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Jelle Boeve-de Pauw*,***, Jan Ardies*,**, Katrien Hens*,***, Ann Wullemen*, Yannick Van de Vyver*, Tom Rydant*, Lotje De Spiegeleer* & Hanne Verbraeken*.

* University of Antwerp, Faculty of Social Sciences, Department of Training and Education Sciences, Research Unit Edubron.

** AP University of Applied Sciences, Department of Education and Training

*** KdG University of Applied Sciences and Arts, Expertise Centre for Urban Education

The immediate and retention effects of a high-tech learning intervention on pupils' attitudes towards technology

Abstract

STEM presents a challenge to education at large. The enrollment numbers in higher education STEM tracks are ever-decreasing numbers all around the globe. More so, young people's interest in and attitudes towards STEM seem to be free falling. Educational interventions that can help boost the attractiveness of STEM are therefore needed, and diverse such interventions are implemented worldwide. We present a longitudinal impact study of a STEM education intervention focusing on the attitudes of pupils towards technology. The intervention involves young students visiting a high-tech truck (Techno Trailer) at their schools. Inside this truck grade 5 and 6 students (average age 11 years) experience diverse interactions with high tech material and exhibits, focusing on how technology can contribute to solving problems in industry and society. 1496 elementary school students aged 10-12 years old (grades 5 and 6) participated in the study. Some of their teachers were prepared for the visit through a preparatory workshop, while others were not. We used the PATT to measure the pupil's attitudes towards technology. Three separate measurement occasions were included: just before, three days after and three weeks after the intervention. Differences between the measurement occasions reflect changes in attitudes over time. Overall, the study shows that the intervention rendered technology as less boring, more interesting and more viable as a career option for the pupils. For girls specifically, the intervention contributed to reversing the gender stereotypical view that technology is mainly a topic for boys. For boys we did not observer such an effect. The immediate educational impacts (three days later) tended to decrease across time but most remained significant (three weeks later) as compared to the base line. The results of this study show that short-term high-tech STEM education interventions can positively impact on students' attitudes towards technology. At the same time, they show that such interventions in themselves are not enough and that they need to be part of a wider strategy to boost STEM attractiveness. Furthermore, our results highlight the added value of the preparatory workshop for teachers in terms of generating educational impact on pupils' attitudes towards technology.

Keywords

PATT, attitudes toward technology, educational impact, techno trailer

Introduction and review of the literature

If you read the newspaper of watch the news, an issue that keep coming up more and more is the number of open vacancies for jobs in specific domains; jobs for which no or not enough (competent) candidates seem to be around. There are some professions where this is increasingly problematic since in the long term no easy solution seems available. Many of these are in the area of STEM (Science, Technology, Engineering and Mathematics). Next to this it is crucial to prepare young people for the society of the future that – more and more - depends on and interacts with technology, whereas we describe technology in the broadest sense. When referring to technology in this paper we will not make a strict distinction between technology and engineering. Often the term "Design and Technology" is used to refer to a subject-matter at school. What in our research is referred to with the term 'Technology' is precisely this view. The concepts 'science' and 'technology' often appear together in policy documents and research reports. It shows that they are, for both policy-makers and researchers, not one single concept. On the other side it also shows that there are links between them and that they go often hand in hand. Moreover, it can be seen as an indication that it is often unclear where the one stops and the other begins. Benenson (2001) describes the difference between science and technology as follows: "where science aims to produce knowledge, technology aims to solve practical problems." Technology is also sometimes described as 'man-made artefacts' and the processes that have been developed (Holbrook & Rannikmae, 2007; Rocard, 2007).

Young people and STEM

Although there is an apparent need in society, the focus of education should not be seen as a player in the supply of men and women for the labour market; education's role is first and foremost in imparting a broad technical background for all citizens (Ardies & Boeve-De Pauw, 2014). Empowering young people with the skills that enable them to actively participate in the 21st century society should be a key concern of education and educators (Marzano & Heflebower 2011). The debate on science and technology in education is on two tracks: first, a broad technological literacy for all, and second greater influx into studies and jobs with a scientific or technological profile. However, a diminishing proportion of young people are attracted to science and technology in higher education and to the professions to which such education typically leads. Many agree that primary and secondary education have an important role to play in addressing this issue. Currently, students' interest in these topics is decreasing throughout their time behind the school desk (e.g. Lindahl 2007; Ardies, De Maeyer, Gijbels & Van Keulen, 2015a, Struyf, Boeve-de Pauw & Van Petegem 2017).

Research has demonstrated that the awareness of young people is key to this debate. A study focusing on 13-year-olds demonstrates that the answer that children give when asked "what do you want to be as a grown up?" isn't trivial (Tai Liu, Maltese & Fan 2006). The same respondents were interviewed again 12 years later, and results show that twice the number of respondents who indicated they wanted to become an engineer, effectively obtained an engineering degree compared with their peers that had given different answers. Deciding what to study in higher education, and consequently a specific career, remains very difficult at the age of 12 -13. The research of Tai Liu et al. (2006) shows however, that a positive image of engineering and technology at a young age may underlie a greater influx into science as technology education and careers. Recent research confirms the role of early interest when it comes to choosing for science or technology in higher education (Ardies et al, 2015a). The challenge of the future lies not only in stimulating senior students for technological studies; interest in technology can be encouraged much earlier, already at the start of secondary education (Ardies, De Maeyer & Gijbels, 2015b).

