the state of the e-waste recycling practice before the race.

5.1.1 MATERIAL

Within this section the material element of the e-waste recycling practice before the e-waste race took place will be discussed. The infrastructure of how to recycle will be discussed within this section.

Infrastructure

When wanting to dispose e-waste in Eindhoven there are three options ("Cure afvalbeheer | Inzameling afval en milieustraat Eindhoven Geldrop-Mierlo Valkenswaard," n.d.). The first option is to bring your e-waste to the local dumping ground. The second option is to hand it in at a store when buying a similar product. The last option is to contact cure so that they will pick up the e-waste. In order to get the e-waste picked up stickers have to be bought at the Cure customer service location. These stickers then need to be placed on the e-waste. The stickers are available for a minimum price of 10 euro per sticker going up to 60 euro per sticker. This is because for a sticker to put on one device the price is € 10,-. For a "Big Bag" of 1 m³ where al lot of small electronic devices can placed in the price is € 40,- and for "Big Bag" of 1,5 m³ with sticker the price is € 60,-.

This shows that for a private person disposing e-waste in a proper way is related to a lot of effort. They have to either transport there e-waste or pay money in order to get it picked up. This could be a reason for why a large amount of e-waste is not recycled appropriately as mentioned in the chapter on introduction. Unlike other waste streams such as residual waste, the e-waste stream is a waste stream where there is not large amount of waste produced in a small time interval. This means that most of the time when e-waste is being produced it is just one product. To put in so much time and effort in order to recycle just one product may be the reason why a large amount of the e-waste is not recycled appropriately.

Above it is mentioned that a large amount of e-waste is not being recycled appropriately. In order to get an inside of the effect of the e-waste race it would be nice to see the amount of e-waste that is being recycled in Eindhoven before the E-waste race took place. This is what the next subsection is about.

5.1.2 COMPETENCE

Within this section the competence element of the e-waste recycling practice before the e-waste race took place will be discussed. In table 5.1 the results of the questionnaire from the not participating school (doe040) are shown. As discussed in the chapter 4 on methods, within the doe040 case study only questionnaires with students were doen. The questions of this questionnaire are color coded. The questions that are marked blue are related to the competence element of the recycling practice. As mentioned in the chapter 4 on methods, these are questions that are for example about what e-waste is and what to do with it so that it is being

recycled appropriately. When looking at the results it shows that the competence related knowledge is quite high, overall well above 50% with an average of 67%. As discussed during the material properties in the chapter on methods the results from this case study are not very representative.

Luckily results of the two other case studies provided some extra insight on the level of competence at the school layer before the e-waste race.

This information about the students was gathered during the four interviews done with the students form the high scoring school and the low scoring school. During these interviews the students were asked if they thought that the E-waste race had an impact on them. All 4 of the students answered with yes and added that they did not know a lot about e-waste before the e-waste race.

> "I did not know anything really about electronic waste etc. Now I know quite a lot about it."

> Student 1, low scoring school

> "I did not know anything really on what electronic devices are and what not. Also I did not know what my parents should do with electronic devices when they are broken……I do know these stuff now so I really learned a lot."

> Student 2, low scoring school

> "Well I knew that you should not through it on the ground or in the sea, but more than that I did not know and now I know that I need to bring it to the dumping ground"

> Student 1, High scoring school

> "I did not know anything on e-waste actually, whether on what it was, that you had to bring it to the dumping ground or…. I know all these things now."

> Student 2, high scoring school

They did not know exactly what e-waste was and where to place it when wanting it to be recycled. This shows that for these 4 students the level of competence related to the e-waste recycling practice was very low before the E-waste race. The teachers from these students mentioned that these 4 students were some of the best students of the class in terms of intelligence etc. So if these 4 "good" students had a low level of competence before the race it can be assumed that most of the elementary school students have a low level of competence before the race.

Belonging to the school layer are also the teachers. Not much information on the competence level before the race was gathered. The only information on the topic comes from an interview with one of the teachers.

"Before the e-waste race I did not recycle e-waste. I knew that I should bring it to the dumping ground, but I was too lazy. Than when I heard all the impact on the environment that it has I was really stunned. I did not know the importance of recycling e-waste before. Now I also know what all belongs to the category of e-waste. Before the e-waste race I did not knew that for example a water boiler should also be recycled. I did not know that this is also e-waste. I know the importance of recycling e-waste now; I now do recycle e-waste."

Samira Saleh Bakir (teacher), high scoring school

This shows that the teacher did know how to recycle e-waste, but she did not knew the broad definition if what belongs to the category of e-waste. The teacher from the high scoring school did not mention anything about his competence related knowledge before the race. The result is that teachers had competence related knowledge in terms of how to recycle e-waste, but not in terms of what e-waste is. This result is based on the statement of only one teacher, so it is not known if this result is highly representable for all teachers.

Above discussed is the level of competence related knowledge present before the race within the school layer. The other two layers will not be discussed within the before section thanks to a lack of data, which is explained in the chapter of method.

The interview from the high scoring school's teacher further shows that she also did not to know the importance of recycling e-waste. This kind of knowledge relates to the element of meaning which will be discussed in the next section.

5.1.3 MEANING

Within this section the last element of the e-waste recycling practice before the e-waste race took place will be discussed, the meaning element. In table 5.1 the results of the student's questionnaire at the school that did not participate (doe040) are shown and the questions that are marked red are related to the meaning element of the recycling practice. These are questions that relate to the sustainability and health reasons of why people should recycle e-waste. When looking at the results of the doe040 questionnaires it shows that the level of meaning from the recycling practice is not that high. The average amount right per question is 20% with the lowest value of 0% right at one question. Here again it is the case that the results from this case study could be not that representative.

So again results from the other two case studies are used to provide some extra insight on the level of meaning at the school layer before the e-waste race.

When asking the 4 students if the E-waste race have had an impact on them, they all answered with yes, as mentioned in the competence section.

"I did not know anything really about electronic waste etc. Now I know quite a lot about it."

"…..Also, I did not know that recycling electronic waste is so important, for example I did not know that gold will be gone in 40 years if we do not recycle. I do know this stuff now so I really learned a lot."

Student 2, low scoring school

"I also did not know why it is so important to recycle. Like for example that in poor countries people than have to burn the e-waste in order to get some of the valuable metals out of the waste and that that id bad for nature but also for the people. So yes I really learned a lot because I know this now".

Student 1, high scoring school

"I did not know anything on e-waste actually….or that it is important for the environment to recycle e-waste. I know all these things now."

Student 2, high scoring school

Further they also added that they did not really know why recycling e-waste was important before the E-waste race. So again it can be assumed that most of the elementary school students have a low level of meaning before the race, because these 4 "good" students had a low level of meaning before the race.

Belonging to the school layer are also the teachers. Also not much information on the meaning level before the race was gathered. The only information on the topic comes from an interview with one of the teachers.

"Before the e-waste race I did not recycle e-waste. …Than when I heard all the impact on the environment that it has I was really stunned. I did not know the importance of recycling e-waste before. …. I know the importance of recycling e-waste now; I now do recycle e-waste."

Samira Saleh Bakir (teacher), high scoring school

This shows that the teacher did not have meaning related knowledge before the race. She did not know the importance of why to recycle e-waste before the e-waste race. Again, the teacher from the high scoring school did not mention anything about his meaning related knowledge before the race. The result is that teachers did not have a high amount of meaning related knowledge before the race. Again, this result is based on the statement of only one teacher, so it is not known if this result is highly representable for all teachers.

Above discussed is the level of meaning related knowledge present before the race within the school layer. Again, the other two layers will not be discussed within the before section thanks to a lack of data, which is explained in the chapter of method.

5.1.4 PRACTICE

The final section of the "before" part is on the overall recycling practice before the E-waste race took place. Within this section it will be discussed how effective or implemented the practice of recycling e-waste is in Eindhoven by looking at three research outcomes.

First is, when looking at the results of the student's doe040 questionnaires one question relates to the level of implementation of the e-waste recycling practice. This is the question of what happens with e-waste at the moment at the homes of the students. This question is marked green in table 5.1. When looking at the results of table 5.1 it shows that only 10 % of the students said that it is brought to the dumping ground. In this case the results can be representable as the students worked together to find the right answer, but still not many of the students filled in that they do recycle e-waste at home. This means that before the e-waste race the e-waste recycling practice is not implemented widely.

A second outcome that implies that the recycling practice was not implemented widely in Eindhoven before the race is the following one. The municipality of Eindhoven payed the E-waste race so that they collect e-waste and spread knowledge about recycling e-waste. The municipality would not have done this if they thought that the e-waste recycling behavior in Eindhoven was sufficient before the race.

The last outcome is that during the E-waste race the children collected a large amount of e-waste, namely 11.666 items of total 14.890 kg("Resultaten - E-Waste Race," n.d.). The fact that the students collected a large amount of e-waste within only 4 weeks suggests that a lot of e-waste was stored at neighbors' homes. If the e-waste was stored at home it means that it was not already recycled. So instead of being recycled appropriately the neighbors just stored the e-waste within their homes. This also shows that the e-waste recycling practice before the E-waste race was not implemented well.

So the outcome form the above section shows that the e-waste recycling practice before the race was not successful. The image 5.1 below shows an overview of all the elements of the e-waste recycling practice before the race. The next section will discuss the changes that the E-waste race made during the race trying to improve this e-waste recycling practice.
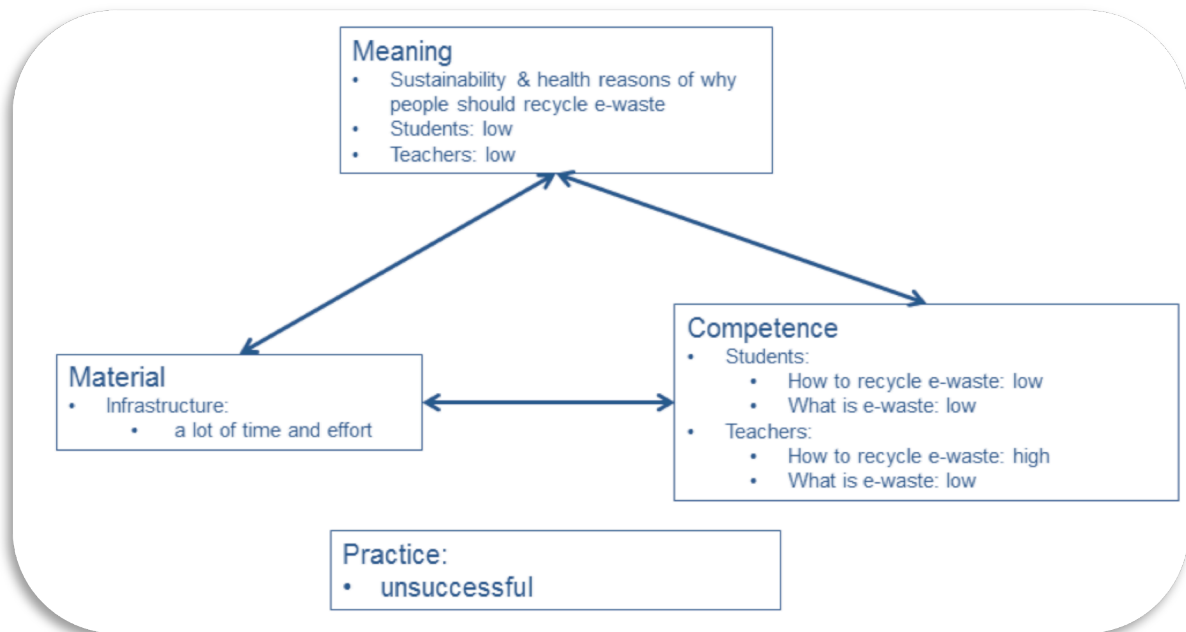
5.2 DURING

This section is about the e-waste recycling practice during the E-waste race. The findings within this section are mainly based on interviews done during the case studies from the high scoring school and the low scoring school.

