Master thesis

Influencing girls' attitudes towards science and technology

by online inquiry-based learning environments in sixth grade of primary education

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Abstract

Research in science education has shown that boys' attitudes towards science and technology are more positive than girls' attitudes. Research has shown that there are several possible causes of girls' low attitudes towards science and technology. Possible measures can be taken which can be linked to six common factors that seem relevant to forming positive attitudes towards school science and technology. Therefore, research was conducted in two sixth grade classes of a Dutch primary school with in total 40 children taking part in this study with the main goal to investigate to what extend it was possible to influence girls' attitudes in a positive way towards science and technology. The researcher divided the participants by purposive sampling in an intervention- and control group. Students in both groups had to fill in a questionnaire at the beginning and at the end of the study, to measure their attitudes towards science and technology. The intervention group received three online inquiry learning lessons based on measures to increase girls' attitudes towards science and technology, which was the main question of this study. Other goals of this study were to investigate if there were differences between girls' attitudes in the control- and intervention group, if there were differences between boys' and girls' attitudes towards science and technology and if there were differences in the way of working between boys and girls in the intervention group. This study expected that girls' attitudes towards science and technology were higher after the intervention than before the intervention, but the results did not correspond with the hypothesis; there was no significant difference. The difference between the attitudes towards science and technology from girls in the intervention- and control group was not significant as well. There was also no significant difference between the attitudes of boys and girls towards science and technology. The log files in the online inquiry learning environments state that in one of the three learning environments, there are significant differences in the average time boys and girls spent in this environment which indicates that there were differences in the way of working between boys and girls in this study.

Keywords: *online learning, inquiry-based learning, influencing attitudes, motivation, science and technology, gender differences, primary education*

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Introduction

Women are underrepresented in the world of science and technology (Berg, Sharpe & Aitkin, 2018; Meyer, Cimpian & Leslie, 2015). In the Netherlands, only 16 percent of the students graduate from a science program and in Europe this is 26% on average. Of all graduates in the Netherlands, less than twenty percent are women (Van Keulen & Oosterheert, 2016). Just a small part of the Dutch population has enough scientific and technological knowledge. The science-technical profiles in high school, the study programs in higher professional education and the university have had too few registrations for new students for years (Van Keulen & Oosterheert, 2016). The National Education Standards (National Research Council, 1996) earlier called for greater participation of women in science, but the shortage of female science professionals remains.

Definition of science and technology

Science and technology is a way of looking at and approaching the world. By asking questions, or by coming up with solutions to problems or needs, but also from their own imagination, children learn about object, events, areas, organisms and phenomena that occur in the world around them, in the past, now or in the future (TechniekPact, 2015). In science and technology, wonder and curiosity are the starting point for education, where there is a lot of room for the wide development of pupils, not only in the field of knowledge, but also on a personal and social level. The science and technology approach is in line with how children relate to their life and fantasy worlds. Children ask a lot of questions and love to make something out of their imagination or to build or invent (Van Graft, Klein Tank & Beker, 2016). Since the last two decades, more attention has been paid to science and technology in primary education. Although in recent years a lot of teaching material for education in science and technology have been developed and teachers have followed courses on the implementation of science and technology education, the number of Dutch schools offering science and technology as a topic remains limited (Van Graft, et al., 2016). Science and technology cannot be ignored from everyday life. Education in science and technology is necessary to give children insight into the meaning in their own lives (TechniekPact, 2015).

Attitudes towards science and technology

Research in science education indicates that there are differences in attitude towards science and technology between boys and girls. Boys' attitudes are more positive than girls' attitudes toward science and technology (Miller, et al., 2006; Ramsden, 1998; Simpson &

Oliver, 1985; Weinburgh, 1995). Boys' and girls' liking of, competence perceptions about and motivation to work with science and technology differs, because they have different experiences with science content and activities. Girls like science less than boys do; they find it more often uninteresting, not useful, unpleasant, or too costly in time or effort (Stoilescu & Egodawatte, 2010). This has been identified as one of the strongest reasons for the relatively small numbers of women working in science and technology (Eccles, 2007; Meelissen & Drent, 2008; Stoilescu & Egodawatte, 2010). This is in line with the fact that boys prefer science books more than girls do (Harkrader & Moore, 1997) and that men enrol in more computer-based courses, which lead to more male, graduated science and technology students (Sanders, 2006). Girls select non-compulsory science classes in high school less often, compared to boys (U.S. Department of Education, 2006). Many studies have identified that boys, on average, believe they are more competent or more successful in science than girls do (Andre, Whigham, Hendrickson & Chambers, 1999; Beghetto, 2007; Patrick, Mantzicopoulos & Samarapungavan, 2008). Kahle and Meece (1994) and Sanders (2006) confirm that; Dutch girls truly have less self-confidence in science and technology than boys have. Meece and Jones (1996) indicated that when girls lack self-confidence, this could result in less motivation and a lower attitude towards science and technology, and low interest can affect the ability and willingness to learn (Baram-Tsabari & Yarden, 2011).

Kennedy, Quinn and Taylor (2016) stated that there are six common factors that seem particularly relevant to students' forming positive attitudes towards science and technology. The first factor is a student's intention to enrol in a science course or science education after the student finished compulsory schooling in high school. The second factor is a student's perception of the enjoyableness of school science. The third factor is a student's perceived difficulty of school science. The fourth factor is a student's perception of their self-efficacy in a school science. The fifth factor is relevance of school science for the student's everyday life, which could be split in relevance to society and world and personal relevance of school science. Personal relevance of school science could be described in three ways: as a personal desire of the student to learn about the science of the natural world; as the applicability of school science to everyday situations and as a student's desire to understand the technologies used in the everyday world. The sixth factor is usefulness of school science for the student's future career, which could be split in usefulness for their later careers in science and usefulness for their later personal career (Kennedy, et al., 2016).

Possible causes of girls' low attitudes towards science and technology

There are various possible causes of girls' low attitude towards science and technology. The first of them is the negative and stereotype image that sticks to science and technology; science and technology would be difficult, heavy and badly paid (Van Keulen & Oosterheert, 2016). Science is often viewed stereotypically as a domain that men prefer and are more competent at, compared to women (Andre, et al., 1999; Berg, et al., 2018; Kerkhoven, Russo, Land-Zandstra, Saxena & Rodenburg, 2016). The media portray science and technology as a male domain (Sanders, 2006) and in various programs and films where scientist occur, many characters show portray the stereotype of the antisocial, unattractive, technology fused and weird male scientists (Chodorow, 1998; Wong, 2016). These programs and films have an impact on the development of stereotypes by children, because some children have these kind of programs and films as their only source of what scientists may look and act like (Cheryan, Plaut, Handron & Hudson, 2013). Kermarrec (2014) noted that primary school children are at the age where they are most likely to be influenced by stereotypes, and by the time they reach higher professional education or university, it is very hard to change views that have been formed earlier.

The upbringing of children by parents could be the second possible cause of girls' low attitude towards science and technology. Related to the first possible cause of girls' low attitude towards science and technology; the stereotypes can be formed by the parents and these could be confirmed in primary school (Sanders, 2006). The upbringing by parents could influence what boys and girls like and prefer to do, now and in the future. Boys receive more science- and math toys than girls do from their parents (Jacobs & Bleeker, 2004) and boys are given more explanations than girls are given by their parents during visits to science exhibits (Crowley, Callanan, Tenenbaum & Allen, 2001).

The third possible cause of girls' low attitude towards science and technology is due to the way of education by teachers. The traditional science instruction has been criticized for continuing the masculine stereotypes of science and scientists (Scantlebury & Baker, 2007); the format and content of science lessons tend to be adapted more to the preferences of boys than to girls' preferences (Koch, 2007) and therefore does not fit the needs of girls. Girls tend to prefer doing science and making a connection with what they know and what they learn at the same time, whereas boys could also enjoy non-contextualized activities (Baker & Leary, 1995).

The fourth possible cause of girls' low attitude towards science and technology is the fact that in the Netherlands 83 percent of the teachers are women (PO-Raad, 2017). Some female teachers could have too little confidence in their knowledge and possibilities to give science and technology education themselves, which could result in less motivation and less stimulation of young girls in primary school towards science and technology (Van Keulen & Oosterheert, 2016).

Possible measures to influence girl's attitudes towards science and technology

It is obvious that there are several possible causes of girls' low attitude towards science and technology, but there are also possible measures to influence girls' attitudes towards science and technology (Çokadar & Külçe, 2008). TechniekPact (2015) stated that it is important to make children early in primary education, especially girls, more familiar with science and technology, with the result that they are more inclined to choose a technical follow-up course or a technical profession. Also, Klawe, Whitney and Simard (2009) stated that there should be an early intervention method when girls are practically a blank sheet, early in primary school, to increase the number of women in careers related to science and technology. Improving girls' learning and achievement in science and technology may be important to increasing their science and technology participation and later career choices. Primary school teachers are at the beginning of the chain and they can make girls enthusiastic about science and technology, show how fun, varied and challenging science and technology is. They can give girls self-confidence, which is very important for them, and encourage them to discover their talents (Magon, 2009). Students with high self-confidence can reach higher achievements in science, whereas those with lower self-confidence tend to be less successful (Andre et al., 1999). The six factors which Kennedy et al. (2016) appointed that seem particularly relevant to students' forming positive attitudes towards school science and technology, could be linked to possible measures to influence girl's attitudes towards science and technology. These possible measures will be discussed below.

The first possible measure to influence girls' attitudes towards science and technology is to use inquiry learning in the science and technology lessons in primary school. Inquiry learning has been shown to be a successful intervention technique in science (Anderson, 1993) and could help to prevent the negative view – more difficult and less enjoyable to learn than other subjects – girls tend to form about science and technology (Andre et al., 1999). Research from Cavallo and Laubach (2001) has shown that women's interest, insight, later

course enrolment and achievement in science and technology are significantly greater in high inquiry classrooms compared to low or non-inquiry classrooms. Teaching that shows consistencies with the ideal inquiry learning cycle is called high inquiry. Teaching that shows inconsistencies with the ideal inquiry learning cycle is called low inquiry (Cavallo & Laubach, 2001). Inquiry-based learning is organized into inquiry phases that together form the inquiry cycle, which was originally developed by Robert Karplus in the late 1950s and early 1960s which consists of three phases; exploration, term introduction and concept application (Cavallo & Laubach, 2001). Nowadays, inquiry-based learning is defined as a process of discovering new causal relations, with the learner formulating hypotheses and testing them by conducting experiments and making observations (Pedaste et al, 2015). Pedaste et al. (2015) made an analysis of a large set of articles describing inquiry phases and developed a synthesized inquiry cycle that consist of five general inquiry phases: orientation, conceptualization, investigation, conclusion and discussion. The orientation phase stimulates the curiosity about a topic and addresses learning challenges through a problem statement. The conceptualization phase generates research questions and hypotheses based on the problem statement. The investigation phase is the process of planning experimentation, collecting and analysing data. The conclusion phase covers the process of drawing conclusions from the data and comparing these conclusions with the hypotheses. The last phase, the discussion phase, is for reflecting on the activities done earlier. Although in the 1960s many inquiry-based curricula were developed to help promote students' critical thinking, concept understanding, and scientific reasoning abilities (Lawson, Abraham & Renner, 1989), not all teachers did know how to use these curricula; therefore they may not implement the inquiry learning cycle as intended (Lawson, et al., 1989). Understanding of the inquiry learning cycle ranged from good understanding to misunderstanding. During the different phases of the inquiry learning cycle, teaching behaviours differed according to the teachers' understanding. When teachers misunderstand, insert or use the phases of the inquiry learning cycle in a wrong way, it leads to lower inquiry-based classrooms (Cavallo & Laubach, 2001). High inquiry learning makes learning science significantly more interesting than the traditional teacher- and textbook-dominated instruction did (Leverink, 2013; Stannard, 2016).