Technology education

Students often like science and technology at school because it is something different, they can do something practical during these lessons, experience learning hands-on. They make things and conduct experiments. Students often like this way of teaching and its participatory and interactive approach (Ardies et al, 2015b). Research shows that education is more powerful and effective in a relevant and authentic learning environment (Van Houte et al. 2013). The broad technological literacy, previously referred to, will not be achieved by off-the-shelf construction packages or by building birdhouses from standard pre-fabricated sets. Education can however reach this goal by providing students essential ideas and keystones about technology (Harlen 2010). This can best be done through authentic learning contents and environments. These incorporate self-directed and profound learning, as well as promoting self-evaluation and cooperative learning (De Corte 1996). This can enable them to actively participate in the lesson. It can also help them in making decisions and in making judgments as critical users of technology (Ardies et al, 2015b).

In the technology classroom however, it is often the teacher who determines the structure of the task or subject (e.g. Ardies et al, 2015b). In this situation the teacher determines which tasks should be performed and how. A narrow focus on knowledge of procedures and technology encourages students not to get a better understanding of technology (Dakers & de Vries 2009; Svenningson 2015). Barak (2010) states that if we want to achieve a more realistic understanding of technology by students, we need to facilitate that students enhance their own learning process and practice themselves in lifelong learning. This provides a strong argument to address the technological process through a framework of autonomous learning, since self-regulating students are more able to understand and tackle technological problems. In inquiry-based learning students take part in small scale research (Zion Cohen & Amir 2007). In this process learning the active construction of knowledge has a central position and students not only gain content knowledge of a particular scientific discipline, they also acquire research skills and develop a more critical attitude (Degroof, Donche & Van Petegem 2012).

On top of this, technology education offers important chances to have an interesting real-life context in the classroom.

Authentic technology at school

This authentic approach, in which technology is used to tackle real life issues (Thibaut et al., 2018), is also more and more applied by organizations outside the formal education system (e.g. Eshach, 2007; Sperling & Bencze, 2015; Fernandez-Limon, Fernandez-Cardenas & Gomez Galindo, 2018). Many educational initiatives are initiated, and they provide a less formal and more self-directed and inquisitive way to bring young people in contact with e.g. technology (e.g. Eckes, Grossman & Wilde, 2018). Firstly, short term initiatives let pupils experience different aspects of technology. This is an interesting approach, complementary to technology education in the classroom when it comes to let young people discover their talents and enthusiasm for a STEM profession. Secondly these initiatives offer students the opportunity to build technological knowledge and attitudes and thus contribute to a broader technological literacy.

Often these kinds of educational intervention provide contexts present learning experiences that are too difficult, expensive or complex for schools to provide to their students (Hill & Smith 1998; McLaren 2015). As a consequence, a substantial amount of the time spent learning technology is currently provided to students outside the classroom or outside the school walls (i.e. in informal learning settings). Students visit science and technology centers, professionals in the area of technology visit schools to talk about their profession, or exhibits are brought into the school as short-term teaching interventions. There is a lot of research that focuses on the effects of such short-term interventions. Prokop, Tuncer and Kvasničák (2007) for example, investigated the learning effects of a one-day school excursions. Three days after the examination they found a significant positive change in the participating students' attitudes towards science as a school subject and as possible career option. A well established and much cited study by Bogner (1998) shows that attitudes can change in response to participation in short term interventions, and that under specific circumstances such changes can be retained over a longer term. Sellman and Bogner (2013) showed that short educational interventions can result in changes in attitudes and feelings of connectedness to the subject of the intervention. Boeve-de Pauw, Van Hoof and Van Petegem (2018) showed that on-site intervention can impact on knowledge as a learning outcome depending and that traits of the site, the educational approach and individual characteristics can moderate such effects. Specifically, about technology attitudes, research into this kind of effects over time is – to our knowledge – absent. For these reasons, the current study focusses on the immediate *and* retention effects that a short-term educational intervention dealing with technology and its relevance for society and the economy have on the attitudes towards technology of school children.

A longitudinal perspective on boys' and girls' attitudes towards technology

Professional development is a lifelong process that begins in kindergarten and continues through life (Hartung, Porfeli and Vondracek 2008). Between the ages of six and twelve, the school is hereby considered to be a very important period when it comes to developing interest for careers and activities (Gottfredson 1981, 2005). The interest that develops at this age will be carried on a whole life and will also affect later choices (Hartung et al. 2008). It is also just around the age of six years that children begin to use gender as a distinctive social category to determine their future career. Stereotypically, boys want to become a firefighter or a pilot and girls a nurse or veterinarian. This distinction is also found in a recent review study which shows that men are primarily interested in 'things' and women in 'people' (Su, Rounds, and Armstrong 2009).