Within this section again the states of the three elements of e-waste recycling practice during the race will be discussed, followed by the state of the e-waste recycling practice during the race.

5.2.1 MATERIAL

Within this section the material element of the e-waste recycling practice during the e-waste race will be discussed. Here again the infrastructure of how to recycle will be discussed within this section.

Infrastructure

During the E-waste race there are two pathways of how the e-waste is being collected.

The first pathway is the one where the students collect the e-waste. This can be done by going door-to-door within the neighborhood, collecting e-waste from their homes or asking relatives and acquaintances for e-waste. When the e-waste is collected the students will bring them to the school. In order to receive points for the e-waste the students have to register the collected e-waste online. This is done on the official E-waste race website. After the e-waste is registered it is thrown in the special e-waste containers that are placed at each school. These special e-waste containers are provided by Eindhoven's garbage disposal firm Cure. The

containers are being replaced and emptied on a weekly basis by Cure. Cure than makes sure that the e-waste is being recycled appropriately.

The second pathway of collecting e-waste during the E-waste race works via an online platform. The e-waste race designed an online platform where neighbors can register e-waste. They fill in the amount and type of e-waste followed by their address and time slots the e-waste can be picked up. The students can then reserve the e-waste at a certain time slot and pick it up. If the reserved time slot has passed the students will automatically receive the points for the e-waste. When the e-waste is collected the students can directly place the e-waste into the special e-waste containers at their school. Where the e-waste is being gathered and recycled by Cure.

Compared to the regular e-waste recycling infrastructure in Eindhoven, the infrastructure during the e-waste race requires less effort and time for the neighborhood inhabitants. They do not have to bring their e-waste to a certain location, but it is being picked up by the students. The knowledge of how to use this infrastructure belongs to the competence elements of the e-waste recycling practice during the race. So the next section will discuss the competence element.

5.2.2 COMPETENCE

This section is about the competence element of the recycling practice that is communicated during the e-waste race. Belonging to the competence element are for example what is e-waste and how to recycle e-waste, as mentioned in the chapter on theory. These two questions are answered and explained during the introduction lecture.

During this lecture two ways of how to recycle e-waste are provided. The first one is the infrastructure used during the race, which is explained in the section above. The second way is the infrastructure used before the race, which is explained in the material before section 5.1.1. So in order to know how to recycle e-waste people need to know where they can place their e-waste so that it is being recycled. During the introduction lecture the students and their teachers get explained how to recycle e-waste during the race, but also how they should recycle e-waste when there is no race taking place.

The knowledge of what e-waste is and how it can be recycled should be spread by the students when collecting e-waste. And that the students should spread knowledge during the collecting hereby is meant that when the students try to collect e-waste they then tell the story of why they are collecting e-waste. Here by they should then tell about how to recycle e-waste and they also know what e-waste is, so what to collect and what not. This again they should also communicate during the collecting. There are two main findings on how these competence elements, of how to recycle e-waste and what is e-waste, are communicated throughout the neighborhood.

The first finding is that in the interviews it was mentioned that most of the e-waste came from their personal network so their parents, family and close friends.

> "I went from door to door, but most of the e-waste came from homes, family or friends. I think this was the case for almost all students."

Student 2, High scoring school

> "Yes, I think so to. For me it was the same"

Student 1, high scoring school

> "Letting the students go from door-to-door is way less effective. People do not have a bag of e-waste standing next to their door and we can see in practice that most of the e-waste comes from the students' homes or personal network."

Guy van der Klein (teacher), low scoring school

> "the students asked more around within their own network then going from door-to-door…..The success was also greatly do to the parents most of the e-waste collected came from them or from their network."

Samira Saleh Bakir (teacher), high scoring school

This shows that a lot of the successful collecting was done within the students' own social network and especially by their parents (home layer). So the knowledge that the students should spread during the collecting mostly reached people within their own social network.

The second finding is that the interviews also show that the message spread on how to recycle e-waste differs.

> "Yes I do think that the students explained how to recycle e-waste when collecting e-waste in the neighborhood, but I think that they only explained how people could recycle e-waste by giving it to them or placing it on the website. So that they did not explain how people should normally recycle e-waste in Eindhoven…. I do think that they told their own environment how the e-waste race works and how they should recycle e-waste in Eindhoven.".

Samira Saleh Bakir (teacher), high scoring school

> "I think that the students told the correct and more complete story about how to recycle the electronic waste to their parents and close family rather than to the people when going from door-to-door".

Guy van der Klein (teacher), low scoring school

This shows that the message that is communicated on how to recycle e-waste differs between the different kinds of people approached.

These two findings show that the competence element was spread to a different extent within the neighborhood and the meaning of the competence differed. The school layer, so the students and the teachers, learned the competence element during the introduction lecture. So they learned what e-waste was and how to recycle it during the race and after. The students communicated this knowledge more within their own social network. Further the students also communicated to their own environment (especially within home layer) both ways of how to recycle e-waste so both infrastructures and how to recycle e-waste. To the rest of the neighborhood (neighborhood layer) they only communicated the infrastructure of recycling e-waste by giving it to them.

When competing within the e-waste race it is important for the students to communicate competence element throughout their neighborhood. It is also important for the students to communicate and know the reason why they should collect e-waste. This belongs to the meaning element of the practice. The meaning element of the e-waste recycling practice during the race will be discussed in the next section.

5.2.3 MEANING

As mentioned above, this section will discuss the element of meaning. Within the e-waste recycling practice during the race the meaning element is the reasons why people should recycle e-waste during the race. During the fieldwork 3 reasons of why to recycle e-waste were identified.

The first reason of why to recycle during the race is the environmental impact along with the health issues. These two were being explained to the students and teachers during the introduction lecture. When colleting e-waste the students are supposed to provide some kind of reason on why people should give their e-waste to them. One of these reasons could be the environmental impact and the health issues.

Another reason could be that they want to win so that they can go on a fieldtrip. This is the second reason of why to recycle e-waste during the race. An interesting finding on this subject relates to statements from the higher and lower scoring schools' teachers.

> "I think that he children did not mention the sustainability story when going from door-to-door. I think that it was more like: we from our school participate at the e-waste race and we collect broken electronic devices and we can win a field trip. I do think that they told the sustainability issues to people in their own social network. "
>
> Samira Saleh Bakir (teacher), high scoring school

> "the children tell the more complete sustainability story to their close family and friends. To strangers they meet during collecting they mostly tell more about winning the school trip"

<div align="right">Guy van der Klein (teacher), low scoring school</div>

This shows that the sustainability impact and health issues reason is communicated toward the students, the teachers and the student's social network (school layer & home layer). The reason of winning a fieldtrip is communicated toward these groups and the rest of the neighborhood (neighborhood layer). So the rest of the neighborhood is only reached with winning a school fieldtrip as the reason for participating during the e-waste race.

The third reason of why to recycle e-waste during the race is that it is a lot of fun. This shows in the answers given during the interviews and questionnaires.

> "The children really enjoyed the project and they were very enthusiastic about it. Often when they were done with their work they would ask if they could upload e-waste on the website. It really lived within the school and that was mostly due to the enthusiasm of the children. The children had so much fun that they sked me when we can join again……A teacher from our school transferred to another school where she got the chance to participate at the E-waste race. She was so happy, because she witnessed at our group how much fun it was participating at the race."

<div align="right">Samira Saleh Bakir (teacher), high scoring school</div>

> "You guys did a great job, when will there be the next e-waste race?"

<div align="right">Parent (questionnaire), high scoring school</div>

> "I really enjoyed doing the race and I would like to participate again."

<div align="right">Student 1, low scoring school</div>

This all shows that students, parents and teachers enjoy participating at the E-waste race. This is also a reason for the teachers to participate again during the race recycling practice.

A finding that relates to all three meanings is shown above in the competence during part 5.2.3 that most of the e-waste came from the students personal network so their parents, family and close friends. So they contacted more people within their own network. This leads to the fact that the meaning that the students should spread during the collecting mostly reached people within their own social network. This counts for all three of the above presented meanings.

Now that all three of the elements of the e-waste recycling practice are discussed it is interesting to see if these three linkages also lead to a successful implementation of the practice. This will be discussed in the next section.

5.2.4 PRACTICE

As mentioned above, this section will discuss whether the e-waste recycling practice during the race was implemented successfully. So if the three elements of practice were linked successfully. It is important to note that the competence element of the infrastructure used before the race, which is explained in the material before section 5.1.1 does not belong to the e-waste recycling practice during the race. It belongs to the e–waste recycling practice during and after the race. So it will not be taken into account within this section.

In order to answer if the e-waste recycling practice during the race was implemented successfully, the amount of e-waste collected during the race can be used as indication. When a lot of e-waste is collected during the race it means that a lot of people gave their e-waste to the participating students. This means that a lot of people used the e-waste recycling practice during the race. So during the period from 7th March till 8th April 2016 the total amount of e-waste collected by all 10 participating schools was 14890 kg("Resultaten - E-Waste Race," n.d.). This is quite a lot considering that the total amount of E-waste collect in Eindhoven in 2016 was 816.000 kg [1]. This means that the 537 students (table 5.2) collected 1.82% of the total amount of e-waste collected in Eindhoven that year. This is calculated by using the equation 5.1.

$$\frac{14.890}{816.00} * 100 = 1.82\% \qquad\qquad \textit{equation 5.1}$$

Name	students	items	points	Score
Theresia	48	2800	49240	1026
Hasselbraam	28	910	16820	601
de Kameleon	42	1409	24880	592
de Hanevoet	87	2380	41670	479
Slingertouw	75	1793	35220	470
Reigerlaan	52	915	17980	346
Driestam	49	685	13870	283
Klimboom	47	429	8430	179
de Schakel	23	243	3790	165
Floralaan	86	97	2370	28

Table 5.2: Results E-waste race Eindhoven 07.03.2016-08.04.2016 ("resultaten @ www.ewasterace.nl," n.d.)