Another possible measure to influence girls' attitudes towards science and technology is to insert online learning environments in the science and technology lessons in primary school. Girls respond very positive to online learning environments (Kay, 2008) and do better

in online learning environments than in face-to-face classrooms (Hsi & Hoadley, 1997; Leong & Hawamdeh, 1999).

Inserting gender neutral – and non-stereotype – activities during the science and technology lessons by the teacher could also be a possible measure to influence girls' attitudes towards science and technology (Kerkhoven, et al., 2016; Koch, 2007). Gender neutrality means that there is no distinction made between how boys and girls are taught (Kerkhoven, et al., 2016). Teaching in a gender-neutral way and the use of gender-equal language by the teachers might be successful in raising girls' interest in science (Patrick, et al., 2008). It will help to match girls' self-image of working in science (a negative image) with their actual capacities of working in science (positive – girls can do science as well as boys), it will help to suppress the stereotypes and it will help to motivate girls more. Gender neutral activities include problem solving, discovering, practical experiences and constant engagement with project or issues over time (Booy, Jansen, Joukes & Van Schaik, 2011).

Making the relevance clear of science and technology to girls' everyday life and issues is another possible measure to influence girls' attitudes towards science and technology. Girls prefer to use science and technology in a way that is meaningful to them (American Association of University Women, 2008), so it must be taught and shown that science and technology is everywhere in everyday life to increase the motivation of girls to learn science and technology (National Research Council, 2007). Girls must become curious because this is an important driving force behind the motivation to learn (Ebbens & Ettekoven, 2013). For girls it is more important than for boys that learning objectives and activities are connected to real life situations and problems (Magon, 2009). It is very important to arouse interest on the topic to motivate the girls, because when the interest is being fed, it promotes effective learning (Vansteenkiste, Sierens, Soenens & Lens, 2007).

A fifth possible measure to influence girls' attitudes towards science and technology is to insert or use female role models during the science and technology lessons. Magon (2009) and Buunk and Van der Laan (2002) mentioned that girls benefit more from and can identify more with same-sex role models than men do. Girls become more inspired by role models from the same sex, appreciate it more than boys do (Booy, et al., 2011; Lockwood, 2006) and it can help to improve girls' self-image about being able to do science (Booy, et al., 2011). Because there are so few female role models, it could help girls when teachers insert an

animated woman as a researcher in their online inquiry learning environment, who guides the girls. The animated woman should give compliments during the online lessons, because compliments help girls to form a positive self-image, gives them self-confidence, motivates desired behaviour and helps to focus on positive behaviour (Bijlsma, 2014). Representing women as scientists, appointing explicitly that girls can also become scientists and that science is practiced by all types of people is highlighted as being critical (Patrick, et al., 2008). Girls suffer more from stereotypical ideas than boys do (Lockwood, 2006), so it is important for them to know that other women have been successful and that they could become successful as well.

Present study

Is it possible to increase girls' attitudes towards science and technology with lessons based on the five measures mentioned above? Could lessons based on online inquiry learning with gender-neutral activities and lessons where female role models are added help to increase girls' attitudes towards science and technology? Should it help to increase girls' attitudes towards science and technology when the relevance and meaningfulness of science and technology are made clear to girls' everyday life and issues? To give an overview of the present study, figure 1 below gives a representation of the procedure of the research.

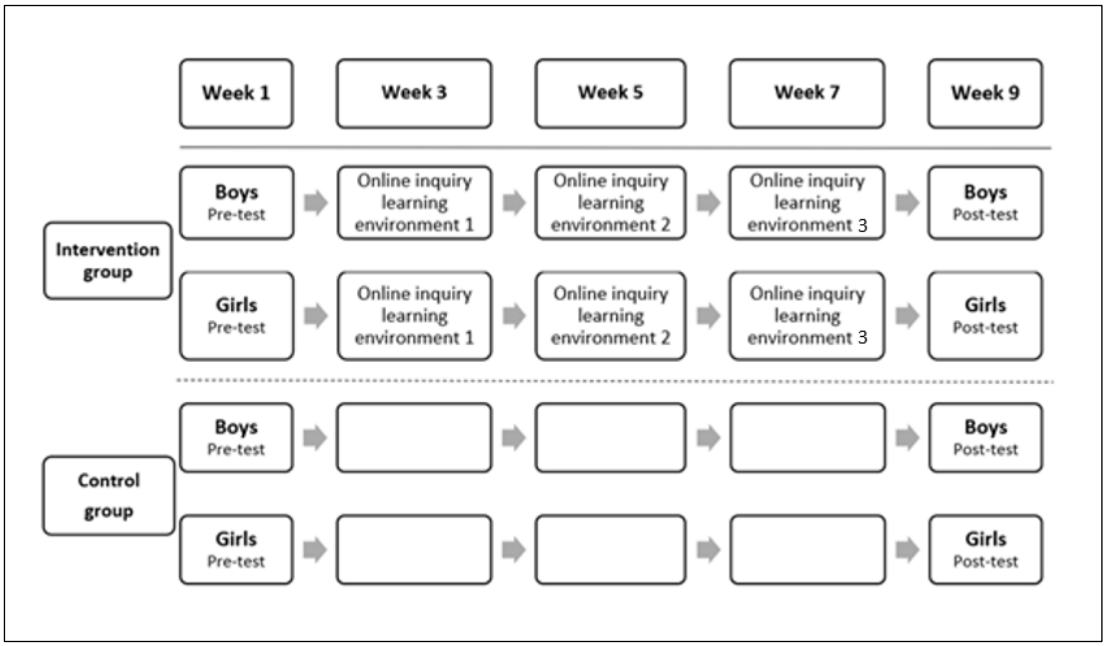

Figure 1: Representation of the procedure of the research.

The main goal of the present study was to investigate whether it was possible to influence girls' attitudes towards science and technology in a positive way. Other goals of this

study were to investigate if there were differences between girls' attitudes in the intervention group and control group, if there were differences between boys' and girls' attitudes towards science and technology and if there were differences in the way of working between boys and girls in the intervention group.

The main question of the present study was therefore as follows:

1. *"Is it possible to influence girls' attitudes towards science and technology in a positive way by online inquiry-based learning environments in primary education?*

Two sub-questions of the main question were formulated:

1.1 "Are girls in the intervention group after the intervention more positive towards science and technology than before the intervention?"
1.2 "Are there differences in the attitudes towards science and technology between girls in the intervention- and control group before and after the intervention?"

The hypothesis for the main question and the two sub-questions was that the attitudes towards science and technology of girls in the intervention group after the intervention was positively influenced and that there would be a significant difference between the attitudes towards science and technology of girls in the intervention- and control group. The girls in the intervention group have worked for three weeks with online inquiry-based learning environments whereas girls in the control group did not. Inquiry learning has been shown to be a successful intervention technique in science (Anderson, 1993) and could help to prevent the negative view girls tend to form about science and technology (Andre et al., 1999). High inquiry learning ensures more interest and insight in science and technology compared to non-inquiry classrooms (Cavallo & Laubach, 2001). In the online inquiry-based learning environments the topics, the learning objectives and activities are related to everyday life science and technology and connected to real life situations and problems, which presents science and technology in an meaningful way (American Association of University Women, 2008) and provides increased motivation for girls in the intervention group (Magon, 2009; National Research Council, 2007). At least girls respond very positively to online learning environments (Hsi & Hoadley, 1997; Leong & Hawamdeh, 1999) and do better in online learning environments than in face-to-face classrooms (Kay, 2008). An animated woman as scientist in the online inquiry-based learning environments can help girls to form a positive

self-image, give them self-confidence and motivate them (Bijlsma, 2014; Patrick, et al., 2008).

The other questions were as follows:

2. "Are there differences between boys' and girls' attitudes towards science and technology before the intervention?"
3. "Are there differences in the way of working between boys and girls in the intervention group?"

The hypothesis for question two was that there would be a significant difference between boys' and girls' attitudes towards science and technology and that boys' attitudes towards science and technology would be significantly higher than girls' attitudes towards science and technology. Girls like science less than boys do (Eccles, 2007; Meelissen & Drent, 2008; Stoilescu & Egodawatte, 2010), boys believe they are more competent at science and technology than girls do (Andre, et al., 1999; Beghetto, 2007; Patrick, et al., 2008) and Dutch boys have more self-confidence in the science subject than Dutch girls have (Kahle & Meece, 1994; Sanders, 2006). For question three there is no hypothesis. There are certain resources in the background of the online inquiry-based learning environments possible to investigate if there are any differences at all.

Method

Participants

The participants were 40 children from two sixth grade classes of a Dutch primary school located in Raalte, a town in the heart of the region of Salland in the province of Overijssel. The school was selected by purposive sampling. Originally, 43 children were to participate in this study, but the data of three students were excluded due to unfinished pre-tests, post-tests or online inquiry learning environment lessons. In total 20 boys and 20 girls participated in this research. Their age ranged from 11 to 13 (M_{age} = 11.33; SD = 0.53). The native language of the participants was Dutch. According to the rules of the primary school, parents were informed, by an e-mail (See appendix A) about their child's participation and the possibility for their child to stop participating at any time in this study if they wanted. When parents did not agree with the participation of their child in this study, they had to send the researcher an e-mail, which no parent did. The researcher of this study is also a teacher in this school and conducted this study as an addition to the school curriculum and during school

time. The participants had no relevant prior knowledge about doing research and the cycle of inquiry learning. The participants were able to use a Chromebook, because they worked on it daily. The participants were assigned to one of the two groups, with the help of purposive sampling. The participants of one class participated as the control group (N=20; M_{age} = 11.35; $_{SD}$ = 0.587) and the participants of the other class participated as the intervention group (N=20; M_{age} = 11.30; $_{SD}$ = 0.470). The participants in the control group followed the traditional school program of science and technology during school time and the participants in the intervention group received extra online inquiry learning lessons, in addition to the traditional school program of science and technology during school time. The school is working with International Primary Curriculum (IPC). The IPC curriculum is a digital curriculum that works with clearly defined learning objectives and themes, which are called units. An IPC unit is an overarching theme that covers different school subjects, like history, nature, science and technology, geography and art. The school subjects (including science and technology) at IPC are connected to each other so students learn to see links between these subjects (International Primary Curriculum, 2018).