According to Gottfredson's (2005) theory of career development, children eliminate around the age of six years their interest in careers that are contrary to their image based on gender. Pupils often not only have a gender-stereotyped image, also their perceptions of what it actually means to be a scientist is a very stereotypical image (Carli, Alawa, Lee, Zhao and Kim 2016). This is most pronounced among pupils in primary school, but also by some students in secondary and higher education, a scientist is visualized as an Einstein figure in a lab coat standing with full and exclusive attention dedicated to its subject matter and thereby losing contact with the outside world and other people (Miele 2014; Minogue 2010). Pupils in primary find science and technology rather topics for boys than for girls. Girls lose interest in technical careers and study choices they consider to be rather masculine (Ardies et al. 2015a). This filter, although fairly coarse, is often permanent, say Woods and Hampson (2010). Moreover, research has shown that the interest of girls in technology mainly decreases between 10 and 14 years (eg Kotte 1992; Catsambis 1995). International research also finds that girls are less likely than boys to choose a STEM-direction in secondary and higher education (Cronin and Roger 1999; Van Langen, Rekers-Mombarg and Dekkers, 2006; Ardies et al, 2015a). This can be partially explained by gender differences in interest in STEM and the perceived (personal and social) relevance of STEM (e.g. Struyf et al. 2017). Alternatively, the study of Wang, Eccles and Kenny (2013) indicate that girls, thanks to their strong verbal skills, have more options on the labor market and are therefore less likely than boys to get into a STEM career. Therefore, it is important that, however educational and professional choices are interpreted, gender difference are taken into account if we want to explore explanations for pupils' career aspirations. As Wang and Degol clearly point in their 2017 review of the gender gap in the STEM, gender differences remain a topic that need scholarly attention in this field. For these reasons we have include gender into our current study as one of the important individual level factors that might explain (1) variation in the attitudes of students towards technology, and (2) differential impact on the learning outcomes of technology education.

Teachers, and their educational approach, may also increase the interest of pupils for a technology, which in turn may affect subsequently their career aspirations. Research shows that there are several methods. Some examples: hands-on learning, extramural activities, demonstrating personal relevance, using humor, the use of vivid texts, the use of puzzles and riddles, ... (Brent ad Schmidt 2011; Žoldošová and Prokop 2006; Hulleman and Harackiewicz, 2009). These teaching methods are, depending on how they are used, situated in constructivist learning theory, which was described in the eighties by Von Glasersfeld, Dewey, Piaget and Vygotsky. According to this theory, young people learn most when they get a chance to gain personal insights based on personal experiences and observations. Research has shown that constructivist teaching has a positive impact on the understanding of STEM concepts and the attitudes towards STEM (Gibson and Van Strat 2001; Liang and Gabel 2005); Previous research illustrates, moreover, a constructivist teaching approach to motivating young people to choose to stimulate technical disciplines in higher education or as a career option (Ardies et al, 2015a).

Measuring of pupils' attitudes toward technology

We used the well-established PATT survey which was initially developed by Raat et al. (1988) for use with upper secondary students, and validated recently for use with younger pupils (start of secondary education) by Ardies, De Maeyer, and Gijbels (2013). The concept attitude in this study can be understood like Ardies et al. (2013) described it, with six interdependent sub-factors.

Technology as a career choice. Pupils' career aspirations in the STEM field appears to be a difference for boys and girls (Ardies & Boeve-De Pauw, 2014). The fact that science is often regarded as 'universal', 'value-free' (Lacey 2005) and objectively contravenes the feminine values. Moreover, science-oriented professions are still, stereotypically, seen as male (e.g. Struyf et al. 2017). This might be reasons for the fact that women in perceive STEM domains as a hobby, in contrast of a possible future job (Van Houte et al. 2013).

*Technology is interesting***.** Having interest for a particular subject is an influencing factor of learning performance (Hummel & Randler 2011). This is equally the case in the domain of technology education. More specifically, it is shown that higher interest leads to higher academic performance in the fourth grade of primary education (Van Houte et al. 2013). The fact that an interest in technology correlates with the learning outcomes of pupils is not the only reason why pupils' interest should be increased; this could also lead to higher participation of young people in the public debate on science and technology (Osborne & Dillon 2008).

Technology is boring It is possible that pupils experience feelings of dullness in respect of a particular school subject. The extent to which they do is the third PATT subcomponent. The feelings of tedium include both an affective, cognitive and motivational component. On the affective level pupils have the feeling that a certain subject, in this case technology is boring. The cognitive experience of these pupils is their perception of the time passing slower than in real life. At motivational level, these pupils want to escape from the situation (Nett, Goetz, and Hall 2011).

Consequences of technology. A fourth subcomponent is the way pupils assess the consequences of technology. In this factor takes to the way in which the pupil estimates the usefulness of the technology for society is taken into account.

*Difficulty of technology***.** Pupils differ in their perception of the difficulty of technology as a school subject. In general researchers found that girls experience technology as more difficult to understand than boys (Jones et al. 1999; Boser, Palmer and Michael 1998). Research has also shown that this attitude is affected by a number of personal characteristics. Thus, younger students feel more positive about technology compared to older students (Edison and Geissler 2003). It is therefore important to check the analyzes for age and sex in the domain of technology education.