So a lot of e-waste was collected during the e-waste race in 2016 which means that it can be concluded that the e-waste recycling practice during the race was successfully implemented.

1: Information from an interview with Kees Zuidhof (project manager at Eindhoven's garbage disposal firm), 6 April 2017. Interviewed by Anna Lena Gompelmann.

This also relates to a statement given during the interview with Paul Wacanno, project manager at the garbage disposal frim in Eindhoven.

> "The E-waste race definitely is a good influence leading to better waste separation and recycling. I think that especially the communication between children and adults during the race leads to an increase in awareness. When children correct their parents and other adults when they for example throw an electrical razor into the residual waste, adults will get more aware of their prototypical role towards children".

<div align="center">Paul Wacanno (project manager), Garbage disposal firm Eindhoven</div>

This shows that the e-waste recycling practice during the race is very successful. An overview of the elements of the e-waste recycling practice during the race is presented in image 5.2.
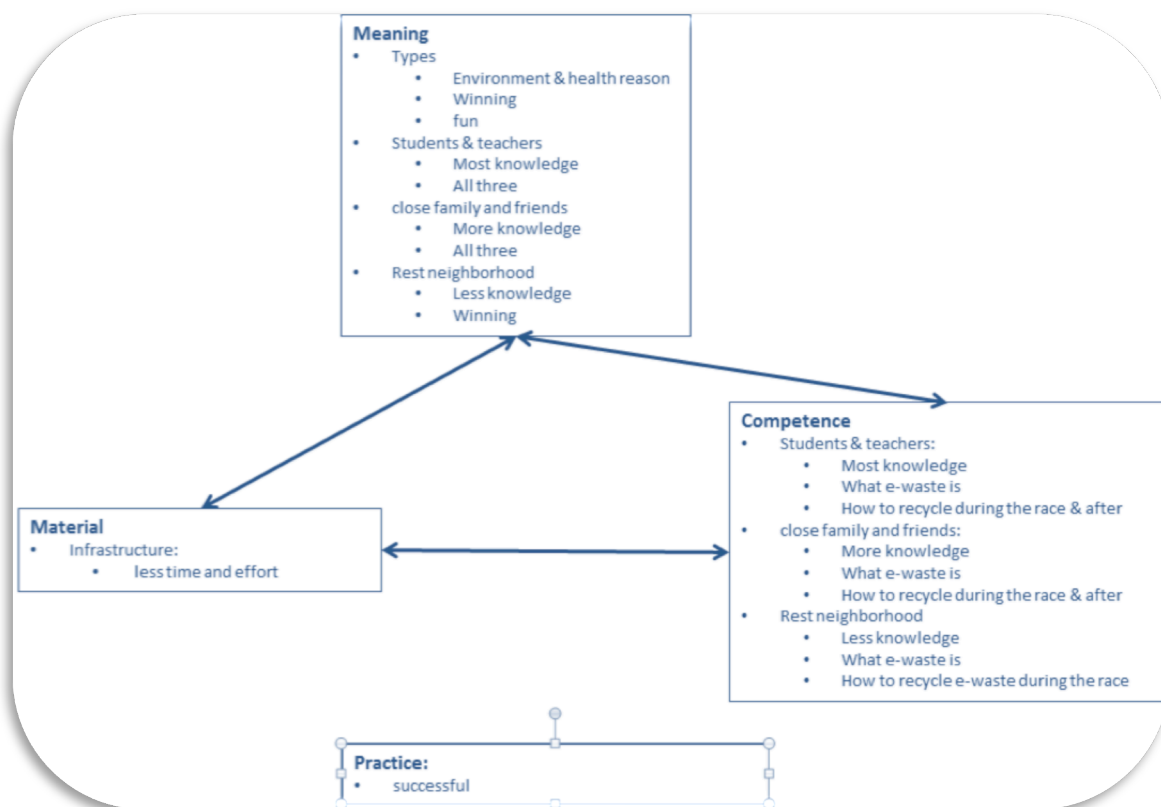

Image 5.2: Overview e-waste recycling practice during the race

In order for the implemented practice to sustain the linkages between the three elements of practice need to be sustained. This will be discussed within the next section. Here the three elements of the e-waste recycling practice after the race took place will be discussed.

5.3 AFTER

Within this section the three elements of the e-waste recycling practice will be discussed together with the practice itself. It will show if the links between the elements of practice that appeared during the race managed to sustain even after the race so that the overall practice will also sustain. The findings in this section are again mainly based on the fieldwork done within the high scoring school and low scoring school. The results of the students' questionnaires are presented at the end of this section in table 5.4. and from the parents questionnaire in table 5.5.

5.3.1 MATERIAL

After the race the infrastructure of recycling e-waste goes back to the infrastructure that was established in Eindhoven before the E-waste race. This means that the material linkage from during the E-waste race does not sustain after the race. So just like before the race, for a private person recycling e-waste is related to a lot of effort and it is quite time consuming. It can be concluded that the material element linkage did not sustain after the e-waste race took place. The next section will discuss if this is also the case for the competence element.

5.3.2 COMPETENCE

The competence element after the race took place, consist of for example what e-waste is and how to recycle e-waste. As mentioned in the competence section during 5.2.2 during the race two options of how to recycle e-waste are presented. After the race took place only one of these is still needed namely the one related to the before and after infrastructure.

Within this section it will be discussed how much knowledge on these competence elements that relate to the practice after the race is still present after the race.

When wanting to find out how much of the competence related knowledge sustained after the race the results of the interviews and questionnaires of the low and high scoring schools will be discussed. These insides will be divided into three layers; the school, the parents and the neighborhood. These were also shown throughout the before5.1 and during 5.2 sections of these chapter and it was explained in the method chapter.

First the level of competence related knowledge still present for the school layer will be discussed. The school layer can be divided into the students and the teachers. First the students will be discussed.

Some insides on students' competence related knowledge can be found in table 5.4 about the questionnaire results of the students. The questions that related to the competence element are shown in blue. The results of these questionnaires show that the overall knowledge on competence related subjects is quite high. At no point is the right answer score lower than 58% and the average amount right per question is 87%. This is higher than the right answer score at the competence related questions before the race presented in table 5.1.

And as mentioned in section 5.1.2 on competence before the race when looking at the interviews, the competence related knowledge before the race was very low. That the competence related knowledge after the race is quite high and way higher than before the race also relates to the statements made during the students' interviews.

> "I did not know anything really about electronic waste etc. Now I know quite a lot about it."

<div align="right">Student 1, low scoring school</div>

> "I did not know anything really on what electronic devices are and what not. Also I did not know what my parents should do with electronic devices when they are broken……I do know these stuff now so I really learned a lot."

<div align="right">Student 2, low scoring school</div>

> "Well I knew that you should not through it on the ground or in the sea, but more than that I did not know and now I know that I need to bring it to the dumping ground"

<div align="right">Student 1, High scoring school</div>

> "I did not know anything on e-waste actually, whether on what it was, that you had to bring it to the dumping ground or…. I know all these things now."

<div align="right">Student 2, high scoring school</div>

This shows that the level of knowing what e-waste is and how to recycle it really changed and it still quite high after the race. Before the race they all state that they knew little to nothing and know after the race the level of knowledge remaining is still pretty high. So the linkage of the competence element sustained for a great deal within group of students.

When looking at the teachers no questionnaires on knowledge were done. But the teachers were also present during the introduction lecture. So they learned roughly the same amount during the race as the students did. This means that the teachers also learned a lot on the subject of competence during the race. It than can be assumed that if they knew roughly the same before the race they still know roughly the same after the race. So a high level of competence related knowledge sustained after the race. This also corresponds to a statement made during the interview with the high scoring school's teacher.

> "Before the e-waste race I did not recycle e-waste. I knew that I should bring it to the dumping ground, but I was too lazy.…… Now I also know what all belongs to the category of e-waste. Before the e-waste race I did not knew that for example a water boiler should also be recycled. I did not know that this is also e-waste. I know the importance of recycling e-waste now; I now do recycle e-waste."

This shows that the teacher did know how to recycle e-waste, but she did not knew the broad definition if what belongs to the category of e-waste. She learned this during the race and she still knows it now. This shows that the competence related knowledge that the teachers received during the race, sustained after the race. As discussed in the during section 5.2 a lot of knowledge that the students and the teachers received was successfully communicated to the children's' the parents and close relatives. The next section discusses how much of this knowledge remained after the race.

Second to discuss is the level of competence remaining within the group of parents, so the home layer. As in the student part also insides in the parent layer can found in the questionnaire results of the parents which are presented in table 5.5 about the. The questions that related to the competence element are again shown in blue. The results of these questionnaires show that the overall knowledge on competence related subjects is quite high. The competence related questions are again on what e-waste is and on how to recycle e-waste. The questions on how to recycle e-waste are about the infrastructure after the race. At no point is the right answer score lower than 50% and the average score is 87%. The level of competence related knowledge before the race is not known so it cannot be assumed that this knowledge is solely due to the e-waste race. What is known is that students communicated the knowledge about what e-waste was and how to recycle it during the race and after more within their own social network.

Further the students also communicated to their own environment both ways of how to recycle e-waste so both infrastructures. To the rest of the neighborhood they only communicated the infrastructure of recycling e-waste by giving it to them. This is explained in section 5.2.2 competence during the race. So the knowledge of how to recycle e-waste after the e-waste race was communicated clearer towards the parents and close relatives and less clear towards the rest of the neighborhood. Out of this it can be concluded that the competence related knowledge is less present in the rest of the neighborhood, compared to the parents, after the race since it was less present during the race.

The above statement says something about the third layer; the neighborhood. As mentioned in the method section, during the fieldwork is was difficult to find people within the neighborhood that have heard from the E-waste race. So besides the statement above there are no findings on the level of competence within the neighborhood sustained after the race.

Looking at the interviews and questionnaires done within the high and low scoring school it seems that the competence level of the practice after the race sustained well within the group of students, teachers and their parents and close family, but not well within the rest of the neighborhood. In the above section we looked at the results of both schools together. There are some clear differences between the results of the high and the low scoring school and that is what the next section will focus on.