Materials

Questionnaire 'Attitudes towards science and technology'

The ten question of the SSAS (School Science Attitude Survey) from Kennedy, et al. (2016) and the 25 questions of the Attitude Questionnaire Science from the Faculty of Education, University of Cambridge (2010) were combined and translated from English to Dutch to make a new questionnaire (See appendix B). The questionnaire consisted of two parts, in the first part he 25 questions of the Attitude Questionnaire Science were presented which could be answered by the participants using a 7-point Likert scale ranging from totally agree to totally disagree. The second part consisted of ten questions of the SSAS and was divided into two parts. The first seven questions of the SSAS were presented which could be answered by the participants using a 5-point Likert scale, ranging from totally agree to totally disagree. The last three questions of the SSAS were statements where the participants had to choose one out of five answer possibilities, which was different for each statement. The questionnaire was printed for the participants and they had to fill this in at the beginning of the study as a pre-test, and also at the end of the study as a post-test.

Online inquiry-based learning environments

Three online inquiry-based learning environments, made with the help of Graasp, were used in this study. With the help of online labs from GoLabz the students can conduct

scientific experiments in the three online inquiry-based learning environments (GoLabz, 2018). The online inquiry-based learning environments used during the intervention were opened on the Chromebooks of the participants. After a brief instruction of what the participants could expect, they could start. The first online inquiry-based learning environment was about plants and light, the second one about electricity and the third one about the colours of light. In the first online inquiry-based learning environment the lab 'Rate of Photosynthesis Lab' was used from Leo Siiman. In the second environment the lab 'Circuit Construction Kit: DC' was used and in the third environment the lab 'Color Vision', both from PhET Interactive Simulations. In the online inquiry learning environments the different phases of the inquiry learning cycle were translated to tabs with meaningful names where the participants themselves could go through, with the help of an animated girl that offered them help and hints. In the end of each phase they were told to click on the next tab in the top of the environment.

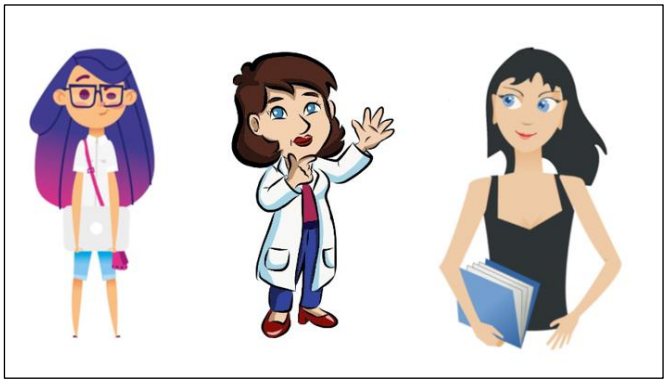

Figure 2: The animated girls of the online inquiry-based learning environments.

In the first online inquiry learning environment, about plants and light, the different phases of inquiry learning were divided in ten tabs. In the first tab the animated girl Sophie introduced herself, her research project about plants in the school greenhouse and asked the participants to help her during the research project. In the second tab Sophie gave some information about chloroplasts and photosynthesis, a video was shown about photosynthesis and a question was asked about the content in the video. The third tab was about the preparation of the research; working in the laboratory was explained with the help of a picture of the lab with corresponding words (figure 3). In the fourth tab the participants had to complete the first hypothesis and made a new hypothesis themselves. In the fifth tab the participants carried out an investigation which was very structured, what they had to do in the lab was already described in a table. The values for the amount of light, the temperature and

the number of seconds were described in the table, the participants only had to note the number of bubbles. In the sixth tab the participants had to do two more investigations where they had to determine the temperature themselves and note the number of bubbles. In the seventh tab the participants had to determine the amount of light themselves and do another investigation after which they noted the number of bubbles. In the eighth tab the participants saw an overview of the tables with their research results. They had to fill in what they discovered in this research project. In the second to last tab the participants had to compare their hypotheses with their results to draw a conclusion. In the last tab Sophie gave two conclusions and the participants had to indicate whether they agree or disagree. In the end Sophie thanked the participants for their help. The link to the online inquiry learning environment is as follows: http://graasp.eu/s/m4zqzd.

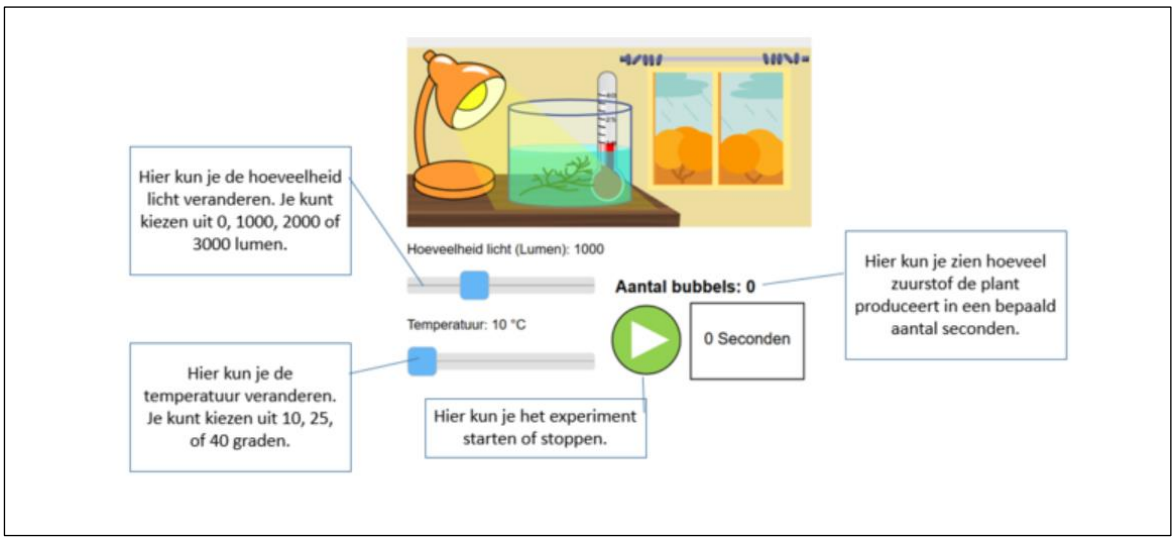

Figure 3: Explanation of working in the laboratory of plants and light.

In the second online inquiry learning environment, about electricity, the different phases of inquiry learning were divided in six tabs. In the first tab the animated girl Kim introduced herself, a short video is shown to introduce the topic of this lesson and to involve the participants, a short explanation about the video was given and the learning goals of the lesson were told by Kim. In the second tab a short video is shown to explain how electricity works and a few terms were explained. In the third tab information about how to work in the laboratory were given with the help of a video and the participants had to complete the first hypothesis and formulate at least one hypothesis. In the fourth tab the participants had to make an electric circuit with various objects in it (e.g. an eraser or a pencil) to see which objects conduct electricity. They had to fill in a table where they noted which object they

added to the electric circuit and whether or not these objects conducted electricity. In the fifth tab the participants had to compare their hypotheses with their results to draw a conclusion. In the sixth tab Kim asked the participants to explain how an electric circuit works and to reflect on the activities in this research project. In the end Sophie thanked the participants for their help. The link to the online inquiry learning environment is as follows: http://graasp.eu/s/e89k0x.

In the third online inquiry learning environment, about the colours of light, the different phases of inquiry learning were divided in eight tabs. In the first tab a new animated girl introduced the topic and her questions about it. In the second tab some theory about the sun and stars as light sources is given. In the third tab some theory about lamps as a light source is given and how it is possible that people can see things with their eyes when light sources shine on objects. In the fourth tab a statement about light was shown and the participants had to choose whether they thought it might be true or not. In the fifth tab the laboratory was explained with text. A few questions were given to investigate in the laboratory. In the table under the laboratory the participants had to fill in which colours they had mixed. In the sixth tab the participants had to answer a few questions to check if they understood what they did in the tab before. In the seventh tab the animated girl gave a summary and an explanation of what the participants did and learned in this online inquiry learning environment. The eighth tab is an additional tab with extra explanation about light waves for participants who finished early. The link to the online inquiry learning environment is as follows: http://graasp.eu/s/9dbugm.

Procedure

The study was conducted during a nine-week period. In the first week, at the start of the experiment, all participants – in both the intervention and control group – filled in the pre-test on paper; the questionnaire about their attitudes towards science and technology. The first page of the questionnaire asked the participants for their name, gender and from which group they were. The questionnaire itself consisted of three pages with in total 35 questions. Subsequently in the third week, participants in the intervention group received a link on the digibord to enter the first online inquiry learning environment about plants and light on their own Chromebook. In the fifth week, participants in the intervention group again received a link on the digibord to enter the second online inquiry learning environment about electricity on their own Chromebook. In the seventh week, participants in the intervention group

received a link on the digibord for the last time to enter the third online inquiry learning environment on their own Chromebook, this time about the colour of light. During working on the three online inquiry-based learning environments the participants were seated apart from each other at separate tables and went through the online inquiry learning environments on their own. They had a maximum of 45 minutes to work on it each time. They were asked to fill in their name to enter the online inquiry learning environment, because the researcher had to link the names of the participants to participant numbers to process the data. However, in the end, all the data was anonymous. After the participants went through all the tabs and reached the end of the online inquiry learning environments, they were instructed to close the online inquiry learning environments. In the ninth week, all participants – in both the intervention and control group – filled in the post-test; the questionnaire about their attitudes towards science and technology. The post-test was the same as the pre-test to see to what extend their attitudes towards science and technology had changed or not.

Data analysis

All analyses were done by using SPSS version 23. Before an analysis could be done, the missing values were deleted from the original data file. Before the analyses could be conducted, the 'negative items' had to be recoded. Item 3, 9, 15, 27, 33, 34 and 35 had to be recoded.

Questionnaire 'Attitudes towards science and technology'

To create an overview of participant's attitudes towards science and technology before and after the intervention, total scores were calculated by adding the answers to each question up, for both part one and two of the pre-test and both part one and two of the post-test. So, a few new variables were created. Consequently, participants' attitudes towards science and technology could be represented as the sum of answers in part one, varying between 25 and 175 points, and as the sum of answers in part two, varying between 10 and 50 points. Together the sum of answers in part one and two were calculated to a total score to represent participants' attitudes towards science and technology, varying between 35 and 225 points. The higher the mean scores, the lower the attitudes towards science and technology. Descriptive statistics were used to get a good representation of the average scores of both boys and girls, in the intervention group and control group, on both the pre- and post-test. The Paired Samples T-Test was used to test if there were differences in scores on the pre- and post-test between girls in the intervention group and to test if there were differences in scores on the pre- and post-test between girls in the control group. The Independent Samples T-Test

was used to test differences in scores on the pre-test between boys and girls (both in the intervention as in the control group), differences in scores on the pre- and post-test between girls in the intervention- and control group, and differences in scores on the pre- and post-test between boys and girls in the intervention group. Levene's Test was significant in the Independent Samples T-Test where the mean score on the pre-test of boys and girls in the intervention group was compared with each other and in the Independent Samples T-Test where the mean score on the pre- and post-test of girls in the intervention- and control group was compared with each other. Because Levene's test was significant, corrected values for the test-statistics of the Independent T-Test were used.