Technology as a subject for both genders. Pupils also have an idea about the gender specificity of technology: the extent to which technology is something exclusively for boys or for both genders. The difference between girls and boys that exists in the field of technology was already addressed in with other aspects of attitude. This difference can also be found in this component of attitude towards technology. Other researchers found that pupils have a prevailing stereotype that boys are better than girls in technology (Hill, Corbett, and St. Rose 2010). In addition, boys find science and technology more suitable for themselves than for girls (Jones, Howe and Rua 1999).

The intervention: The Techno Trailer

The current study examines the impact of a one-day intervention at school: The Techno Trailer (T^2). This is an initiative of the education service of the Province of Antwerp (2010) in Belgium. The overall concept gives primary schools the opportunity to learn about technological innovations and how they contribute to solving problems and meet human, societal and technical needs in industry. In this respect the term technology education could, within the current study, be interpreted as learning toward design technology. It should be noted tough that participants in the intervention do not design technological solutions themselves, but they get acquainted with and interact with existing technological solutions for real and prevalent problems. The intervention consists of a truck that has been designed as an interactive classroom and which visits schools. The truck contains workstations on various topics focusing on different high-tech aspects of technology. Students who visit the techno trailer spend a complete day with and in it. This day consists of four main parts that the students go through in groups of maximum 15.

The first workshop consists of a visit in the trailer itself where they are introduced to five different interactive activities, that resemble different industries. For the *first*, biochemical industry, students are invited to make a hair gel. In a *second* activity the focus is on the control and follow up of an automated production process. The *third* activity students do is programming a robot. *Fourthly*, to explore the graphical industry, students develop a newspaper. The *fifth* and last activity focusses the production of green energy.

The three other workshops take place in the classroom and not in the trailer, although with materials, tools and supervisors from the techno-trailer project. The first of these workshops in the classroom is building a bridge that meets certain requirements with rubber bands and bamboo sticks. In the second workshop students are making their own wooden dice, with attention to the safety instructions. Finally, there is also a workshop where students explore electronic circuits and programming with tablets. In this workshop they also make a mobile phone holder by folding plastic.

The aim is twofold: to improve the students' attitudes towards technology and at the same time to close the gap between education and industry. The T^2 aims to respond to both these goals of technology education in schools. In this, the T^2 aims to let young people discover their own technical talents, which may lead to pupils who make a positive choice towards a technological career. The aim thus is that participation in the T^2 project changes pupils' attitudes towards technology. The degree to which a visit to the T^2 has a positive effect on the attitude with respect to the subject technology is the focus in the present study. More detailed information including video impressions of the truck can be found on www.technotrailer.be. In conclusion, we can state that the overall objective of the intervention is to contribute to the participants' attitudes towards technology, in the sense that these attitudes can be considered the main learning objective that is targeted by the educational intervention.

Research Questions

In the introduction and problem statement we mentioned that it is appropriate to examine the impact of a one-day intervention on the attitudes of students towards technology. Based on the above theoretical framework, we can further refine this problem to two specific research questions.

1. Does the Techno Trailer intervention have an immediate and retention effect on pupils' attitude (on each of the six sub-factors of the PATT) towards technology?
2. Is the effect of the Techno Trailer intervention (on each of the six sub-factors of the PATT) different for boys and girls?

Material and Methods

Respondents

A total of 1496 pupils and 75 teachers from 18 different schools participated in this study. Although not all participants participated in all three measuring points, we found sufficient overlap with respondents to make significant predictions. In total, 52% boys and 48% girls we included in the research, which reflects a balanced gender ratio in our sample. The students were all in grades 5 and 6 (which corresponds the two last years of primary school in Flanders) and were on average 11 years old while participating in the intervention.

Independent variables

Pupils' gender is also taken into account to determine whether there is a difference between boys and girls in their attitude towards technology after the intervention. In preparation of the intervention training sessions for teachers were organized in which the participating teachers voluntarily could participate, 50 teachers out of the total of 75 took part in these sessions.

Primary teachers often don't have a broad knowledge of technology. Technology is in the primary curriculum a part of the wider subject 'World Orientation' which often leads to minor amount of time spent on technology. When analyzing the data, it is therefore necessary to include a variable which makes it possible to determine whether the pupils had a teacher's whit or without the specific training course, to measure the variation that can be explained by the training course on pupils' attitudes towards technology.

This training course prepared teachers on the intervention on both content and materials involved in the intervention. At first teachers got an overview of the program and structure of the day. Subsequently an explanation was given about the different activities, and their goals. Teachers got explained what their role in the activity would be, and were able prepare themselves. Suggestions were given on how to set up the classroom and what materials to provide as some of the activities would take part in the classroom guided by the teachers. By participation in this training teachers could also mentally prepare themselves and ask questions about the different activities they weren't familiar with.