When looking at the differences in results between the high and the low scoring school an interesting relation showed. It showed that there is a relation between the amount of e-waste collected during the race and the amount of competence sustained after the race. When looking at the tables 5.4 and 5.5 it shows that the high scoring school which collected the higher amount of e-waste during the race (see table 5.3) also scored higher with the competence related questions. This means that the school that collected the higher amount of e-waste also sustained a higher level of competence related knowledge after the race. This is not the only interesting relation between the high scoring and lows coring school. The next relation will be discussed in the chapter on the element of meaning from the e-waste recycling practice after the race.

5.3.3 MEANING

In this section is will be discussed whether, the element of meaning that was presented during the race, still sustained after the race. As mentioned in previous meaning sections the meaning of the e-waste recycling practice consists of the reason why people should recycle. Three types of meaning were presented in the meaning section 5.2.3 of during the race. These three types were: the sustainability impact and the health issues, wanting to win the school fieldtrip and having fun while recycling e-waste. From these three types of meaning only one still holds for the e-waste recycling practice after the race. The option to win a field trip is not available anymore after the race. The option of fun is also very unlikely after the race since it was not there beforehand and the process of recycling stayed the same as before the race. This leaves the sustainability impact and health issues as reasons of why people would recycle e-waste after the race.

When wanting to find out how much of the meaning related knowledge sustained after the race the results of the interviews and questionnaires of the low and high scoring schools will be discussed. These insides will again be divided into three layers; the school, the parents and the neighborhood.

First the school layer which can be divided into the students and the teachers. First the students will be discussed and then the teachers.

The student layer can be analyzed by looking at two things; the student questionnaire table 5.4 and the interviews. When looking at table 5.4, the sustainable meaning related questions are marked in red. The average amount right per meaning related question is 62% with the lowest value being 35%. These results are way higher than the meaning related results before the race when looking at table 5.3 and the results of the interviews mentioned in section 5.1.3. The questionnaire results also show that level of meaning related knowledge remaining after the race is lower than the competence related knowledge. This means that after the race the children know less about the sustainability reasons of why to recycle when compared with what e-waste is and how to recycle it, but they still know way more than before the race. This also relates to several statements made during the interviews. A student from the low scoring school stated that

"I did not know anything really about electronic waste etc. Now I know quite a lot about it."

Student 1, low scoring school

"…..Also, I did not know that recycling electronic waste is so important, for example I did not know that gold will be gone in 40 years if we do not recycle. I do know this stuff now so I really learned a lot."

Student 2, low scoring school

"I also did not know why it is so important to recycle. Like for example that in poor countries people than have to burn the e-waste in order to get some of the valuable metals out of the waste and that that id bad for nature but also for the people. So yes I really learned a lot because I know this now".

Student 1, high scoring school

"I did not know anything on e-waste actually….or that it is important for the environment to recycle e-waste. I know all these things now."

Student 2, high scoring school

All these statements show that the students learned a lot on the subject of meaning and that quite a high level of this knowledge sustained after the race.

When looking at the teachers no questionnaires on knowledge were done. But as mentioned in the section on competence above, because the teachers were also present during the introduction lecture it can be assumed that they learned roughly the same amount as the students did. This means that the teachers also learned a lot on the subject of meaning and that a high level of this knowledge sustained after the race. This also corresponds to a statement made during the interview with the high scoring school's teacher.

Before the e-waste race I did not recycle e-waste. …Than when I heard all the impact on the environment that it has I was really stunned. I did not know the importance of recycling e-waste before. …. I know the importance of recycling e-waste now; I now do recycle e-waste."

Samira Saleh Bakir (teacher), high scoring school

This shows that the teacher did not know the details of sustainability related meaning of recycling e-waste. She learned this during the race and she still knows it now. As discussed in the above "during" section a lot of knowledge that the students and the teachers received was successfully communicated to the children's' the parents and close relatives. The next section discusses how much of this meaning related knowledge remained after the race.

The second layer is the parents' layer. In order to find out if the meaning related knowledge sustained after the race the results of the parents' questionnaire in table 5.5 will be discussed. The questions that give insides on the meaning related knowledge are marked red. When looking at table 5.5 it shows that the remaining level of knowledge is quite high. It shows that the parents answered 84 % of the meaning questions right with the lowest percentage of 50 % for one question. It is known that the level of meaning related knowledge remaining after the race is quite high, but it is not known if this is due to the e-waste race. The level of meaning related knowledge before the race is not known so it cannot be assumed that this knowledge is solely due to the e-waste race. What is known is that students communicated the knowledge about why to recycle e-waste more within their own social network. Further the students also communicated to their own environment all three reasons of why to recycle e-waste. To the rest of the neighborhood they mostly communicated the meaning of winning instead of the sustainability impact and health issues. This is explained in section 5.2.3 meaning during the race. So the sustainability reason of why to recycle e-waste after the race was communicated clearer towards the parents and close relatives and less clear towards the rest of the neighborhood. Out of this it can be concluded that the meaning related knowledge is less present in the rest of the neighborhood, compared to the parents, after the race since it was less present during the race.

The above statement about the relation between parents and the rest of the neighborhood says something about the third layer; the neighborhood. As mentioned in the method section, during the fieldwork is was difficult to find people within the neighborhood that have heard from the E-waste race. So besides the statement above there are no findings on the level of meaning within the neighborhood sustained after the race. This is the same as the competence related knowledge as mentioned in section 5.3.2.

Looking at the interviews and questionnaires done within the high and low scoring school it seems that the same as at the competence level, the meaning level of the practice after the race sustained well within the group of students, teachers and their parents and close family, but not well within the rest of the neighborhood. In the above section we looked at the results of both schools together. Again, there are some clear differences between the results of the high and the low scoring school and that is what the next section will focus on.

Again, when looking at the differences in results between the high and the low scoring school an interesting relation showed. It showed that there is a relation between the amount of e-waste collected during the race and the amount of meaning sustained after the race. When looking at the tables 5.4 and 5.5 it shows that the high scoring school which collected the higher amount of e-waste during the race (see table 5.3) also scored higher with the meaning related questions. This means that the school that collected the higher amount of e-waste also sustained a higher level of meaning related knowledge after the race.

Now that the three elements of the recycling e-waste practice after the race are discussed, the next section will discuss whether the overall practice did sustain after the race.

In section 5.2.4 it was concluded that the practice during the e-waste race was quite successful. The important question is whether this successful practice has sustained after the race. This will be discussed within this section. Several things will be discussed within this section; first the results of the questionnaires, second the amount of e-waste collected and third the option of an e-waste race on a yearly basis.

Questionnaires

First the results of the students' and parents' questionnaires will be discussed. Within both questionnaires the questions that relate to whether the e-waste race has led to a better implementation of the practice are marked green.

Question 1 from the parents' and the children's questionnaires ask people what they do with their e-waste. If the practice of recycling e-waste from after the race was implemented successfully than almost all students and parents will answer that hey bring their e-waste to the dumping ground. From the children 46% stated that at home the e-waste is brought to the dumping ground and from the parents this is 84%. This large difference can be due to the fact that a lot of children answered they did not know what they do with the e-waste at home. Also the reason why these few parents answered this questionnaire could be because they are very involved within the class or because they are very interested in sustainability. The parents are not necessarily very representative for all parents so the actual percentage of parents that use that e-waste recycling practice could be way lower.

Question 16 and 17 from the children's and parents questionnaires and question 15 from the parents questionnaire are about whether the e-waste race had an effect on the students, parents or neighbors. So the questions were about if they learned a lot and recycled more thanks to the e-waste race.

With the question about if they think that the students have learned a lot thanks to the e-waste race, the students answered 92.5% with yes and 7.5% with no. The parents answered 67% with yeas, 25% with no and 8% answered that they already knew a lot from home before the race so no. The students that answered that they did not learn a lot thanks to the e-waste race did not provide and explanation. The 25% parents that answered no also did not provide an explanation. The answers are not about collecting behavior after the race. So they are not directly about the implementation of the overall practice. The answers are more about the knowledge gained about meaning and competence. It show that the students have gained a large amount of knowledge on meaning and competence thanks to the race and that this knowledge also sustained after the race.

With the question that asks if they think that their family, neighbors and other neighborhood members will recycle in a better way thanks to the e-waste race the students answered 47% yes, 39% no and 14% that they do not know. The parents answered this question with 50% yes, 30% no and 20% that they do not know. From the explanations provided with these answers it can be seen that the students and parents that answered with

yes base this on the changes in recycling behavior within their group of close relatives. The parents that answered with no based this on their experience within the broader neighborhood. This also correlates with the findings within this after section 5.3 on the three elements of practice. The three elements that are related to the e-waste race practice after the race are communicated better within the group of students, teachers and close relatives. The elements from after the race are not communicated well throughout the rest of the neighborhood. The linkages of the three elements of practice are not established within the rest of the neighborhood so the practice is also not implemented within the rest of the neighborhood.

The last relevant question in the questionnaires is the question where the parents are asked whether they think that they have learned a lot about e-waste during the race. The parents answered 42% with yes and 58% with no because they already recycled e-waste before the race. The way the parents answered the question there answers were based on whether they thought that the e-waste race had improved their recycling behavior. Apparently 58% of the parents already did recycle e-waste before the race. This shows that a large amount of the parents that were willing to answer the questionnaire find recycling e-waste important. This could mean that the results from these questions are not very representative as explained above in this section. What is interesting is that apparently all parents that did not recycle e-waste before have changed their recycling practice due to the e-waste race. This means that within the group of parents that answered the questionnaire the e-waste recycling practice has sustained after the race.

Overall the questionnaire results show that the students learned a lot about competence and meaning during the e-waste race and that this knowledge sustained after the race. This resulted in the fact that in a lot of the students' households the e-waste recycling practice sustained even after the race. For the parents that did not already recycle e-waste before the race the positive influence of the e-waste race on their recycling practice sustained after the race. The e-waste race also had a positive influence on the recycling practice of the students' close family and friends and this influence again sustained. The rest of the neighborhoods' recycling practice after the race was not influenced by the e-waste race. This is because the three elements of this practice were not communicated well towards the rest of the neighborhood. To determine whether the overall influence on the recycling practice throughout all layers had a large influence on the amount of e-waste recycled after the race the amount of e-waste collected after the race will be discussed.

E-waste collected

So second to the questionnaire results, the amount of e-waste collected after the race will be discussed. The yearly amount of e-waste collected in Eindhoven in shown in table 5.5. This table shows that there is no real increase in Eindhoven's yearly total amount of collected e-waste since 2015. The values also show that there is a fluctuation in the total amount since 2010. Since the E-waste race only first started in Eindhoven in 2015 it shows that there are a lot of factors apart from the E-waste race that influence the collection of e-waste in Eindhoven.