The reliability of the questionnaire (pre-test) has been calculated by Cronbach's alpha. To give a correct image, the reliability of part one and part two of the questionnaire were first calculated separately. Cronbach's alpha for this first part of the questionnaire was very good, $\alpha = 0.94$ and Cronbach's alpha for the second part was also good, $\alpha = 0.81$. When calculating the reliability for part one and part two together, also a very good Cronbach's alpha appeared, namely $\alpha = 0.95$ (Cronbach, 1951).

Log files

To capture participant's activities, their actions in the online inquiry learning environments were logged to see if there are differences in the way of working between boys and girls in the intervention group. In the background of the three online inquiry-based learning environments two tracking systems were added which only the researcher could see; the Time Spent Summary app and the Timeline app. The Time Spent Summary app displays a table with the time spent by all the participants in each phase of the online inquiry-based learning environments. The Timeline app shows a timeline with the activities of the participants, it displays the times during which the participants were active in the different phases and apps of the online inquiry-based learning environments. Because Levene's Test was significant in the Independent Samples T-Test when comparing the average time of boys and girls spent in the third online inquiry-based learning environment, corrected values for the test-statistics of the Independent T-Test were used.

Results

Attitudes towards science and technology

To see if there were differences between the mean scores of both boys and girls, in the

intervention and the control group, on both the pre- and post-test, a few tables were created. Table 1.1 summarizes the mean scores of boys and girls of the intervention group and table 1.2 summarizes the mean scores of boys and girls of the control group. Table 1.3 gives an overview of the mean scores of boys and girls, both in control- and intervention group. The total score could vary between 35 and 225 points. The higher the mean scores, the lower the attitudes towards science and technology (S&T).

Table 1.1

Mean scores for the intervention group. The higher the mean scores, the lower the attitudes towards S&T.

		Pre-test part 1	Pre-test part 2	Post-test part 1	Post-test part 2	Pre-test total	Post-test total
Boys	Mean	85,73	28,45	93,27	29,55	114,18	122,82
	N	11	11	11	11	11	11
	SD	25,338	6,788	29,432	6,788	31,619	35,589
	Min.	44	15	45	16	59	64
	Max.	127	39	149	37	160	186
Girls	Mean	89,44	29,78	92,00	30,22	119,22	122,22
	N	9	9	9	9	9	9
	SD	22,567	5,426	26,163	7,120	27,504	32,721
	Min.	63	21	62	22	88	87
	Max.	126	37	134	45	163	179
Total	Mean	87,40	29,05	92,70	29,85	116,45	122,55
	N	20	20	20	20	20	20
	SD	23,578	6,091	27,286	6,761	29,177	33,429
	Min.	44	15	45	16	59	64
	Max.	127	39	149	45	163	186

The mean score for boys in the intervention group on the pre-test total is lower than the mean score on the post-test total. The mean score for girls in the intervention group on the pre-test total is lower than the mean score on the post-test total. The Paired Samples T-Test showed that the mean score for girls in the intervention group on the pre-test total and the mean score on the post-test total do differ, but this difference is not significant ($t = -.379$, $df = 8$, $p = .715$).

The Independent Samples T-Test showed that the mean score on the pre-test total for boys and girls in the intervention group do differ, but there is no statistical evidence that there are significant differences between boys and girls in the intervention group (t = -3.76, df = 18, *p* = .712). The Independent Samples T-Test showed that the mean score on the post-test total for boys and for girls in the intervention group do differ, but there is no statistical evidence that there are significant differences between boys and girls (t = .039, df = 18, *p* = .970).

Table 1.2

Mean scores for the control group. The higher the mean scores, the lower the attitudes towards S&T.

		Pre-test part 1	Pre-test part 2	Post-test part 1	Post-test part 2	Pre-test total	Post-test total
Boys	Mean	68,78	23,78	71,00	26,11	92,56	97,11
	N	9	9	9	9	9	9
	SD	31,160	7,067	35,178	9,020	37,954	43,979
	Min.	30	14	25	14	44	39
	Max.	114	37	124	42	151	166
Girls	Mean	85,27	27,64	105,27	31,27	112,91	136,55
	N	11	11	11	11	11	11
	SD	10,827	4,696	14,332	2,611	15,050	16,275
	Min.	75	22	80	27	98	109
	Max.	112	38	121	35	150	154
Total	Mean	77,85	25,90	89,85	28,95	103,75	118,80
	N	20	20	20	20	20	20
	SD	23,268	6,043	30,581	6,692	28,873	36,863
	Min.	30	14	25	14	44	39
	Max.	114	38	124	42	151	166

The mean score for boys in the control group on the pre-test total is lower than the mean score on the post-test total. The mean score for girls in the control group on the pre-test total is lower than the mean score on the post-test total. The Paired Samples T-Test showed that the mean score for girls in the control group on the pre-test total and the mean score on the post-test total do differ and that there is statistical evidence that the scores on the post-test are significantly higher than the scores on the pre-test (t = -4.572, df = 10, *p* = .001).

Table 1.3

Overview mean scores boys and girls, for the control- and intervention group. The higher the mean scores, the lower the attitudes towards S&T.

Gender	Group		Pre-test total	Post-test total
Boys	Control	Mean	92,56	97,11
		N	9	9
		SD	37,954	43,979
	Inter-vention	Mean	114,18	122,82
		N	11	11
		SD	31,619	35,589
	Total	Mean	104,45	111,25
		N	20	20
		SD	35,420	40,659
Girls	Control	Mean	112,91	136,55
		N	11	11
		SD	15,050	16,275
	Inter-vention	Mean	119,22	122,22
		N	9	9
		SD	27,504	32,721
	Total	Mean	115,75	130,10
		N	20	20
		SD	21,168	25,371
Total	Control	Mean	103,75	118,80
		N	20	20
		SD	28,873	36,863
	Inter-vention	Mean	116,45	122,55
		N	20	20
		SD	29,177	33,429
	Total	Mean	110,10	120,68
		N	40	40
		SD	29,364	34,786

The Independent Samples T-Test showed that when boys and girls from the intervention- and control group were compared with each other, the mean score for boys on the pre-test total was lower than the mean for girls on the pre-test total. There is no statistical evidence that boys' attitudes towards science and technology is higher than girls' attitudes towards science and technology in the pre-test ($t = -1.225$, $df = 31.037$, $p = .230$).

The Independent Samples T-Test showed that the mean score on the pre-test total for girls in the control group and the mean score on the pre-test total for girls in the intervention group do differ, but there is no statistical evidence that there are significant differences in mean scores for the pre-test total between girls in the control group and girls in the intervention group ($t = -.617$, $df = 11.832$, $p = 0.549$). The test also showed that the mean score on the post-test total for girls in the control group and the mean score on the post-test total for girls in the intervention group do differ, but also here is no statistical evidence that there are significant differences in mean scores for the post-test total between girls in the control group and girls in the intervention group ($t = 1.198$, $df = 11.199$, $p = 0.256$).

Log files

To capture participant's activities, their actions in the online inquiry-based learning environments were logged to see if there are differences in the way of working between boys and girls in the intervention group. In figure 3.1 a timeline is shown, that was made in Timeline app of the online inquiry-based learning environment 'Plants and light'. This figure shows that most of the students follow the structure of the online inquiry learning environment. As intended most of the time was spent in the 'research-phases'. From the figure below it can be concluded that it is remarkable that many participants did not finish this lesson in time.

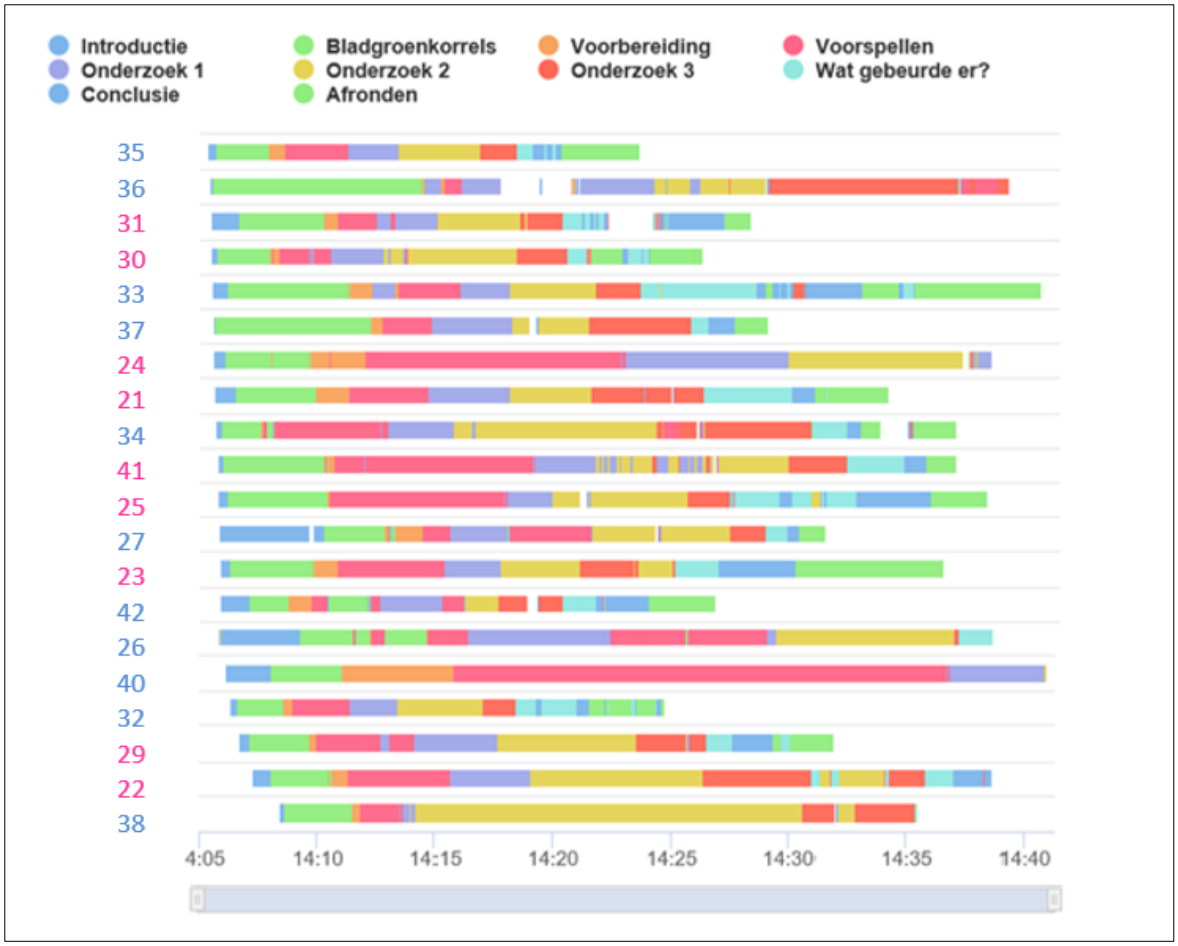

Figure 3.1. Time the participants spent in each phase of the online inquiry-based learning environment 'Plants and light' (blue number = male participant, pink number = female participant).