Dependent variables

To investigate the attitude that pupils have regarding technology, we based ourselves on the PATT questionnaire as validated by Ardies et al. (2013). It gauges the attitudes of students towards technology in six different underlying factors, namely 'ambition for a technical career,' 'interest in technology, 'the level boredom', 'the perception of technology as subject for both genders', 'the perception of the impact of technology' and 'the perceived difficulty of technology'. For each of these scales there are a number of statements that are scored on a 5-point Likert scale (1 = completely disagree, 2 = disagree a little, 3 = neither agree nor disagree, 4 = agree a little, 5 = completely agree). In Table 1, the numbers of items for each subfactor is displayed with the corresponding Cronbach's alpha as a measure for the reliability of the scale. The table also displays for each of the six sub-factors PATT a preview item. For the full list of items, we like to refer to the work of Ardies et al. (2013).

<< Table 1 near here >>

Design

Data were collected in different phases as shown in figure 1. (1) In the first phase of the study, all pupils who participated in the project completed the questionnaire (T0). This had to be completed before the intervention. (2) Representatives of the Techno Trailer provided the questionnaires the first (T1) and second post intervention measurement (T2) to the teachers. Then the pupils filled out the questionnaires of post-test within the first three days. These questionnaires returned to the researchers by post in pre-addressed envelope. (3) 21 calendar days after the intervention, pupils completed the second post intervention questionnaire (T2). Teachers again send these questionnaires to the researchers by post.

<< Figure 1 near here >>

Analyses

In a first phase, the reliability of each of the six sub-factors of the PATT instrument was analysed. The Cronbach alpha values are reported for each scale in Table 1. The construct validity of the questionnaire was assessed using confirmatory factor analysis. Subsequently the averages and standard deviations were calculated for each of the three assessments. With a repeated measures t-test the differences in the sub factor scores for each of the different times of measurement were controlled for their significance. On significant differences we calculated the effect size (Cohen's d). In addition, the rule of thumb that applies an effect is "small" since it has a minimum size of 0.2 "average" from 0.5, and "large" from 0.8.

To assess if the effect of the measurement occasions correlates with the training (preparatory workshop) of the teachers, and to simultaneously study interactions with pupils' gender, while taking into account the complex nested structure of the data, a multilevel regression model was used (Hox, 2002). On the first level of this model we palace the three measurement occasions (MO) within each pupil. The pupils themselves are within the model the second level. Since pupils are not randomly distributed across schools, but rather grouped purposefully within schools, we also include a third level in our model: the schools. As such the three levels of our data (and model) are: MOs within pupils within schools. The explanatory variables were added to the models through a stepwise approach: first the MOs, then pupils' gender, and lastly teachers' participation to the preparatory workshop). Model fit was ascertained by means of the likelihood ratio test. Finally, the interaction effect between gender and MO was added to the model. This was necessary to determine the differences in the evolution across the genders. When likelihood-ratio test lead to a model that fitted the data significantly better, then the variable or interaction between variable was retained in the model.

We tested validity and reliability of the PATT instrument through a confirmatory factor analysis. Fit indices in the CFA showed excellent model fit (Chi² = .00, RMSEA = .05, CFI=.94; Hu and Bentler, 1999). To asses reliability of the different subscale we calculated Cronbach's alpha values for the different factors. These demonstrate reasonable to excellent internal consistency (all values between .69 and .88). Based on these analyses we can claim the PATT to be valid and reliable for use in our context and with our target audience of students. Table 2 shows, for each sub factor, an average score with the standard deviation. As the students completed a questionnaire three times, for each moment a sum score is made. The tables as such reflect the score on the Likert scales. We calculated the effect sizes of the differences between the measurement occasions.

<< Table 2 near here >>

Results

A significant difference between T0 and T1 was found for each of the six sub-factors of attitude towards technology. After the intervention pupils have more ambition for a technological study or profession and they find technology more interesting and less boring. They also estimate the consequences of technology more positively and they have a more positive perception of technology as a subject for boys and girls. We note that these effects three weeks after the intervention are still present (no significant differences between T1 and T2), although the effect size is smaller between T0 and T2. After the intervention, pupils found technology more difficult, three weeks later, this effect disappeared.

Table 3 summarizes the fixed and random effects in the multilevel regression models for the six sub-factors of the PATT. These models estimate the effect of background variables on the attitude towards technology of the participants in the intervention, and the impact it has had to take part in the intervention on that attitude. Whether their teacher had training before the intervention of not has only a significant effect on the subfactor boredom. The analysis model controls also for pupils' gender, where we find significant effects on all sub factors. In addition, we also added an interaction effect between the measurement occasions and pupils' gender. Doing so we determine could found differences in trends between boys and girls. The results for each sub factor are briefly discussed below.

<< Table 3 near here >>

Technology as a career option. The results in Table 2 demonstrate that pupils, prior to the intervention, have a moderate ambition for a technological career (with a score just above the neutral three). Participants herein evolve positively as a result of the intervention ($t > 2$, $p < .05$). The results also show that girls are less positive about a technological career (Table3: beta = -.55). Moreover, pupils with a teacher who participated in the training course, prior to the intervention, did not score any better than their peers with a teacher without training ($t < 2$, $p > .05$). No significant interaction effect of pupils' gender and the three measurements was observed, showing that boys and girls in this sample did not evolve differently across time. Hence girls' careers ambitions also develop positively, but they retain a lower score than the boys after the intervention.