This means that there is no real increase or decrease to see in Eindhoven's yearly total amount of e-waste collected that is clearly due to the e-waste race. So the overall influence on the recycling practice throughout all layers did not have a large influence on the total amount of e-waste recycled after the race. This is because the change in practice appeared in a relative small group and not in the rest of the neighborhood. This is because the material element changes after the race into how it was before the race and the rest of the elements are not communicated sufficiently throughout the whole neighborhood. So the practice during the race was quite successful, but it did not sustain throughout the whole neighborhood after the race took place. In order to find out why the practice during the race did not sustain the next section will focus on the option of an e-waste race on a yearly basis.

year	2010	2011	2012	2013	2014	2015	2016
Total amount of collected E-waste in Eindhoven during a year in 1000 kg	829	809	745	766	816	785	816

Table 5.5 : The total amount of e-waste collected in Eindhoven per year1.

E-waste race on a yearly basis

Third and section will discuss the option of an E-waste race on a yearly basis. Within the low scoring school the e-waste race takes place every year. This fact led to some interesting results in terms of sustaining the recycling practice.

> "We collect our e-waste during the year so that we can dispose it during the yearly e-waste race at our school"

> Parent, low scoring school

> "I collect my e-waste throughout the year and then I give it to the students during the e-waste race".

> Guy van der Klein (teacher), low scoring school

This shows that when the e-waste race takes place on a yearly basis the regular practice from before and after the race took place is being replaced by the practice during the race. This shows that when the race is on a yearly basis, the elements of the practice from during the race are so strong linked and refreshed every year that people prefer the e-waste race practice and keep using it on a yearly basis. This relates to findings from the high scoring school.

1: Information from an interview with Kees Zuidhof (project manager at Eindhoven's garbage disposal firm), 6th April 2017. Interviewed by Anna Lena Gompelmann

"even after the race people from the neighborhood still offer us e-waste for the e-waste race"

Parent, high scoring school

"My grandma and grandpa now bring their electronic devices to the dumping ground, but they also look in the papers for when there is a next e-waste race and then they give the e-waste to a school that participates. They gave e-waste to another school this year that competed at the e-waste race this year"

Student 1, high scoring school

This shows that also in the high scoring school, where the e-waste race does not takes place on a yearly basis, the people show intention to keep on sustaining the practice from during the race. This also relates to a statement given during the interview with Paul Wacanno, project manager at the garbage disposal frim in Eindhoven.

"I think that it is important that the E-waste race takes place on a yearly basis within a school. The information needs to be repeated in order to make a real difference in the recycling behavior of people".

Paul Wacanno (project manager), Garbage disposal firm Eindhoven

This shows that the e-waste recycling practice during the race is very strong and when it takes place on a yearly basis it can replace the before and after practice.

Within this section the e-waste recycling practice after the race took place was discussed. An overview of the elements of the e-waste recycling practice after the race is shown in the image 5.3, displayed below.
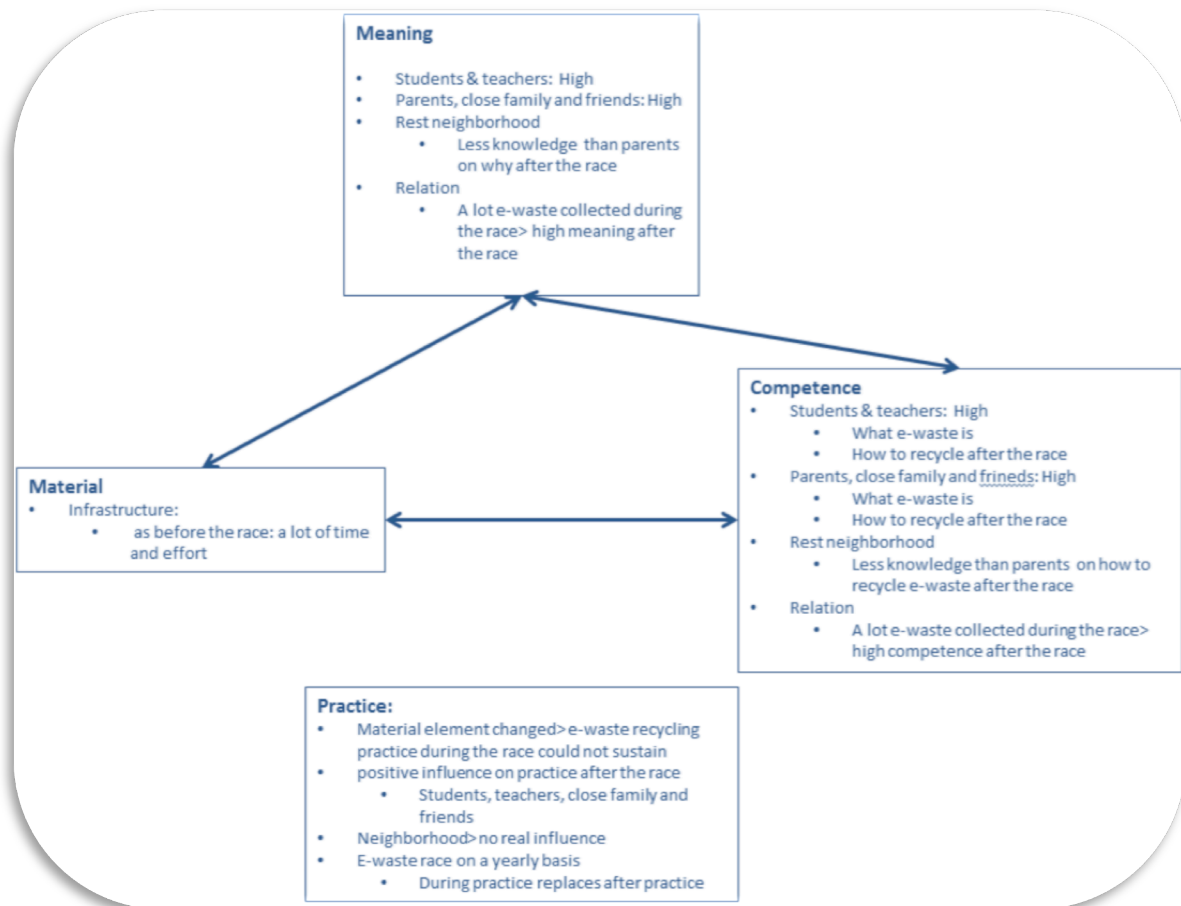
Image 5.3: overview of e-waste recycling practice after the race

During this chapter a relation between the amount of e-waste collected and the difference s in results between the high scoring and low scoring school was mentioned. The next section will go further in this relation and differences between those two schools.

School & number of students		Low scoring school de Schakel 18/19 students	High scoring school Theresia 12 students
Question 1	What do you do with this waste at home?	% right	%right
	vegetables and fruit waste		
	Electronic waste (right answer: Bring it to the dumping ground)	33%	58%
	residual waste		
Question 2	What is electronic waste? A. Only everything that has/had a plug or had batteries inside. B. Only everything that has computer chips inside such as for example phones, computers and TV's	58%	58%
Question 3	What is no e-waste? A. The computer case (so not the monitor) B. Ink cartridges	95%	100%
Question 4	What is no e-waste? A. Batteries B. Milk frother	84%	92%

Question	Text		
Question 5	What is no E-waste A. Kable **B**. Light bulb	68%	83%
Question 6	What is no E-waste A. Toy car with remote controle **B**. CD's	89%	92%
Question 7	What is recycling?	70%	100%
Question 8	Why is recycling Important?	50%	75%
Question 9	What should you do with your electronics if they are broken? A. Keep them at home in a closet B. Place it outside on the street and the garbage men will collect it then C. Throw it away together with the residual waste at home **D**. Bring it to the dumping ground	85%	100%
Question 10	What should you always check before you throw away e-waste? A. If it is switched of **B**. If it is really broken	95%	100%
Question 11	What can you do best if devices still work, but you do not want them anymore? A. Throw them away, because you do not need them anymore B. Leave them laying around at home **C**. Give it to someone would use that device or bring it to a thrift shop	100%	100%
Question 12	In countries where a lot of electronic devices are used (such as the Netherlands) are important raw materials that are needed to produce these devices often not available. These raw materials then have to be received from other countries. Often this happens by unsustainable transportation. Why is this not good?	40%	100%
Question 13	What happens with e-waste in developing countries when It is not recycled in a proper way?	35%	75%
Question 14	Which way collecting e-waste shown below has your class used? - Flyers - Radio - Made a Youtube clip - from door to door collecting - a different option namely: ………………	Flyers: 89% door to door: 84% collected from the website: 0.05% My dad's job and at home: 1%	flyers: 17% door to door:92% from home:17% ask people you know:17%
Question 15	With who have you talked about the e-waste race? (results in per student) - My parents and stepparents How much: - My brothers and sisters How much: - My neighbors How much: - Friends of mine that are not in my class How much: - My grandparents How much: - My uncles and aunts How much: - My nieces and nephews How much: - Acquaintances How much: - People on the streets that I do not knew How much:	o My parents ..(1.85) o My siblings (0.75) o My neighbors (1.15) o Friends of mine.. (2.65) o My grandparents (1.15) o My uncles.. (1.1) o My nieces.. (1.3) o Acquaintances (2.3) o People on the streets..(6.2) Total (18.45)	o My parents ..(2.12) o My siblings (0.83) o My neighbors (2.83) o Friends of mine.. (2.67) o My grandparents (1.92) o My uncles.. (2.33) o My nieces.. (1.08) o Acquaintances (2.92) o People on the streets..(24.75) Total (41.5)
Question 16	Do you think that you have learned a lot about e-waste and sustainability during the e-waste race? And why? Give an example.	Yes: 85% No:15%	Yes: 100%
Question 17	Do you think that your family, neighbors and other neighborhood members will recycle in a better way thanks to your participation at the e-waste race? And why? Give an example.	Yes: 35% No:55% I do not know:10%	Yes: 58.3% No:25% I do not know: 16.6%