In figure 3.2 a table is shown, that was made in the Time Spent Summary app of the online inquiry-based learning environment 'Plants and light'. The average time they worked in the first online inquiry-based learning environment 'Plants and light' was 27:29 minutes. The average time of boys was 26:66 minutes and the average time of girls was 27:93 minutes. There is no statistical evidence that there are significant differences in the average time boys and girls spent in this online inquiry learning environment (t = -.505, df = 18, p = .62,).

	Introductie	Bladgroenkorrels	Voorbereiding	Voorspellen	Onderzoek 1	Onderzoek 2	Onderzoek 3	Wat gebeurde er?	Conclusie	Afronden	Totaal
38	0:14	2:56	0:19	1:51	0:29	17:13	3:50	0:03	0:00	0:02	27:01
26	3:19	4:46	0:06	8:49	6:27	7:34	0:12	1:26	0:00	0:05	32:48
42	1:15	3:23	1:01	2:01	2:41	1:25	2:12	1:24	2:06	2:48	20:22
31	1:14	3:38	0:36	1:58	2:27	3:35	1:43	1:27	3:04	1:08	20:53
21	0:58	3:25	1:23	3:18	3:28	3:26	4:32	3:49	0:59	3:00	28:22
37	0:10	6:35	0:28	2:04	3:24	2:47	4:20	0:43	1:05	1:24	23:06
29	0:20	2:33	0:16	3:48	4:00	5:56	2:50	1:31	1:44	2:06	25:09
23	0:23	3:33	0:59	4:30	2:22	4:52	2:30	1:51	3:11	6:15	30:31
33	0:37	5:10	1:04	2:38	3:01	3:44	2:22	5:26	3:42	7:09	34:57
35	0:21	2:14	0:38	2:42	2:06	3:27	1:32	0:53	0:58	3:18	18:13
40	1:49	3:02	4:43	21:05	4:00	0:05	0:00	0:00	0:00	0:00	34:47
25	0:26	4:11	0:05	7:30	1:58	5:41	1:51	4:13	3:52	2:20	32:11
32	0:18	1:52	0:23	2:28	2:01	3:36	1:23	2:43	0:59	2:37	18:24
27	4:16	2:49	1:21	4:42	2:31	5:35	1:29	0:56	0:29	1:07	25:20
36	0:18	8:54	0:12	2:08	6:00	4:13	8:43	0:04	0:00	0:00	30:36
41	0:16	4:19	0:22	8:26	4:48	5:27	2:48	2:27	0:53	1:16	31:06
22	1:26	2:37	0:40	4:19	3:26	9:45	6:18	1:58	0:57	0:00	31:28
30	0:14	3:33	0:24	2:16	2:29	5:22	2:08	1:37	0:20	2:15	20:41
24	0:32	3:38	2:22	11:08	7:36	7:22	0:00	0:00	0:00	0:00	32:40
34	0:27	1:53	0:08	5:39	3:00	8:25	5:39	1:28	0:37	2:36	29:58

Figure 3.2. Timetable that shows how much time participants spent in each phase of the online inquiry-based learning environment 'Plants and light' (blue number = male participant, pink number = female participant).

In figure 4.1 a timeline is shown, that was made in the Timeline app of the online inquiry-based learning environment 'Electricity'. This figure shows that most students follow the structure of the online inquiry-based learning environment as intended and that most of the time was spent in the 'research-phase'. Remarkable is that most of the participants finished this lesson on time.

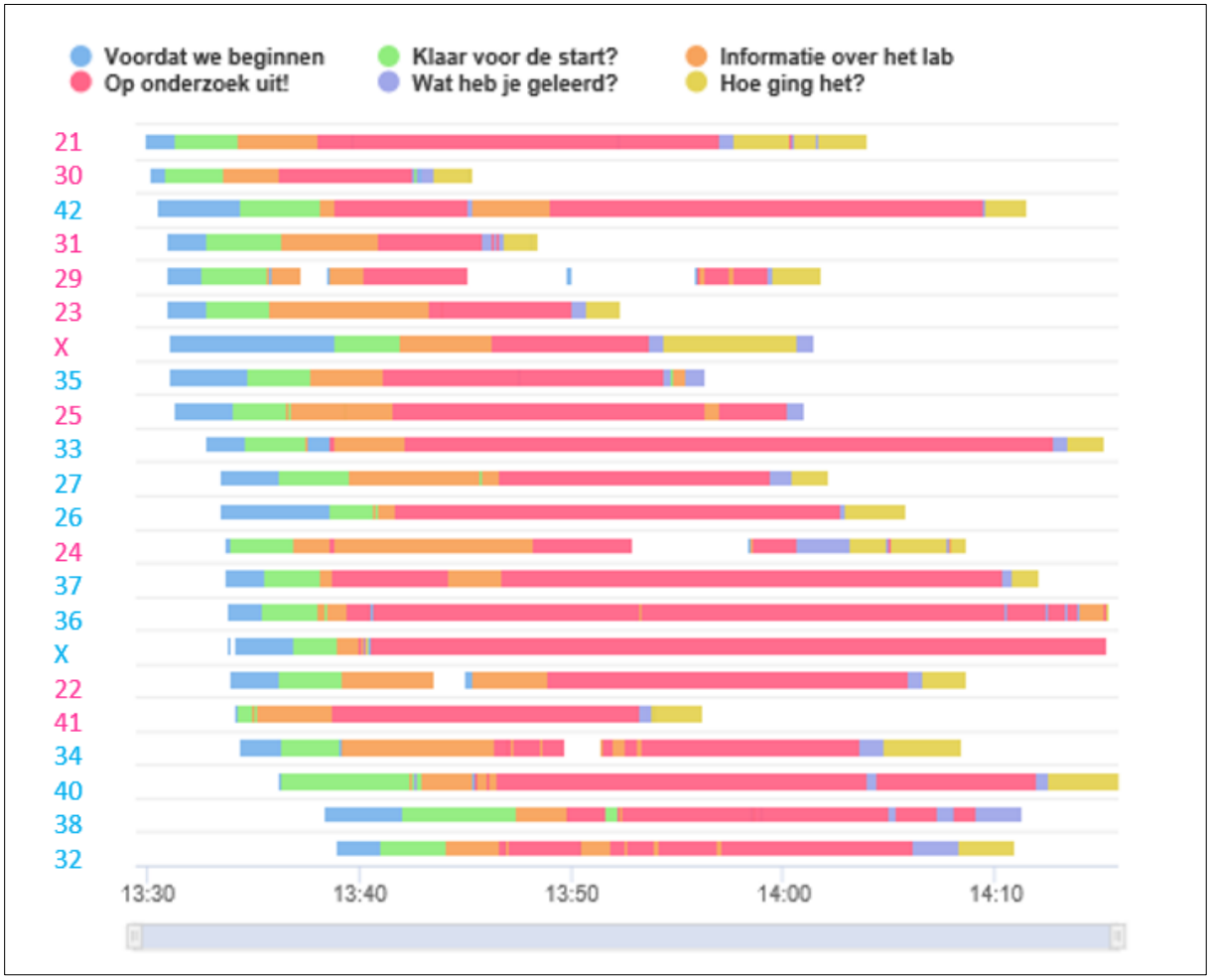

Figure 4.1. Time the participants spent in each phase of the online inquiry-based learning environment 'Electricity' (blue number = male participant, pink number = female participant, X = excluded because of missing values).

In figure 4.2 a table is shown, that was made in the Time Spent Summary app of the online inquiry-based learning environment 'Electricity'. The average time they worked in the second online inquiry-based learning environment was 29:65 minutes. The average time of boys was 34:93 minutes and the average time of girls was 24:37 minutes. There is statistical evidence that there are significant differences in the average time boys and girls spent in this online inquiry learning environment (t = 3.660, df = 18, p = .002).

	Voordat we beginnen	Klaar voor de start?	Informatie over het lab	Op onderzoek uit!	Wat heb je geleerd?	Hoe ging het?	Totaal
38	3:44	5:58	2:31	17:15	3:17	0:00	32:47
26	5:04	2:09	0:56	21:00	0:09	2:56	32:16
42	3:53	3:48	4:17	26:41	0:21	1:55	40:59
X	2:50	2:00	1:08	34:52	0:00	0:05	40:57
31	1:52	3:32	4:36	5:09	0:46	1:29	17:27
21	1:26	3:00	3:46	18:59	0:54	5:55	34:02
37	1:44	2:43	3:04	28:59	0:33	1:16	38:20
29	2:03	3:06	3:39	7:36	0:13	2:18	18:59
23	1:47	2:57	7:33	6:42	0:41	1:34	21:17
33	2:49	2:53	3:23	30:47	0:43	1:37	42:15
35	3:42	3:06	3:58	13:13	1:14	0:00	25:14
40	0:11	6:27	3:25	25:08	1:05	4:04	40:22
25	2:48	2:41	5:21	18:03	0:47	0:00	29:42
32	2:01	3:05	4:35	17:26	2:05	2:38	31:52
27	2:52	3:19	6:58	12:44	1:02	1:39	28:37
36	1:44	2:55	2:22	34:13	0:10	0:05	41:31
41	0:02	0:52	3:32	14:29	0:42	2:15	21:54
X	7:47	3:02	4:23	7:26	1:31	6:11	30:23
22	2:36	3:00	7:45	17:05	0:35	2:07	33:11
30	0:55	2:41	2:38	6:21	0:42	1:46	15:07
24	0:18	3:02	11:11	7:03	2:37	5:02	29:15
34	2:03	2:51	8:28	14:08	1:09	3:32	32:13

Figure 4.2. Timetable that shows how much time participants spent in each phase of the online inquiry-based learning environment 'Electricity' (blue number = male participant, pink number = female participant, X = excluded because of missing values).

In figure 5.1 a timeline is shown, that was made in the Timeline app, of the inquiry-based learning environment 'The colour of light'. This figure shows that most students follow the structure of the online inquiry-based learning environment as intended and that most of the time was spent in the 'research-phase'. Remarkable is that most of the participants finished this lesson in time. A second remarkable point is the fact that in the end of the lesson many participants click back from 'what did you discover?' to the 'research-phase'.