Interest in technology. The results show that pupils have a moderate interest in technology. The visit of the techno trailer does not cause large changes in perception regarding their interest in technology. Girls are just slightly less interested in technology compared to boys (see Table 3) and this difference remains over also after the intervention. Pupils, of which the teacher did not follow a training course, do not exhibit another degree of interest compared to those pupils where the teacher was present.

Technology is boring. The results in Table 2 indicate that pupils find technology, even before they had participated in the intervention, perceive as not very boring. The results in Table 3 indicate that girls consider technology more boring than their male peers do. The analysis of this model shows that both boys and girls undergo an evolution in their perception of technology as (not) boring. The intervention has the effect that the participants find technology less boring. Moreover, for girls, the effect of the intervention is larger than for boys (significant interaction effect, see Table 3). The participation of teachers in the training also appears to have a significant effect on the perception of the pupils of finding whether or not boring technique. If the teacher has participated in the training, pupils find technology even less boring.

Consequences of technology. The results in table 3 show that after the intervention pupils will have a more positive attitude towards the consequences of technology. In addition, also the effect of pupils' gender on this variable significant. Girls estimate in general, the consequences of technology less positive than boys. The training of the teacher has no significant effect on this attitude. Finally, it can also be shown that, for this sample, that a few weeks after the intervention pupils attitude stagnates (see Table 2).

Difficulty of technology. The results indicate that students prior to the intervention perceive technology as difficult. The results indicate that the intervention has no effect on boys' nor girls' attitude towards technology as being a difficult subject. Also, the effect of the teacher who have received training not significant. Pupils' gender does prove to be significant. Girls estimate technology to be as equally difficult as boys do.

Technology as a subject for boys and girls. The results indicate that pupils before the intervention moderately agree that technology can be something for both boys and girls. However, girls believe that technology is something for both genders, far more than their male counterparts. This effect is the largest that was found in our study, and girls score on this factor nearly a full standard deviation higher than boys (beta = 0.95). Both girls and boys evolve however positively in their view that technology is indeed something for both genders, after the intervention. And, on top of the positive effect for both genders, the effect of the Techno Trailer is even stronger for girls. The variable that controls whether the teacher followed the training course or not, is not significant ($t < 2$, $p > .05$) and thus does not contribute to a change in the image of the pupils.

<< *Figure 2 near here* >>

Discussion

The central goal of this study was twofold: first to pinpoint the effect of a one-day educational intervention on the attitudes toward technology of the participating pupils, and second to estimate the effect to which this effect is different for boys and girls. To tap into those attitudes, we used the well-established PATT survey which was initially developed by Raat et al. (1988) for use with upper secondary students, and validated recently for use with younger pupils (start of secondary education) by Ardies et al. (2013). We used this instrument in a novel target population, namely pupils at the end of primary education (ten to twelve-year olds). The instrument showed to be valid and reliable within the context of the present study. This in itself is already result worth mentioning and adds to the body to knowledge on the PATT.

The results of our descriptive analyses of the data that was collected (measurement occasion zero) before the intervention confirm what is known about young pupils' attitudes towards technology (e.g. Kennedy, Quinn & Lyons, 2018). They only have moderate interest in technology as a career choice, and do not score particularly high when judging the relevance of technology, which is in line with earlier research by Ardies et al. (2013, 2015a). Though they do not perceive technology as boring, their interest in the subject is only moderate. Also, when asked about the gender specificity of technology they do not show an outspoken stance towards it being gender neutral. Furthermore, the responses of the girls in our sample differ substantially from those of the boys. While they do perceive technology as equally important for both genders, girls also perceive it less as a career possibility, less interesting, less relevant for society and more boring. Surprisingly in our sample, we also showed a negative effect of gender (girls) on the perceived difficulty of technology.

Our first research question zoomed in on the impact of the educational intervention Techno Trailer on our participants´ attitudes towards technology. Our results show that this impact is clearly present and, more so, shows the direction we would want it to have. Immediately after have visited the techno trailer, the pupils perceived technology more as a career option. Furthermore, they found more interesting and less boring. They also impute more positive consequences to technology after the intervention than before. These results are encouraging since we know from other studies that perceived relevance – be it socially of societally – of science and technology can results into better motivated career choices in related field (Struyf, Boeve-de Pauw & Van Petegem, 2017). On top off those results, our study shows that the intervention contributed to the perceived gender neutrality of technology as a subject and a career. On the downside, the intervention increased the perceived difficulty of technology. It is very plausible that this is a direct consequence of the fact that the techno trailer uses a challenging hands-on learning approach and high-tech modules. These results merit consideration by the program designers. At one hand they could be interpreted as a more realistic view on technology and as such possibly resulting in better motivated study and career choices. They might however also be a sign of needed caution since high perceived difficulty of (learning) science and technology are very real obstacles for student when making such choices (e.g. Evans, 2015, Chi et al., 2017).