55

Table 5.4: results student questionnaires De schakel and Theresia, x=competence x=meaning x=practice

		high scoring school 6 parents	low scoring school 6 parents
Question 1	What do you do with this waste at home?	% right	% right
	vegetables an fruit waste		
	Electronic waste **(right answer: Bring it to the dumping ground)**	100%	67%
	residual waste		
Question 2	What is electronic waste? **A.** Only everything that has/had a plug or had batteries inside B. Only everything that has computer chips inside such as for example phones, computers and TV's	100%	83%
Question 3	What is no e-waste? A. The computer case (so not the monitor) **B. Ink cartridges**	83%	50%
Question 4	What is no e-waste? **A.** Batteries B. Milk frother	83%	75%
Question 5	What is no E-waste A. Kable **B.** Light bulb	100%	67%
Question 6	What is no E-waste A. toy car with a remote **B.** CD's	83%	83%
Question 7	What is recycling?	100%	100%
Question 8	Why is recycling Important?	100%	100%
Question 9	What should you do with your electronics if they are broken? A. Keep them at home in a closet B. Place it outside on the street and the garbage men will collect it then C. Throw it away together with the residual waste at home **D**. Bring it to the dumping ground	100%	100%
Question 10	What should you always check before you throw away e-waste? A. If it is switched of **B.** If it is really broken	83%	83%
Question 11	What can you do best if devices still work, but you do not want them anymore? A. Throw them away, because you do not need them anymore B. Leave them laying around at home **C.** Give it to someone would use that device or bring it to a thriftshop	100%	100%
Question 12	In countries where a lot of electronic devices are used (such as the Netherlands) are important raw materials that are needed to produce these devices often not available. These raw materials then have to be received from other countries. Often this happens by unsustainable transportation. Why is this not good?	100%	80%
Question 13	What happens with e-waste in developing countries when It is not recycled in a proper way?	75%	50%
Question 14	With who have you talked about the e-waste race? (number of people per parent) - MY partner : How much - My parents and stepparents How much: - My brothers and sisters How much: - My neighbors How much - other relatives How much	MY partner :0.75 My parents and stepparents How much:3.5 - My brothers and sisters How much:2.75 - My neighbors How much:9.5 - other relatives How much:4 -colleagues How much:5.5 - Acquaintances How much:10.75 - People on the streets that I do not knew	MY partner :0.5 My parents and stepparents How much:1 - My brothers and sisters How much:1 - My neighbors How much:2 - other relatives How much:0.75 -colleagues How much:2.75 - Acquaintances How much:4.5 - People on the streets that I do not knew

	-colleagues How much: - Acquaintances How much: - People on the streets that I do not knew How much:		How much: the children did the whole neighborhood	How much:0
Question 15		Do you think that you have learned a lot about e-waste and sustainability during the e-waste race? And why? Give an example.	yes:50 we already recycled e-waste so no: 50	yes: 33 we already recycled e-waste so no: 67
Question 16		Do you think that your family, neighbors and other neighborhood members will recycle in a better way thanks to your participation at the e-waste race? And why? Give an example.	yes:40 no:40 I do not know:20	no:20 yes 60; I do not know:20
Question 17		Do you think that your child has learned a lot about e-waste and sustainability due to its participation at the e-waste race? And why? Give an example.	yes:67 no: 33	yes:67 no:17 he already knew so no: 17
Question 18		Are there questions or remarks you would like to make about the e-waste race?		
Question 19		Did you gave e-waste to your child to bring to school during the race?	100% yes	yes:83 no:17

Table 5.5: results parents questionnaires De schakel and Theresia, x=competence x=meaning x=practice

5.4 SOCIAL RELATIONS AND CONTEXT

This section will focus on the material properties of high and low scoring schools. So the social context of these case studies and the properties and restrictions of the students, parents and teachers. These material properties can serve as an explanation for some results in terms of differences between the two case studies. Four material properties were identified that could explain the differences in results between the two case studies.

The first material property is the school context. Hereby is meant the overall quality level of the school and the teacher.

The elementary schools' level of quality can be very different within one city depending on which neighborhood the school is in. The level can be indicated by looking at the students' grades for the central final elementary school test or by looking at the teachers' quality. The level of the school can have influence on the school's success during the e-waste race. If this would be the case the results for schools that participated several times would be quite similar, as the level of the school probably does not change that rapid. The low scoring school, de Schakel, participated during each year of the E-waste race in Eindhoven. Their score during the race varied each year("resultaten @ www.ewasterace.nl," n.d.). Within the first year they made the 5th place out of 12 schools. In their second year (2016) they made the 9th place out of 10. With the third race they finished 2nd out of 10. This shows that even though the level of quality of de Schakel probably did not change a lot during the last 3 years their success within the e-waste race did vary a lot. This indicates that the school's level of quality does not have a strong influence on the success of a participating school during the race. This cannot be seen at the high scoring school, because it was the first time this school did participate and it did not participate in 2017 either.

The teacher's way of dealing with the E-waste race can also vary strongly between the different participating schools. During the interview the low scoring school's teacher mentioned that he each year changed the level of his involvement during the race.

> "Each year again I am pretty much searching for the right amount of involvement from my side. This is way I change my level of involvement each year. I do this to find the perfect balance between the students' independent thrives and my involvement. I find it very important that students show own initiative, because I feel that students then learn the most. At the same time I experience that students need some guidance, because otherwise the tasks may be too difficult and they lose interest. This is what I also experienced during the E-waste race last year. In that year I gave the students little guidance it became unorganized and the students lost a lot of their interest and enthusiasm. This year I plan to be more involved and to give the students some more structure."

> Guy van der Klein (teacher), low scoring school

This also explains the variation in results between the different years that the low scoring school participated. This indicates that the differences in results between schools can be influenced by the teachers' different levels of involvement and enthusiasm.

On the other hand both teachers mentioned that their level of involvement and enthusiasms is influenced by the enthusiasm of the children. If the children are not taking initiative then the teachers are less likely to put a lot of effort into the project.

> "The amount of energy I put into the project really depends on the class. In the beginning the class is of course always very enthusiastic. If this enthusiasm stays and if the students are willing to put some effort into the project, then I also get enthusiastic. In that case I am also willing to put some effort into the project."

> Guy van der Klein (teacher), low scoring school

> "Everybody was very enthusiastic during the project. I think that the students and I really positively influenced each other in this."

> Samira Saleh Bakir (teacher), high scoring school

This suggests that there is some kind of mutual shaping between the enthusiasm of the children and the teachers. These findings indicate that the differences in results between schools can be influenced by the teachers' and the students' different levels of involvement and enthusiasm.

The second material property that can explain the differences in results between the two case studies is the types of parents. When interviewing students and teachers from both schools, all stated that the parents' involvement is very important.

> "I went from door to door, but most of the e-waste came from homes, family or friends. I think this was the case for almost all students."

Student 2, High scoring school

> "Yes, I think so to. For me it was the same"

Student 1, high scoring school

> "Letting the students go from door-to-door is way less effective. People do not have a bag of e-waste standing next to their door and we can see in practice that most of the e-waste comes from the students' homes..."

Guy van der Klein (teacher), low scoring school

> "the students asked more around within their own network then going from door-to-door.....The success was also greatly do to the parents most of the e-waste collected came from them ....."

Samira Saleh Bakir (teacher), high scoring school

So this shows that if the parents are very active within the race and if they contact their own personal network in a large extent it is more likely for the school to receive good results within the race.

The third material property within this row is the usage of flyers. In table 5.4 a large difference between the usages of flayers is shown. At the low scoring school, 89% has stated to have used flyers as a collecting technique versus only 17% at the high scoring school. This means that the high scoring school used their flyers more effectively. Another explanation can be that the high scoring school focused more on the personal network where mouth to mouth propaganda is more used than flyers. As the reason is not clear, it cannot be said with certainty if the usage of flyers has a strong influence on the results of a school.

The last material property that can explain the differences in results between the two case studies is if the school has participated for the first time at an E-waste race or not. The low scoring school has participated more than once during an E-waste race in Eindhoven. This could have an influence on the enthusiasm and involvement of the students, parent and teacher. But as the low scoring school has participated already three times and their scores very so much it is not likely that this has a negative influence on the results.

The material properties mentioned above influence the success of each school during the race. So it influences how much e-waste the school collect. In the section 5.2 on during the race, it is shown that the amount of e-waste collected relates positively to the level of meaning and competence created. The level of meaning and competence created again influences level of practice after the race that is sustained. So these material properties have influence on the level of practice sustained after the race.

During this chapter, the differences in practice before and during the race have already been discussed and if the success of the practice during the race can be sustained after the race. In the next chapter a conclusion of all these findings and what they mean for the e-waste race will be presented. Further some recommendations are being made out of these findings.

Within this chapter the results from the previous chapter will be discussed and from this material conclusions will be drawn. This will be followed by some recommendations for the municipality of Eindhoven and for the E-waste race. The chapter will be closed with a recommendation for further research.

6.1 CONCLUSION

After having discussed the results, this chapter will go back to discussing the (sub-) research questions and drawing some conclusions.

The main research question mentioned in chapter 2 was: "Does the E-waste race help changing people's e-waste recycling practice?". With the following sub-research questions: "Are there existing linkages between the elements of practice before the race took place?", "Does the E-waste race create new linkages between the elements of practice during the race?" and "Do these new linkages sustain after the race took place?". First all these sub-research questions will be answered followed by answering the main research question.

"ARE THERE EXISTING LINKAGES BETWEEN THE ELEMENTS OF PRACTICE BEFORE THE RACE TOOK PLACE?"

As shown in the previous chapter, there were existing material elements before the race took place. The material element of infrastructure was quite time consuming and it costs a lot of effort.

When looking at the element of competence and meaning, these both were not really present before the race. The students level of knowledge related to meaning and competence were both very low. So was the teachers' level of knowledge related to meaning. The teachers' level of knowledge related to competence was high in terms of" how recycle e-waste" and low in terms of "what is e-waste".

The e-waste recycling practice before the race was clearly not successful enough. This resulted from the fact that the meaning and competence elements were not really present before the race. So no there were no existing linkages between the elements of practice before the race.

"DOES THE E-WASTE RACE CREATE NEW LINKAGES BETWEEN THE ELEMENTS OF PRACTICE DURING THE RACE?"

As shown in the previous chapter, there were existing material elements during the race. The material element of infrastructure solved the problem from the infrastructure before the race by being way less time consuming and costing less effort.

Elements of competence were present during the e-waste race. Although the competence element was spread to a different extent within the neighborhood and the meaning of the competence differed. During the race, the teachers, the students and the students close social network knew what e-waste was and how to recycle it

during and after the race. The rest of the neighborhood only knew what e-waste is and how to recycle e-waste during the race.

Elements of meaning were also present during the race. There were three elements of meaning during the race. The first was the sustainability impact and health issues reason of why to recycle e-waste. The second was having fun as reason of why to recycle e-waste and the third was winning the fieldtrip as reason of why to recycle e-waste. The first three reasons were know by the teachers, the students and the student's close social network. The rest of the neighborhood only knew winning the fieldtrip as reason of why to recycle e-waste. For all people of the neighborhood at least one element of meaning was present.