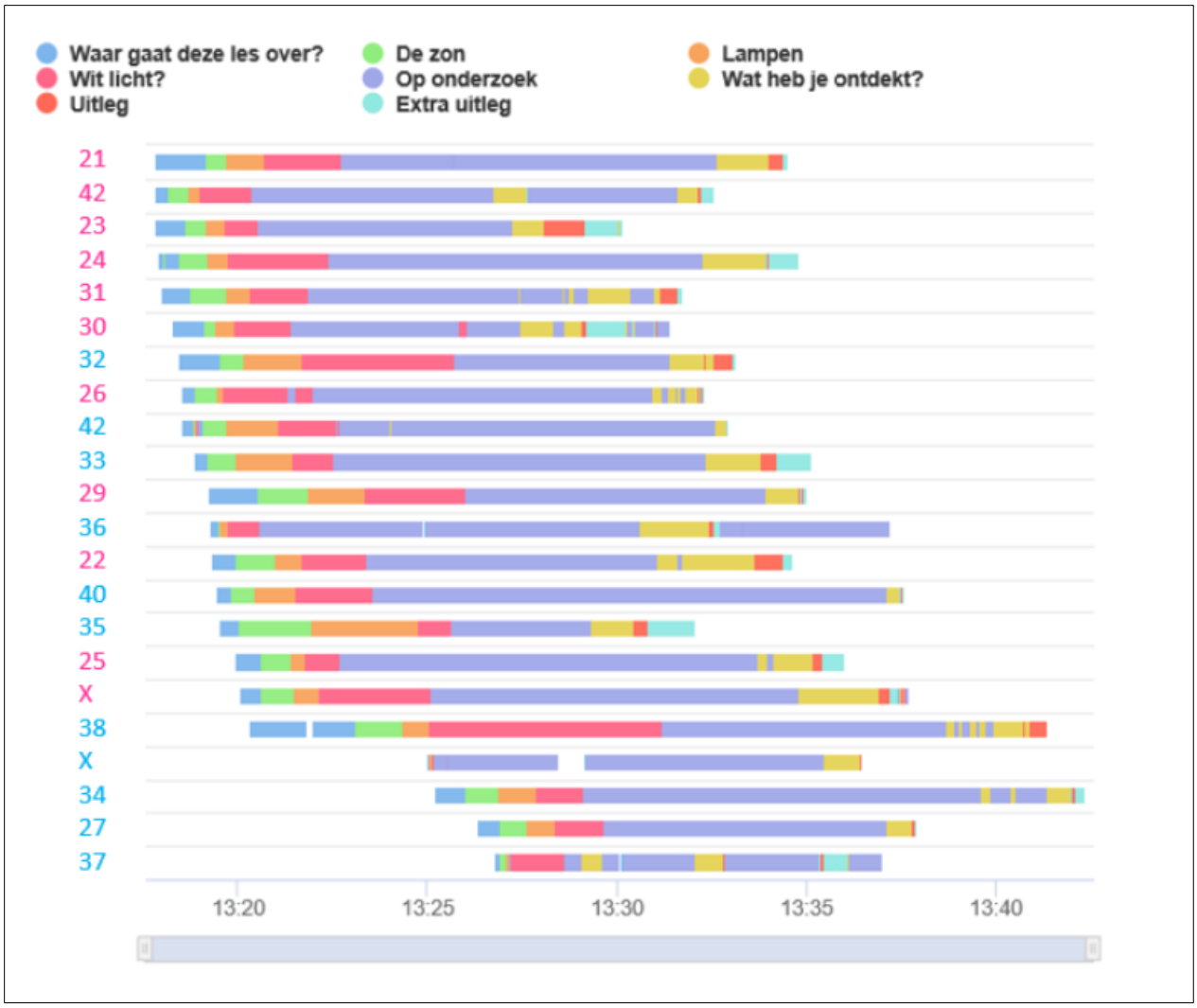

Figure 5.1. Time the participants spent in each phase of the online inquiry-based learning environment 'The colour of light' (blue number = male participant, pink number = female participant, X = excluded because of missing values).

In figure 5.2 a table is shown, that was made in the Time Spent Summary app of the online inquiry-based learning environment 'The colour of light'. The average time they worked on the third online inquiry-based learning environment was 14:88 minutes. The average time of boys was 15:02 minutes and the average time of girls was 14:74 minutes. There is no statistical evidence that there are significant differences in the average time boys and girls spent in this online inquiry learning environment (t =.253, df = 15.191, p = .804).

	Waar gaat deze les over?	De zon	Lampen	Wit licht?	Op onderzoek	Wat heb je ontdekt?	Uitleg	Extra uitleg	Totaal
38	2:39	1:14	0:41	6:07	8:09	1:31	0:28	0:00	20:53
26	0:20	0:35	0:10	2:10	9:29	0:52	0:06	0:04	13:48
42	0:19	0:41	1:23	1:37	10:01	0:19	0:01	0:00	14:23
X	0:04	0:01	0:05	0:01	9:31	0:58	0:01	0:00	10:43
31	0:43	0:57	0:38	1:31	7:50	1:29	0:27	0:06	13:43
21	1:19	0:33	0:58	2:02	9:55	1:21	0:23	0:07	16:42
37	0:10	0:10	0:05	1:25	6:16	1:18	0:08	0:37	10:11
29	1:16	1:19	1:29	2:39	7:55	0:52	0:05	0:07	15:45
23	0:47	0:32	0:29	0:50	6:44	0:50	1:06	0:56	12:19
33	0:18	0:45	1:29	1:05	9:48	1:28	0:23	0:55	16:15
35	0:29	1:54	2:48	0:51	3:43	1:07	0:21	1:14	12:31
40	0:22	0:36	1:06	2:00	13:34	0:20	0:01	0:03	18:07
25	0:41	0:46	0:22	0:53	11:14	1:17	0:13	0:35	16:04
32	1:03	0:39	1:31	4:02	5:41	1:06	0:33	0:05	14:41
27	0:35	0:41	0:45	1:17	7:27	0:41	0:04	0:03	11:35
36	0:13	0:04	0:12	0:50	14:25	1:48	0:09	0:07	17:52
41	0:20	0:31	0:17	1:24	10:18	1:23	0:05	0:20	14:42
X	0:33	0:54	0:41	3:01	9:46	2:09	0:18	0:10	17:36
22	0:39	1:01	0:40	1:41	7:49	2:25	0:44	0:16	15:20
30	0:49	0:15	0:30	1:44	7:06	1:22	0:08	1:06	13:05
24	0:30	0:46	0:33	2:38	9:53	1:38	0:05	0:46	16:52
34	0:46	0:53	1:00	1:12	11:52	1:02	0:03	0:17	17:07

Figure 5.2. Timetable that shows how much time participants spent in each phase of the online inquiry-based learning environment 'The colour of light' (blue number = male participant, pink number = female participant, X = excluded because of missing values).

Conclusion and discussion

The main goal of this study was to investigate whether it was possible to influence girls' attitudes towards science and technology in a positive way. Other goals of this study were to investigate if there were differences between girls' attitudes in the intervention group and control group, if there were differences between boys' and girls' attitudes towards science and technology and if there were differences in the way of working between boys and girls in the intervention group. The mean scores of girls in the intervention group increased and there is no statistical evidence that girls in the intervention group were more positive towards science and technology after the intervention than before the intervention. The intervention did not lead to what was expected and the results did not correspond with the hypothesis for the main- and first sub question. It was expected that girls' attitudes towards science and technology after the intervention were higher than before the intervention, because it was stated that girls respond very positively to online learning environments and do even better in online learning environments than in face-to-face classrooms (Hsi & Hoadlye, 1997; Kay, 2008). Besides this, there is also no significant difference between the attitudes towards science and technology of girls in the intervention- and control group. This study has shown that girls were not more positive towards science and technology after the online inquiry-guided lessons than before, but these results are not in line with the theory of Anderson (1993) and Andre et al. (1999). Anderson (1993) showed that inquiry learning could be a successful intervention technique in science and technology and could help to prevent the negative view girls tend to form (Andre et al., 1999).

In this study there is also no statistical evidence that there are significant differences in attitudes towards science and technology between boys and girls, neither before the intervention nor after the intervention. The mean scores of boys on the pre- and post-test were lower than the mean scores of girls on the pre- and post-test, but it was not a measurable difference. This conclusion is not in accordance with what was expected and what was found in literature, namely that there were differences between boys and girls and that boys' attitudes towards science and technology would be more positive than girls' attitudes towards science and technology. Eccles (2007) and Stoilescu and Egodawatte (2010) stated that girls like science less than boys do, Beghetto (2007) and Patrick et al. (2008) stated that boys believe that they are more competent at science and technology than girls do and Kahle and Meece (1994) and Sanders (2006) concluded that Dutch boys have more self-confidence in the science subject than Dutch girls have, which has not been found in this study.

There are hardly any differences between the average time boys and girls spent in the three online inquiry-based learning environments. For just one of the three online inquiry-based learning environments there is statistical evidence that there are significant differences in the average time boys and girls spent in this online inquiry-based learning environment. Boys went faster than girls in only one online inquiry-based learning environment. It was expected that there would be a difference in the way of working between boys and girls in the intervention group, namely that boys went faster through the online inquiry-based learning environment than girls because of their higher self-confidence in science and technology (Kahle & Meece, 1994; Sanders, 2006) and therefore felt more secure about their choices they had to make, but this is not what was shown in this study. Boys indicated in the questionnaire that they wanted to learn more about electricity and not that much about plants in their environments, is this the reason why boys spent more time in the lesson about electricity and less time in the other two? Or does it perhaps have to do with their motivation, the quality of the questionnaire or the duration of the intervention?

Data from the logfiles showed that most of the students, boys and girls, followed the structure of the online inquiry learning environment as intended and that most of the time was spent in the 'research-phases' of the online inquiry learning environments. From this, it can be concluded that the participants spent their time seriously during working in the online inquiry learning environments. But what also can be noticed is the fact that some participants spent little time in some other phases of the online inquiry-based environments. What does this say about their seriousness? From participants' responses and answers to the questions in the online inquiry learning environments it also appeared that they have been working seriously because most of them gave clear and serious answers. To questions that asked for their opinion about this way of working their responses were very positive. They said they liked this way of working on science and technology in online inquiry learning environments, which concludes that the participants were motivated during the intervention. They filled the following in to the answer boxes: they liked that they 'could discover a lot of things', they found it 'educational', they enjoyed 'trying out over and over', they found it 'interesting', they learned 'new things' and 'things they did not knew before'. They were motivated to work on the online inquiry learning environments, also because of the topics that were used in the online inquiry learning environments. They found the topics interesting and were therefore more motivated to work and learn about science and technology, which Magon (2009), Ebbens and Ettekoven (2013) and National Research Council (2007) pointed out as being

very important. Their general response and experience were positive, but apparently this does not change the answers to such an extent that there were significant changes in the post-test.