In our current study we also investigated retention effects in the learning outcomes of the Techno Trailer intervention. The question here was whether the immediate impact that is the consequence of just having taken part in the intervention can be attained over a longer period of time. In other words, do the pupils keep their changed perspective or do they migrate back to their initial attitudes towards technology. We surveyed the participants a third time, three weeks after the intervention took place. Our results show that the scores on the PATT diminish somewhat, but the participant still perceive technology significantly more as a career option, as interesting, as gender neutral, as relevant and as less boring. They do, on the other hand, no longer perceive it is more difficult. We can this conclude that the intervention has caused desired immediate as well as retention effects. The extent to which the effects last even longer than the three weeks in our study and can be considered a permanent (or 'sustained' effect, e.g. Schönfelder & Bogner, 2017) is an important topic for further study.

The second research question focused on the gender specificity of the intervention´s impact. To assess this issue, we included interaction terms into the multilevel regression models we built to explain the participant attitudes towards technology. Where statistically significant, these interactions effect mark the differences between boys and girls in the evolution of their attitudes towards technology. Only two such differences are present in our results, indicating that in general boys and girls tend to evolve in a comparable way. This means that the divide in, for example, their career aspirations stays equally big: girls grow as much in their career aspirations in technological fields as boys do. This is in itself an encouraging finding: the intervention is not more effective for boy than it is for girls when it comes to career aspirations. The two interaction effects that are present are in favor of girls: the negative effect of the intervention on the perceived boringness in larger for girls than it is for boys. This actually means that the changes in perceived boringness are larger for girls as compared to boys: the intervention thus seems to be more effective in reducing the perceived boringness for girls. Given the gender gap that still needs to be bridged in this area (Wang & Degol, 2017), this result is meaningful and encouraging. Also, even though the girls started out with a more gender-neutral attitudes towards technology than the boys, the intervention has a bigger impact on this sub factor for girls as compared to boys. The results of our study thus suggest that for these two sub factors the intervention is more effective for girls than for boys. With the gender imbalance in technological studies and professions in mind, these results are encouraging since they suggest that even short-term interventions such as the Techno Trailer can make a contribution towards closing the gap. More research is needed, though, on the impact of these changes on the actual choices girls make concerning their studies and professional life.

This current study also sheds light on the importance of teacher professional development, since in general those pupils in schools where the teacher attended a preparatory workshop on the intervention, seemed to benefit more from the techno trailer. Specifically, the negative effect on perceived boringness of technology increased with teacher participation in the workshop. In other words, pupils from 'prepared' teachers appear to perceive even stronger that technology is not boring after the intervention than pupils from 'unprepared' teachers. Nevertheless, this result could also be, partiality biased by teachers' enthusiasm for the subject, especially if the teachers participated in the preparatory workshop. This could suggest a transfer of teachers' enthusiasm for the subject to students, but it could also reflect a stronger presence of social desirability in the responses of those students. To examine this in more details we would need another research design in which we also include either a measurement for the tendency to reply to questions in socially desirable way (e.g. Miller, 2012) or in which we include qualitative data collection with a subset of student to explore their responses and learning more in detail.

Other future research could focus on the impact this or other interventions have on the teachers, and tap into the possible changes in their attitudes towards technology and their willingness, self-confidence, and self-efficacy concerning teaching technology in class, and how these issues are connected to the impact of intervention on the pupils (e.g. Van Driel, Beijaard and Verloop 2001). Finally, our results also show that the PATT questionnaire as proposed by Ardies et al. (2013) is a valid and reliable measure to study the attitudes towards technology of younger pupils than those the questionnaire was validated for. Future research could focus the psychometric properties and the measurement invariance of the instrument across age groups. Such research would especially be useful if the instrument were to be applied in long term studies to follow pupils as they move from primary into secondary education.

We should also that all the observed effect sizes here were between small and moderate (all $d < 0:5$). Nevertheless, they are significant both in the statistical and educational sense. Small changes in, for example, the career aspirations of young children could tilt over into study choices and in the long-term result in an increase in the number of technological professionals (as suggested by Tai et al. 2006). Likewise, less perceived boredom and increased interest, though only being small, could lead greater interest in technology as a school subject, which could on its turn lead to increased technological literacy. To study such hypotheses, more longitudinal research is needed. It might also be an opportunity to attune the intervention further to the results of our current study, e.g. through design research, where the educational objectives of can guide the further design process of the Techno Trailer (e.g. Sandoval, 2014).

Conclusions

Our study has revealed that pupils' attitudes towards science are susceptible to changes due to short term interventions. Some of these changes even persist when measured in a retention test three weeks after the intervention. Overall, it can be concluded that the Techno Trailer intervention can be considered successful in shaping favorable attitudes towards technology in its target population (children aged 10-12 years old) in terms of interest, perceived relevance and career aspirations. Since gender specific effects were observed it might be relevant for designers of these kinds of intervention to pay targeted attention of both genders. Finally, it should be noted though that the high-tech nature of the exhibits in the trailer may have caused some adverse effects in terms of perceived difficulty of technology.