The e-waste recycling practice from during the race was very successful. This was the case because all three elements of practice were linked. So the answer to the sub-research question is yes, the E-waste race created new linkages between the elements of practice during the race.

"DO THESE NEW LINKAGES SUSTAIN AFTER THE RACE TOOK PLACE?"

After the race, the material element form during the race changed. So the changes made at the material element during the race did not sustain.

Some parts of the meaning and the competence elements sustained after the race and were used for the practice after the race. This was the sustainability impact and health issues reason of why to recycle e-waste for the element of meaning. This also was the knowledge of "what e-waste is" and "how to recycle it after the race" for the element of competence. These types of meaning and competence did sustain within the group of students, teachers and close family & friends. These types of meaning and competence did not sustain within the rest of the neighborhood.

Because the material element of during the race did not sustain it was not possible for the practice during the race to sustain after the race. The practice from after the race is implemented quite well within the group of students, teachers and close family & friends. The practice from after the race is not implemented well within the rest of the neighborhood.

So to answer the sub-research question, some of the linkages from during the race sustained, but not all of them.

"DOES THE E-WASTE RACE HELP CHANGING PEOPLE'S E-WASTE RECYCLING PRACTICE?"

The e-waste recycling practice from during the race did not sustain after the race. But the practice from after the race is implemented quite well within the group of students, teachers and close family & friends. This is the case, because some types of meaning and competence did sustain within the group of students, teachers and close family & friends. The element of competence and meaning, these both were not really present before the race.

So to answer the main research question, yes the e-waste race help changing people's e-waste recycling practice.

For the short timeframe and small scale, the e-waste race did very well in terms of recycling more e-waste. The e-waste race definitely created a successful practice for during the race with which it collected a large amount of e-waste.

For the period from after the race, it did manage to sustain a high level of meaning and competence related knowledge which resulted into a reasonable good implementation of the practice after the race. The level of competence and meaning related knowledge was not high for the rest of the neighborhood and so no real implementation of the practice happened after the race. Both of these results are fine considering the scale of the race. To improve or change e-waste recycling practice of a whole neighborhood is a way to large task for a project of this scale. The e-waste race succeeded in reaching the goal of collecting a large amount of e-waste during the race. It also reached the goal of increasing (the meaning and competence related) knowledge about e-waste during the race and sustaining it after the race. It also definitely improved the existing e-waste recycling practice even if only temporarily. It is possible to improve some of the other results by making some changes. These possibilities for improvement are discussed in the following section.

6.2 RECOMMENDATION

Within this section, first the recommendations for the municipality will be discussed, followed by the recommendations for the e-waste race.

6.2.1 MUNICIPALITY

From the above section it clearly shows that the practice during the race works way better than the practice before and after the race which is provided by the municipality of Eindhoven. The municipality of Eindhoven could adapt their e-waste recycling practice so that it would be similar to the e-waste race recycling practice. So the municipality could learn from the e-waste race practice. Providing meaning and competence related knowledge by educative projects like the e-waste race is already a good start. Another good improvement would be to change a part of the material element; namely the infrastructure. By changing the infrastructure to a less time consuming and more effortless model, just like the e-waste race did. This needs some amount of investment from the municipality of Eindhoven. As mentioned in the introduction chapter, the e-waste stream is the fastest growing waste stream which also has quite a high environmental impact. So investing in a more sufficient e-waste recycling infrastructure seems like a good direction into a more sustainable future. Especially when taking in mind that several of the raw materials in e-waste are being depleted, as mentioned in the introduction chapter. This means that a better recycling of e-waste could also be an economic advantage. Two examples of a more efficient e-waste recycling infrastructure are "the BEST tas" and the PostNL deal.

The BEST-tas is concept from a garbage disposal firm in the south of the Netherlands("BEST-tas," n.d.). It is a bag that is being picked up at people homes ones every two months. This bag can be filled with e-waste. If the BEST-tas was used the citizen will receive a new BEST-tas via the mail.

The PostNL deal is a test that started 8th of May 2017 from the recycling company Weee in the Netherlands("Veel afgedankte apparaten mee met PostNL | NOS," n.d.). Package carriers from a Dutch mail company pick up small e-waste at peoples' homes. The result is that per route of 150 packages 6 devices get picked up. If this is being calculated for the whole of the Netherlands it is equal to 3 till 4 million devices per year.

Second to the recommendations for the municipality, recommendations for the E-waste race will be discussed in the following section.

6.2.2 E-WASTE RACE

For the E-waste race, improvement could be achieved by creating a better communication towards the rest of the neighborhood, during the race. This would than result into a better implementation of the recycling practice after the race. Three options of how to improve the communication toward the rest of the neighborhood are presented below. First, the E-waste race could give extra points for sharing information of the e-waste race on media platforms, such as the local TV-channel or newspaper. With this way more people can be reached with information that is more structured and complete. A second option would be to provide extra information about the meaning and competence of e-waste within the confirmation mail that people receive when they upload an item on the website. The third option would be to provide extra information on the flyers that the children hand out during the collection process. Some extra information could be mentioning that several raw materials in e-waste will be depleted in a short amount of time. To know what kind of extra information to place in option two and three, extra research could be done on this subject. This leads us to the next section. The next section is on 7 options on further research that could be done to make this report more complete.

6.3 FURTHER RESEARCH

The first option, as mentioned in the previous section, is that it would be helpful to do some further research on what kind of extra information to place on flyers and websites. So to research what kind of knowledge sticks with people and will convince them to recycle e-waste.

The second option would be to do more research on the people within the neighborhood. So to locate people that participated during the previous e-waste race and interview on the same subjects as the rest.

The third option would be to also include a school were research can be done during the e-waste race. In order to get a better inside on the level of knowledge and practice present during the race.

The fourth option would be to also interview teacher, parents and the neighborhood at a school that did not participated at the race. Also to redo the students' questionnaires at a different school that did not participate during the race.

The fifth option would be to let the teacher from the high and low scoring school also fill in a questionnaire on their level of knowledge.

The sixth option would be to do interviews with other students within the schools that participated during the race. This would be done to get some inside on how much the knowledge and practice did spread within the schools.

The last option would be to do research within more cities that participated at the E-waste race.

After having discussed the further research options, the next section will be about my personal evaluation of this research process.

EVALUATION

Doing this research was a very educating process.

There are so many little things that have to be done and looked at during the process of writing a report. I really underestimated the time that it took to do this research. Especially the task of writing turned out to be very difficult. Even after totally understanding and knowing what to write it was very difficult for me to not get lost within my own report. There were so many things I wanted to write down and tell that I got really overwhelmed by it. Structuring all this information is something very important that I learned during this writing process. Also taking a step back and keeping an overview of what I am writing. Even though I learned a lot about this I think that I still have a very long way to go before I will perfection this skill. So I think it is a very good idea for me to continue with the IS mater, since I still have a lot to learn.

Another thing that I really underestimated was the time it took to do fieldwork. Very in the beginning of my research I had already found the schools that wanted to participate within my research. Because this went so fast I thought that the rest of the fieldwork process would go just as smoothly. This was definitely not the case. It turned out that the communication with schools is a very slow process. It took a lot of time and rescheduling before I finally had the chance to do my interviews and questionnaires. Due to this I did not have the change to do all the interviews and questionnaires that I planned to do in the beginning.

Even though the fieldwork process took so much time, it definitely was the part that I enjoyed the most. When doing interviews I feel that it is much easier to get a real understanding about the participants and the results. Also doing the fieldwork gave me some new and interesting insides that I did not foresee beforehand.

Even though now I am really happy that I finally finished this report, I still very much enjoyed doing a research all by myself.

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Enquête buurtbewoner

1. **Wat doet u thuis met dit afval?**

   Groente en fruit afval →…………………………………………………………

   ………………………………………………………..

   Elektronisch afval   →…………………………………………………………

   ………………………………………………………..

   Rest afval   →…………………………………………………………

   ………………………………………………………..

   U kunt kiezen uit bijvoorbeeld: We doen het in de kliko, we brengen het naar de milieu straat, we zetten het buiten aan de straat en het wordt opgehaald, het blijft gewoon thuis liggen.

2. **Heeft u ooit van de E-waste race gehoord? En als ja, via wie/waardoor heeft u hiervan gehoord?**

   ……
   ……
   ……

3. **Wat is elektronisch afval?**

   A.   Alleen alles waar een stekker aan zit (of aan gezeten heeft) en waar een batterij in gezeten heeft.

   B.   Alleen alles waar computer chips inzitten zoals bijvoorbeeld telefoons, computers en TV's

4. **Wat moet je met elektronische apparaten doen als ze kapot zijn?**

   A.   Thuis in een kastje bewaren

   B.   Buiten voor de deur zetten en de vuilnismannen halen het dan op

   C.   Thuis bij het rest afval gooien

D.   Naar de milieustraat brengen

5. **Heeft u op dit moment nog E-waste thuis liggen? En hoeveel?**

………
………
……

6. **In welke straat woont u?**

………

Onderstaande vragen alleen invullen als u al eens van de E-waste race hebt gehoord!

7. **Wat is de E-waste race?**

………
………
………

8.   **Heeft de E-waste race invloed gehad op uw gedrag en houding tegenover elektronisch afval en duurzaamheid over het algemeen? Waarom en geef een voorbeeld**

………
………
………..

9. **Heeft u tijdens de E-waste race ook elektronisch afval bij een school ingeleverd of laten ophalen?**

………
………
………

10. **Denkt u dat de E-waste race invloed heeft gehad op het bewustzijn en gedrag van de wijk tegenover elektronisch afval en duurzaamheid over het algemeen? En waarom/ geef een voorbeeld.**

………
………
………

11. Zijn er nog bepaalde opmerkingen over de E-waste race die u graag met ons zou willen delen?

………
……..

Interview leerkracht

12. Wat doet u thuis met dit afval?

Groente en fruit afval →……………………………………………………………

…………………………………………………………..

Elektronisch afval   →……………………………………………………………

…………………………………………………………..

Rest afval   →……………………………………………………………

…………………………………………………………..

U kunt kiezen uit bijvoorbeeld: We doen het in de kliko, we brengen het naar de milieu straat, we zetten het buiten aan de straat en het wordt opgehaald, het blijft gewoon thuis liggen.

13.   Heeft de E-waste race invloed gehad op uw gedrag en houding tegenover elektronisch afval en duurzaamheid over het algemeen? En waarom/als het kan noem een voorbeeld.

………
………
…….