It may be wondered if the quality of the questionnaire was good, but the high Cronbach's alpha and the differentiation in the questionnaire say that it is a good questionnaire. The answers were also widespread; some participants scored low and others scored high, so that was not the problem. For this study the participants did not receive marks for their process or answers, and they could not win something, what if this was the case? For future research it is interesting to investigate this. Should participants spend more time in each phase, to be sure that they are doing well? And what could this say about their attitudes towards science and technology; would this have a positive effect or not? Some other limitations of the present study should be considered. First, the study was conducted with a relatively small group; it should be interesting for future research to replicate this study with a larger group to see if there would be significant differences then. Another point of criticism on this research is the intervention itself; because of time the intervention was no longer than nine weeks and only consisted of three online inquiry-based lessons. A remarkable fact is that many participants did not finish the first online inquiry-based lesson in time, but easily finished the third lesson in time. Before this study the participants were not familiar with inquiry learning, so maybe this also influenced the outcomes of this study. Interesting for future research could be to not only make the group of participants bigger, but also to make the intervention bigger and longer to see whether this influences the attitudes of girls towards science and technology in a positive way.

To conclude, participants' general responses and experiences to the online inquiry-based environments and lessons were positive, but this does not have an influence on the outcomes of this study. There may be no statistical evidence that girls' attitudes are increased courtesy the intervention, but it is remarkable that the mean scores of girls in the intervention group did not increase that much as the mean scores of girls in the control group, which can be an interesting starting point for future research.

References

American Association of University Women (2008). *Where the girls are: The facts about gender equity in education.* Retrieved from: https://www.aauw.org/resource/where the-girls-are-the-facts-about-gender-equity-in-education/.

Andre, T., Whigham, M., Hendrickson, A. & Chambers, S. (1999). Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects. *Journal of Research in Science Teaching, 36,* p. 719-747.

Anderson, B.T. (1993). Minority females in the science pipeline: Activities to enhance readiness, recruitment, and retention. *Initiatives, 55*(3), p. 31-37.

Baker, D. & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching, 32,* p. 3-27.

Baram-Tsabari, A. & Yarden, A. (2011). Quantifying the Gender Gap in Science Interests. *International Journal of Science and Mathematics Education, 9*(3), p. 523-550.

Berg, T., Sharpe, A. & Aitkin, E. (2018). Females in computing: Understanding stereotypes through collaborative picturing. *Computers & Education, 126,* p. 105-114.

Booy, C., Jansen, N., Joukes, G., & Van Schaik, E. (2011). *Trendanalyse gender in het bèta/technisch hoger onderwijs.* Amsterdam: VHTO.

Bijlsma, J. (2014). *Complimenten geven. 20 werkvormen voor in de klas.* Retrieved from: www.klassenkracht.nl/wp.../09/complimenten-leren-geven2.docx.

Buunk, B.P. & Van der Laan, V. (2002). Do women need female role models? Subjective social status and the effects of same-sex and opposite sex comparisons. *Revue Internationale De Psychologie Sociale, 15,* p. 129–155.

Cavallo, A.M.L. & Laubach, T. (2001). Students' science perceptions and enrollments decisions in differing learning cycle classrooms. *Journal of Research in Science Teaching, 38,* p. 1029-1062.

Cheryan, S., Plaut, V.C., Handron, C. & Hudson, L. (2013). The Stereotypical Computer Scientist: Gendered Media Representations as a Barrier to Inclusion for Women. *Sex Roles 69,* p. 58-71. doi: 10.1007/s11199-013-0296-x

Chodorow, N. (1998). *Gender, relation and difference in psychoanalytic perspective. In: The polity reader in gender studies.* Cambridge: Polity Press.

Çokadar, H. & Külçe, C. (2008). Pupils' Attitudes Towards Science: A Case of Turkey. *World Applied Sciences Journal 3*(1), p. 102-109.

Cronbach, L. (1951). Coefficient alpha and the internal structure of tests. *Psychomerika, 16,* p. 297-334.

Crowley, K., Callanan, M.A., Tenenbaum, H.R. & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science, 12*(3), p. 258 – 261. DOI: 10.1111/1467-9280.00347.

Ebbens, S. & Ettekoven, S. (2013). *Effectief leren.* Groningen: Noordhoff Uitgevers bv.

Eccles, J.S. (2007). Where are all the women? Gender differences in participation in physical science and engineering. Washington, DC: American Psychological Association.

GoLabz (2018). *About.* Retrieved from: http://support.golabz.eu/about.

Harkrader, M.A. & Moore, R. (1997). Literature preferences of fourth-graders. *Reading Research and Instruction, 36,* p. 325-339.

Hsi, S. & Hoadley, C.M. (1997). Productive Discussion in Science: Gender Equity Through Electronic Discourse. *Journal of Science Education and Technology, 6*(1), p. 23-26.

International Primary Curriculum (2018). *IPC.* Retrieved from: https://ipcnederland.nl/ipc/het-ipc-curriculum.

Jacobs, J.E. & Bleeker, M.M. (2004). Girls' and boys' developing interests in math and science: Do parents matter? *New Directions for Child and Adolescent Development, 106,* p. 5-21.

Kahle, J.B. & Meece, J. (1994). Research on gender issues in the classroom. In D. Gabel (Ed.), *Handbook of research on science teaching and learning.* New York: Macmillan.

Kay, R. (2008). *Exploring Gender Differences in Computer-Related Behaviour: past, present, and future.* Canada: University of Ontario Institute of Technology.

Kennedy, J., Quinn, F. & Taylor, N. (2016). The school science attitude survey: a new instrument for measuring attitudes towards school science. *International Journal of Research & Method in Education, 39*(40), p. 422-445.

Kerkhoven, A.H., Russo, P., Land-Zandstra, A.M., Saxena, A. & Rodenburg, F.J. (2016). Gender Stereotypes in Science Education Resources: A Visual Content Analysis. *PLOS ONE 11*(11), p. 1-13. DOI: 10.1371/journal.pone.0165037.

Kermarrec, A.M. (2014). Computer Science: Too young to fall into the gender gap. *IEEE Internet Computing, 18*(3), p. 4-6.

Klawe, M., Whitney, T. & Simard, C. (2009). Women in computing- take 2. *Computing of the ACM, 52*(2), p. 68-76.

Koch, J. (2007). A gender inclusive approach to science education. In Sadker, D.M. & Silber, E.S. (Eds.), *Gender in the classroom: Foundations, skills, methods, and strategies across the curriculum* (p. 205-223), Routledge: London.

Lawson, A.E., Abraham, M.R. & Renner, J.W. (1989). A Theory of Instruction: Using the Learning Cycle to Teach Science Concepts and Thinking Skills. *Narst Monograph, 1*, p. 1-131.

Leong, S.C. & Hawamdeh, S. (1999). Gender and learning attitudes in using Web-based science lessons. *Information Research, 5*(1). Retrieved from: http://www.informationr.net/ir/5-1/paper66.html.

Leverink, R. (2013). Omgaan met verschillen j/m. *Van twaalf tot achttien, 3,* p. 38-39.

Lockwood, P. (2006). "Someone like me can be successful": do college students need same-gender role models? *Psychology of Women Quarterly, 30*, p. 36–46.

Magon, A.J. (2009). *Gender, the Brain and Education: Do Boys and Girls Learn Differently?* Victoria: University of Victoria.

Meece, J.L. & Jones, M.G. (1996). Gender Differences in Motivation and Strategy Use in Science: Are Girls Rote Learners? *Journal of Research in Science Teaching, 33*(4), p. 393-406.

Meelissen, M.R.M. & Drent, M. (2008). Gender differences in computer attitudes: Does the school matter? *Computer in Human Behavior, 24,* p. 969-985.

Meyer, M., Cimpian, A. & Leslie, S. (2015). Women are underrepresented in fields where success is believed to require brilliance. *Frontiers in Psychology, 6,* p. 1-12.

Miller, P. H., Slawinski Blessing, J., & Schwartz, S. (2006). Gender differences in highschool students' views about science. *International Journal of Science Education, 28* (4), p. 363–381.

National Research Council. (1996). *National science education standards.* Washington: National Academy Press.

National Research Council (2007). *Taking science to school: Learning and teaching science in grades K-8.* Washington: National Academy Press.

Patrick, H., Mantzicopoulos, P. & Samarapungavan, A. (2008). Motivation for Learning Science in Kindergarten: Is There a Gender Gap and Does Integrated and Literacy Instruction Make a Difference. *Journal of Research in Science Teaching, 46*(2), p. 166-191.

Pedaste, M., Mäeots, M., Siiman, L.A., De Jong, T., Van Riesen, S.A.N., Kamp, E.T., Manoli, C.C., Zacharia, Z.C. & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14,* p. 47-61. DOI: 10.1016/j.edurev.2015.02.003.

PO-Raad (2017). *Feiten & Cijfers Primair Onderwijs 2017*. Retrieved from: https://www.poraad.nl/system/files/nieuws_en_achtergronden/poraad_feiten_en_cijfers_2017.pdf.

Ramsden, J.M. (1998). Mission impossible? Can anything be done about attitudes to science? *International Journal of Science Education, 20*(2), p. 125-137.

Sanders, J. (2006). Gender and technology: A research review. In C. Skelton, B. Francis, & L. Smulyan (Eds.), *Handbook of Gender and Education.* London: Sage.

Scantlebury, K. & Baker, B. (2007). Gender issues in science education research: Remembering where the difference lies. In S.K. Abell & N.G. Lederman (Eds.), Handbook of research on science education (p. 257-285). Mahwah: Erlbaum.

Simpson, R.D. & Oliver, J.S. (1985). Attitude toward science and achievement motivation profiles of male and female science students in grades six through ten. *Science Education 69*(4), p. 511-526.

Stannard, K. (2016). Taking gender into account in the classroom. Retrieved from: https://www.futurelearn.com/courses/girls-education/0/steps/21045.

Stoilescu, D. & Egodawatte, G. (2010). Gender differences in the use of computers, programming, and peer interactions in computer science classrooms. *Computer Science Education, 20*(4), p. 283-300.

TechniekPact (2015). *Monitor TechniekPact 2015.* Den Haag: Platform Bèta Techniek.

University of Cambridge, Faculty of Education (2010). *Attitude Questionnaire Science.* Cambridge: University of Cambridge.

U.S. Department of Education (2006). The condition of education 2006. Washington, DC: Institute of Education Sciences.

Van Graft, M., Klein Tank, M., & Beker, T. (2016). *Wetenschap & technologie in het basis- en speciaal onderwijs.* Enschede: SLO.

Van Keulen, H. & Oosterheert, I. (2016). Wetenschap en techniek op de basisschool. Groningen: Noordhoff Uitgevers bv.