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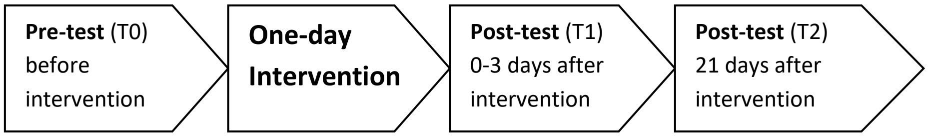

Figure 1. *Procedure of the data collection*

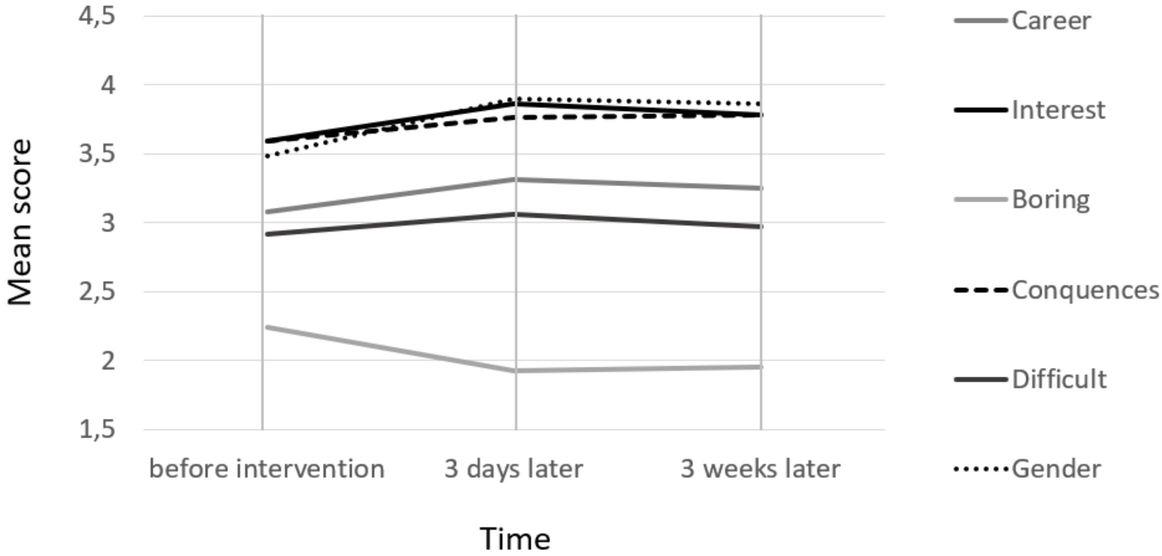

Figure 2. *Evolution of the six sub factors over the three measurement occassions.*

Table 1. Six subscales of the PATT questionnaire (Ardies et al., 2013), and their reliability

	Factors	Sample item	items	α
1	Technological career aspirations	*Working in technology would be interesting*	4	.88
2	Interest in technology	*There should be more education about technology*	5	.76
3	Tediousness towards technology	*I think machines are boring*	4	.75
4	Consequences of technology	*Technology is very important in life*	4	.72
5	Technology is difficult	*To study technology you have to be talented*	4	.69
6	Technology is for both boys and girls	*Boys know more about technology than girls do (inverted item)*	3	.84

Table 2. Pupils' mean scores (*M*) and standard deviation (*SD*) on the 5-point Liker scale for each sub factor, and differences between the measurement occasions. N=1496.

PATT	T0	T1	T2	T0-T1		T1-T2		T0-T2	
	M ± SD	*M ± SD*	*M ± SD*	*t*	*d*	*t*	*d*	*t*	*d*
Career	3.08 ± 0.95	3.31 ± 1.00	3.25 ± 1.01	4.72*	0,15	-1.19	/	3.34*	0,11
Interest	3.59 ± 1.00	3.86 ± 0.97	3.78 ± 1.03	5.48*	0,18	-1.60	/	3.61*	0,11
Boredom	2.24 ± 1.05	1.93 ± 0.94	1.95 ± 0.92	-6.22*	0,22	0.43	/	-5.70*	0,18
Consequences	3.59 ± 1.02	3.76 ± 0.98	3.78 ± 1.02	3.40*	0,11	0.40	/	3.60*	0,11
Difficulty	2.92 ± 1.01	3.06 ± 0.95	2.97 ± 1.02	2.86*	0,07	-1.76°	/	0.95	/
Gender	3.48 ± 1.04	3.90 ± 0.94	3.86 ± 0.91	8.47*	0,29	-0.86	/	7.55*	0,26

T0=before the intervention, T1=3days after the intervention, T2=21 days after the invention, * p-value < 0.05, ° p-value<0.1

Table 3. Overview of the fixed and random effects (*betas*) of the multilevel regression models.

	Career	Interest	Boredom	Consequences	Difficulty	Gender
Fixed effects						
Intercept	.17*	.20*	.04	-.06	.10	.59*
MO	.08*	.02	-.09*	.09*	.02	.24*
Girls	-.55*	-.42*	.39*	-.23*	-.23*	.95*
Teacher workshop	.09	.02	-.18*	.09	.00	.04
MO*Girls	/	/	-.10*	/	/	.16*
Random effects						
Variation of students over time	.43	.37	.59	.56	.51	.42
Variation between students	.35	.30	.31	.32	.39	.47
Variation between schools	.05	.07	.05	.06	.06	.06

* p-value < 0.05; MO=Measurement Occasion