14. Heeft u op dit moment nog E-waste thuis liggen? En hoeveel?

……
……
……….

15. **Heeft het meedoen aan de E-waste race het bewustzijn en gedrag van uw leerlingen tegenover elektronisch afval en duurzaamheid over het algemeen veranderd? En waarom/als het kan noem een voorbeeld.**

……
……
……….

16. **Heeft het meedoen aan de E-waste race u manier van lesgeven in het opzicht van duurzaamheid gerelateerde onderwerpen veranderd?**

……
……
……….

17. **Met wie heeft U allemaal over de E-waste race gesproken?**

   o   Mijn ouder of stiefouders

       Hoeveel:…………

   o   Mijn Partner/ ex-partner

       Hoeveel:………….

   o   Mijn broers en zussen

       Hoeveel:…………

   o   Andere familie leden

       Hoeveel:…………

   o   Mijn collega's op het werk

       Hoeveel:…………

o   Mijn buren

Hoeveel:…………

o   Kennissen

Hoeveel:…………

o   Mensen op straat die ik niet ken

Hoeveel:…………

18. **Waar en hoe hebben de kinderen campagne gevoerd voor het inzamelen van e-waste?**

    En hoeveel mensen gokt u hebben de kinderen benaderd?

    ………
    ………
    ………

19. **Denkt u dat de E-waste race invloed heeft gehad op het bewustzijn en gedrag van de wijk tegenover elektronisch afval en duurzaamheid over het algemeen? En waarom/als het kan noem een voorbeeld.**

    ………
    ………
    ………

20. **Zijn er nog bepaalde opmerkingen over de E-waste race die u graag met ons zou willen delen?**

    ……
    ……….

21. **Heb jij ooit van de E-waste race gehoord? En als ja, via wie/waardoor heb jij hiervan gehoord?**

………
………
………

22. Wat doen jullie thuis met dit afval?

Groente en fruit afval →………………………………………………………

……………………………………………………..

Elektronisch afval   →………………………………………………………

……………………………………………………..

Rest afval   →………………………………………………………

……………………………………………………..

Je kunt kiezen uit bijvoorbeeld: We doen het in de kliko, we brengen het naar de milieu straat, we zetten het buiten aan de straat en het wordt opgehaald, het blijft gewoon thuis liggen.

23. Wat is elektronisch afval?

C.   Alleen alles waar een stekker aan zit (of aan gezeten heeft) en waar een batterij in gezeten heeft.

D.   Alleen alles waar computer chips inzitten zoals bijvoorbeeld telefoons, computers en TV's

24. Wat is geen e-waste?

A.   Computer kastje

B.   Inktpatronen

25. Wat is geen e-waste?

A.   Batterijen

B.   Melk opschuimer

26. Wat is geen e-waste?

A.   Kabel

B.   Gloeilamp

27. Wat is geen e-waste?

    A.   Speelgoed auto

    B.   CD's

28. Wat is recyclen?

………
………
……

29. Waarom is recyclen belangrijk?

………
………
………
………………………………………………………………………………

30. Wat moet je met elektronische apparaten doen als ze kapot zijn?

    E.   Thuis in een kastje bewaren

    F.   Buiten voor de deur zetten en de vuilnismannen halen het dan op

    G.   Thuis bij het rest afval gooien

    H.   Naar de milieustraat brengen

31. Wat moet je altijd even controleren voordat je kapotte elektronische apparaten weggooit?

    A.   Of het nog aan staat.

    B.   Of het ook echt kapot is.

32. Wat kun jij het beste doen met de apparaten die het nog goed doen maar die je niet meer wilt?

A.   Weggooien, want je hebt ze niet meer nodig.

B.   Thuis laten liggen

C.   Aan iemand geven die ze wel nog wil of naar een kringloop winkel brengen.

33. In landen waar veel elektronische apparaten gebruikt worden (zoals Nederland) zijn belangrijke grondstoffen om die apparaten te maken vaak niet beschikbaar en moeten die grondstoffen dus uit andere landen gehaald worden. Vaak gebeurt dit met niet duurzaam vervoer. Waarom is dit niet goed?

………
………
…………………………………………………..

34. Wat gebeurt er met e-waste in ontwikkelingslanden wanneer er niet goed gerecycled wordt?

………
………
……………

NOTES ON METHODS RESEARCH

- Visual research methods in education

It is a qualitative research method that uses artistic mediums as research tool, such as photos, videos and drawings (Spencer, 2011). It is quite a useful method in the educational sector when focusing on the perspective of the student, especially when the students have problems with ordinary communication such as speaking and writing (Moss, 2016).

-It could also help students that are traumatized and that have difficulties to communicate in a direct way about the problem. This is also used in therapy. For this research this method is not really applicable since this method would require too much time. Also we are more interested in direct knowledge and knowledge spreading between actors that will most likely have no problems with regular communication such as speaking and writing. We are not that interested in the perspective of the students that participated within the e-waste race, but more the knowledge that they have, knowledge spreading and their practices.

- Actor network theory

A research method that focusses on the connections (ties) between the different human and non-human actors within a network. The methods used to analyze the connections are

participant observation, in-depth interviews, and document analysis (Elliot,2017).

-Within this research it is the goal to find out how and if the knowledge from the E-waste race has spread from the students and teachers within their network. When analyzing the knowledge spread within the networks the network theory could be used together with the methods belonging to the network theory. Within this research the results from the e-waste race form last year are analyzed so

the process of spreading knowledge has already happened. The process from the participants cannot be observed anymore as it has already happened.

-In depth interviews are a good method for analyzing the knowledge spreading. For example when asking the participants of the neighborhood how they heard from the E-waste race or when asking the children how they promoted the E-waste race.

Document analysis is to compare a range of related texts by extracting relevant information from each document to then group them into categories of related information to see how the documents relate to each other and the context in which they were produced (Elliot, 2017).

-This could be a useful tool to analyze the interviews and questionnaires conducted during this research.

- Interviews

"One of the most important techniques of gathering both qualitative and quantitative data in social science research by asking questions. Interview questions are normally determined in advance, and may be part of the initial research design or may be developed during the course of the research as in grounded theory and ethnography. When conducting quantitative research, interviews need to be structured. An interview schedule is designed so that the same questions can be asked to each interviewee in the same order. For qualitative research it is common to use either semi-structured interviews or open-ended unstructured interviews."(Elliot,2017)

- Agent-based modeling

It is the modeling of a dynamic system using computer simulations to simulate behaviors, interactions, and movements of actors in their environments in simulated space, over simulated time (Elliot, 2017).

-This is a great method to analyze, simulate and display the spreading of knowledge through a social network over time. This method is less suitable, because it is difficult to gain the knowledge needed to reproduce the spreading of knowledge in so much detail.

- Comperative case study

A Case study is the detailed and intensive analysis of a single case in order to reveal its complexity (Elliot,2017).

-Within this report 3 schools are going to be analyzed so three case studies will be conducted.

"An extension of the single case-study method to either the systematic analysis of patterns or the close qualitative in-depth investigation of how similar events are caused (process tracing). In either case, ontological depth in casing is commonly one aim of the exploratory stage of research. Fieldwork and documentary research are commonly used. The systematic approaches such as qualitative comparative analysis (QCA) and fuzzy-set measurement use a range of binary indicators and ordinal rankings to draw contrasts. Process tracing focuses attention on concrete instances of causal chains."(Elliot, 2017)

- process tracing

"A form of qualitative research in which a case-based, triangulated form of research is carefully focused on a narrow or medium range of contexts (e.g. West African border wars or European political regime change), and change over time is examined by going backwards historically to find out what caused current outcomes."(Elliot,2017)

-This research tries to find out how much knowledge is still present from the e-waste race and why this is the case so what happened in the past during the knowledge spreading process.

- census follow-up survey

"A survey carried out immediately after a census to check for error rates in the census itself. Follow-up surveys can take a variety of forms: census quality surveys aim to assess the accuracy of census responses and where there are errors to establish the reasons for them; census coverage surveys on the other hand attempt to identify the degree of coverage and the predictors of non-response." (Elliot,2017)

-Taking two surveys will not be convenient within this research, but it would be possible to include some test questions to see whether the participant pay attention and understood the questions.

- natural experiments (quasi-experiments)

"Designs for studies in the field or in real-life situations commonly applicable in social sciences and education. In such settings, the researcher has little control over the treatment or inclusion criteria (control being the ideal scenario in true experimental designs, according to naturalism). The researcher may be able to manipulate some independent variables. In natural experiments the experimenter does not have control over the assignment to control and experimental groups (which distinguishes them from field experiments). Instead the researcher studies existing or intact groups of participants, which can be labelled as treatment and comparison groups."(Elliot,2017)

-This is the case within this study. Already existing classes are studied after the knowledge spreading process had happened the only way participants were influenced was during the E-waste race itself.

- mixed methods

"The use of multiple research methods in a single piece of research or research program. Mixed methods can be employed at various levels of the research process, including paradigm frameworks, methodological approaches, and analytical techniques. Often, the term is used to denote the integration of quantitative and qualitative approaches and thus involves triangulation. Such an approach is increasingly advocated as it helps overcome the deficiencies of individual methods."(Elliot,2017)

-Within this research mixed methods will be used such as different kind of surveys and interviews.

- survey modes

"Approaches used either to contact or to obtain data from survey respondents. The traditional modes of face-to-face, paper/pencil, postal, and telephone surveys have been extended widely recently with the introduction of web surveys and various other tools (e.g. mobiles, tablets, etc.). New electronic modes thus include Computer-Assisted Personal/Self/Telephone Interviewing (CAPI/CASI/CATI), Audio/Text/Video Computer-Assisted Self-Interviewing (ACASI/TCASI,VCASI), Interactive Voice Response (IVR), and Touch-Tone Data Entry (TDE). The mode of delivery of a survey influences the coverage and response rate, so it should be considered carefully. Mixed mode surveys designs incorporate the advantages of various modes for more efficient designs."(Elliot,2017)

-This depends on how well the different actors can be reached within this research. When it is not able to contact the parents of the students directly than online surveys can be used. The children will then get a link address send home with them and the parents can then go online and fill them in.

- online surveys (web surveys)

"A mode of survey administration which involves any survey developed using software and delivered to potential respondents over the Internet, via email, mobile phone, or a web page. Because of the low cost and short time needed, online surveys can be a good method with which to perform large-scale research. The suitability of online surveys as the mode of administration depends on who can

(or cannot) be reached when using the Internet as a mode of communication. Online surveys usually suffer from coverage error because of the exclusion of subjects without Internet access."(Elliot,2017)

-See above.

- cross-sectional design

  A single group of respondents at one point in time (Gifford, 2016)

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