Vansteenkiste, M., Sierens, E., Soenens, B., & Lens, W. (2007). Willen, moeten en structuur in de klas: over het stimuleren van een optimaal leerproces. *Begeleid zelfstandig leren*, *16*(2), p. 37-58.

Weinburgh, M. (1995). Gender differences in student attitudes towards science: A Meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching, 32*(4), p. 387-398.

Wong, B. (2016). 'I'm good, but not that good': Digitally-skilled young people's identity in computing. *Computer Science Education, 26*(4), p. 299-317.

Appendix

Appendix A – Informed Consent

UNIVERSITEIT TWENTE.

Beste ouder(s)/verzorger(s) van de leerlingen van groep 8,

Voor mijn master Learning Sciences (ontwikkelings-/onderwijspsychologie) aan de Universiteit Twente in Enschede ben ik bezig met mijn afstudeeronderzoek. Mijn afstudeeronderzoek gaat over wetenschap en technologie (W&T) op de basisschool. W&T is een manier van kijken naar de wereld. Door het stellen van vragen, of door oplossingen te bedenken voor problemen, maar ook vanuit kinderen hun eigen fantasie, leren kinderen over dingen die in de wereld om hen heen voorkomen. Nieuwsgierigheid, zelf op onderzoek uitgaan, iets ontwerpen en/of maken en oplossingen bedenken hoort allemaal bij W&T.

In mijn onderzoek staan de verschillen tussen jongens en meisjes binnen W&T centraal en daarbij ook hoe meisjes meer gestimuleerd, gemotiveerd en betrokken kunnen worden bij W&T. Het blijkt namelijk dat vrouwen in deze richting sterk ondervertegenwoordigd zijn, zowel in Nederland als in Europa. Aangezien W&T een steeds belangrijkere rol gaat spelen in de (toekomstige) maatschappij, is het van belang dat er onderzoek wordt gedaan naar de (mogelijke) oorzaken en (mogelijke) oplossingen hiervan om zo meisjes op de basisschool al te betrekken bij, en te motiveren voor, W&T.

Om dit alles goed uit te kunnen zoeken heb ik data nodig om te kunnen verwerken. Hierbij wil ik u graag mededelen dat ik voor de leerlingen van groep 8a en 8b een vragenlijst heb opgesteld welke gaat over hun houding ten opzichte van W&T. Deze vragenlijst zal ik de leerlingen twee keer in laten vullen, één keer aan het begin van het onderzoek en één keer aan het einde van het onderzoek. Het invullen hiervan neemt ongeveer 15 minuten in beslag en zal gebeuren onder schooltijd. Daarnaast ga ik de kinderen uit groep 8b drie digitale W&T-lessen aanbieden tijdens de lesuren onder schooltijd welke alle drie ongeveer 30 minuten duren en een verrijking zullen zijn op de bestaande IPC-lessen. Groep 8a dient als controlegroep en zal mij hierdoor helpen om onderzoek uit te voeren waarbij de resultaten tussen de leerlingen in groep 8a en 8b goed vergeleken kunnen worden met elkaar om vervolgens een passende conclusie te kunnen stellen.

Belangrijk om te vermelden is dat ik voor dit onderzoek toestemming heb verkregen van de ethische commissie van de Universiteit Twente. Dit houdt in dat we de gegevens van uw kind zorgvuldig behandelen. Dit zal betekenen dat de gegevens van uw kind anoniem in de dataset verwerkt zullen worden waarbij de gegevens niet terug te leiden zijn naar uw kind. Ieder kind krijgt een persoonlijk nummer waar alle scores van de vragenlijsten en de gegevens van de W&T-lessen aan worden gekoppeld. De koppeling tussen naam en participantnummers zijn alleen bekend bij mij. De voordelen van dit onderzoek zijn dat uw kind een bijdrage levert aan wetenschappelijk onderzoek voor onderwijs i.c.m. W&T en dat er op een leuke, speelse manier aan W&T wordt gewerkt.

Ik ga er van uit dat u hiermee akkoord gaat. Indien u toch liever niet heeft dat uw kind mee werkt aan dit onderzoek kunt u mij voor vrijdag 21 december 2018 een mail sturen. Ook als uw kind wel meedoet, kunt u uw kind alsnog te allen tijde terugtrekken uit het onderzoek. De toestemmingsverklaring (geldig wanneer u géén mail stuurt waarin staat dat u uw kind niet wil laten meewerken aan het onderzoek) is geldig tot maart 2019. Voor eventuele vragen kunt u altijd contact opnemen met mij. Ik houd u graag op de hoogte.

Met vriendelijke groet,
Dayen Zwakenberg
d.zwakenberg@mijnplein.nl
Leerkracht groep 8b KC de Bolster

de Bolster
Kindcentrum

Appendix B – Questionnaire 'Attitudes towards science and technology'

Vragenlijst 'Wat vind jij van wetenschap en technologie op school?' Pretest/Posttest

Beste leerlingen uit groep 8,

Voor jullie ligt een vragenlijst over jullie houding tegenover wetenschap en technologie (W&T) op school. Deze vragenlijst is onderdeel van mijn afstudeeronderzoek aan de Universiteit Twente in Enschede. Mijn afstudeeronderzoek gaat over W&T op de basisschool en wat hierin de verschillen zijn tussen jongens en meisjes. Maar wat is W&T nou eigenlijk? W&T is een manier van kijken naar de wereld. Door het stellen van vragen, of door oplossingen te bedenken voor problemen, maar ook vanuit jouw eigen fantasie, leer jij over dingen die in de wereld om jou heen voorkomen. Nieuwsgierigheid, zelf op onderzoek uitgaan, proefjes doen, iets ontwerpen/maken en oplossingen bedenken hoort allemaal bij W&T. Deze vragenlijst zal jij twee keer in gaan vullen, één keer in het begin van het onderzoek en één keer aan het einde van het onderzoek, om te kijken of jij er dan misschien anders over denkt. Het invullen duurt ongeveer 15 minuten per keer. De vragenlijst bestaat uit drie delen en 35 korte vragen. Stop pas als je '**EINDE**' ziet staan. Leg de vragenlijst dan op de hoek van jouw tafel en deze zal daarna door mij worden opgehaald.

Wat belangrijk voor jou is om te weten dat je naam niet wordt gebruikt in het onderzoek, je naam zal gekoppeld worden aan een nummer zodat ik wel jouw antwoorden van de eerste keer kan vergelijken met jouw antwoorden van de tweede keer invullen van deze vragenlijst. Vul je voor- en achternaam hieronder maar in. Wat voor het onderzoek ook van belang is, is dat jij aangeeft of je een jongen of een meisje bent en of je in groep 8a of 8b zit. Dit mag je hieronder aanvinken.

Naam: _____

Ik ben een ☐ jongen of ☐ een meisje

Ik zit in groep ☐ 8a of ☐ 8b

Alvast bedankt voor jouw medewerking aan mijn onderzoek.

Juf Dayen Zwakenberg

Deel 1

Geef aan of jij het eens of oneens bent met de volgende stellingen door **1** van de **7** antwoorden te kiezen en aan te kruisen:
Totaal eens – eens – beetje eens – neutraal – beetje oneens – oneens – totaal oneens.

		Totaal eens	**Eens**	**Beetje eens**	**Neutraal**	**Beetje oneens**	**Oneens**	**Totaal oneens**
1	De W&T die wij leren op school kunnen wij ook gebruiken bij andere vakken.							
2	Het begrijpen van de W&T-lessen in de klas is belangrijk voor mij.							
3	W&T is saai.							
4	Meestal lukt het om de opdrachten uit te voeren in de W&T-lessen.							
5	Ik zou het leuk vinden om een baan te krijgen waarin ik W&T moet gebruiken.							
6	Veel van de dingen die we leren in de wetenschap en technieklessen kunnen we gebruiken in het dagelijks leven.							
7	Ik vind W&T leuk.							
8	Ik vind het belangrijk om na te denken over de dingen in de W&T-lessen zodat ik het ook goed begrijp daarna.							
9	Ik vind W&T moeilijk.							
10	Ik ga misschien wel iets doen met W&T na de middelbare school.							
11	W&T is belangrijk voor het leven in de wereld.							
12	Ik kijk uit naar de W&T-lessen.							

		Totaal eens	**Eens**	**Beetje eens**	**Neutraal**	**Beetje oneens**	**Oneens**	**Totaal oneens**
13	Ik vind het interessant om te weten waarom we W&T leren.							
14	Ik ben goed in W&T.							
15	Ik zal niet zo snel voor W&T kiezen wanneer ik mijn middelbareschooldiploma heb gehaald.							
16	Ik kan de opdrachten in de W&T-lessen maken zonder het echt goed te begrijpen.							
17	Iedereen heeft een beetje kennis van W&T nodig in hun volwassen leven.							
18	Ik vind W&T interessant.							
19	Ook als ik dingen moeilijk vind in de W&T-lessen, kan ik de opdracht uitvoeren.							
20	Het lijkt mij leuk om later W&T te gaan studeren.							
21	Ik wil graag begrijpen wat ik leer in de W&T-lessen.							
22	W&T leren in belangrijk voor een toekomstige baan.							
23	Ik vind het leuk om te leren over W&T.							
24	Ik denk dat ik moeilijkere W&T-lessen ook leuk zou vinden.							
25	Ik kan me voorstellen dat ik later een baan kies waar W&T een rol in speelt.							

Deel 2

Geef aan of jij het eens of oneens bent met de volgende stellingen door **1** van de **5** antwoorden te kiezen en aan te kruisen:
Totaal eens – eens – neutraal – oneens – totaal oneens.

		Totaal eens	**Eens**	**Neutraal**	**Oneens**	**Totaal oneens**
26	Zeer waarschijnlijk zal ik na de middelbare school kiezen voor een W&T-studie.					
27	Ik heb moeite met het voltooien van de opdrachten in de W&T-lessen.					
28	Ik denk dat ik heel goed ben in W&T.					
29	Een baan in de W&T lijkt bij interessant.					
30	W&T helpen om het leven in de wereld beter te maken.					
31	Ik wil graag leren over planten in mijn omgeving.					
32	Ik wil graag leren over elektriciteit en hoe het thuis gebruikt wordt.					

Deel 3

Omcirkel bij de volgende 3 stellingen welke van de 5 antwoorden jij het beste vindt passen in de zin zodat hij het beste bij jou past. Tip: relevant is een ander woord voor belangrijk en irrelevant is een ander woord voor onbelangrijk.

33. Ik denk dat W&T *heel saai / saai / neutraal / leuk / heel leuk* is.

34. Voor mijn toekomstige baan/carrière, kennis van W&T is *heel onbelangrijk / onbelangrijk / neutraal / belangrijk / heel belangrijk.*

35. Voor mijn dagelijkse leven denk ik dat de W&T die we op school krijgen *heel irrelevant / irrelevant / neutraal / relevant / heel relevant* is.

EINDE