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Effects of company visits on Dutch primary school children's attitudes toward technical professions

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Abstract Technology-oriented company visits could potentially provide children with a stimulating 'real-world' setting to develop more broad and positive images of and attitudes toward technology and technical professions. The present study was the first to explore whether children's images of and attitudes toward technology, technical competencies and technical professions could be affected by technology-oriented company visits, as they are presently carried out in the Netherlands. A previously validated measurement instrument was used to measure children's images and attitudes prior to and after the visits and results were compared to similar measurements among children who did not take part in the visits. In addition, based on recent review studies about school visits to science centers, we derived several key theoretical guidelines for organizing effective school visits. Based on these guidelines, structured interviews were carried out with all teachers prior to the company visits. Results indicated that children's images and attitudes remained mostly unaffected by the company visits, a finding that could be explained by the fact that the level of in-school preparation, follow-up activities and teachers' level of involvement during the visits was generally low. In addition, observations during the visits showed that the activities at the technical companies were mostly 'hands-on' and stereotypical (e.g., working with machines). Based on these findings, we formulate a set of new guidelines for technology-oriented company visits that could improve the desired attitudinal effects.

Keywords Company visits · Outdoor school activities · Field trips · Attitude development · Technology · Technical professions

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Introduction

There is a growing demand for technical professionals and technologically literate citizens to understand and ensure technological innovation (Osborne and Dillon 2008). Although primary-aged children show a natural interest in and curiosity for societal issues related specifically to the domain of science and technology, the number of science and technology students has been decreasing in the last decade (De Grip and Smits 2007; OECD 2006). Children seem to be unaware of how their interests in technology relate to technical professions and as such do not envision themselves being part of the future technological workforce (Dekker et al. 2007; Walma van der Molen 2007). Because children's images of and attitudes toward technology, as well as their professional ambitions, seem to be already matured by the end of primary school, this often leads them to disregard technical oriented study careers based on stereotypical beliefs and misconceptions (e.g., scarcity of job offers, heavy and dirty work, male dominancy, etc) before entering secondary school (Osborne and Dillon 2008; Tai et al. 2006; Turner and Ireson 2010; Young and Kellogg 1993). In order to positively affect students' study and career choices, it is, therefore, important to inform and inspire them at an early age if we want to make any difference.

In Dutch primary education, children spent only little time on the subject matter of technology (de Vries et al. 2011). While many initiatives are currently invested in allocating more time to teach technology as part of the curriculum goals, effectively implementing technology education in schools is often times not straightforward: most technology lessons are (1) too narrow-oriented, requiring children to only remember, understand and apply knowledge (not allowing for much higher-order, creative thinking), and (2) rely too heavily on 'hands-on' activity that leaves little room for children to develop reflective inquiry or design skills (van den Berg and van Keulen 2011; Walma van der Molen et al. 2010). Moreover, many primary school teachers feel insecure and unable to adequately provide technology teaching in their classes and consequently fail to effectively improve primary children's attitudes toward technology (for a review, see van Aalderen-Smeets et al. 2012). Among other issues, primary teachers find it difficult to deal with children's original and creative questions in this area and often prefer to rely primarily on standardized methods and assignments through top–down instruction. Given the observation that this seems to be common practice, it is not surprising how children would be likely to develop negative images of and attitudes toward technology that lead them to neglect (or even avoid) technological study paths later on.

To counter the generally low level of technological literacy that seems to exist among Dutch primary school teachers today, various school communities have started to organize school trips to local technology-oriented companies to better educate and inspire children on the topic of technology. During these visits, children receive a guided tour in and around the company facility, learn about the company's corporate organization and production processes, and are in some cases allowed to creatively work on solutions to authentic design problems using actual materials, tools and machinery under close supervision of the company's technical workers. By allowing children to actively experience and acquire knowledge of the industry in this real-world setting, teachers and schools aim to improve children's images of and their attitudes toward technology and technical professions, while educating them on the topic of technology at the same time.

However, thus far, to our knowledge, the potential positive effects of such company visits on children's attitudes towards technology or technical professions have not been tested. A literature search in the main electronic databases (Psychinfo, ERIC, Web of Science) targeting recent empirical studies and international reviews in dedicated scientific

ISI-ranked journals did not yield any results. This implies that, although the initiative of organizing school visits to technical companies could be a means of countering children's negative images of or attitudes toward technical studies or professions, we do not know whether this practice indeed has the desired effect, nor what factors may influence the effects of such visits. The present study aimed to remedy this void in research, by means of a field experiment where the attitude change of children that did participate in a company visit program was compared to children that did not participate in such a program. Because of the lack of scientific literature on company visits thus far, and in order to investigate the possible underlying factors that may influence children's attitude changes or learning outcomes due to outdoor visits, we turned to literature on the effects of children's visits to science centers or field trips to nature.

School visits to technical companies seem to share much similarity with school visits to public science exhibits, such as science centers, museums and zoos, including features of field trips (e.g., visits to nature for studying wildlife), where children are allowed to go outdoors for having a direct experience with a certain phenomenon within a real-world setting (Morag and Tal 2011). Several studies have shown that school visits to science exhibits and field trips to nature have positively affected the early study choices of trained professionals who later on pursued scientific or technological careers (Bitgood 1989; Heimlich et al. 2011; Jarvis and Pell 2002; Knapp 2000, 2007; Salmi 2003). Potentially, outdoor school activities may improve children's motivations, curiosities and attitudes toward the subject domain and afford for a unique kind of personal meaning-making while relating to curricular objectives covered in school programs (Davidson et al. 2010; DeWitt and Storksdieck 2008; Ramey-Gassert 1997; Knapp and Barrie 2001; Price and Hein 1991). Concordantly, teachers and museum educators frequently acknowledge the motivating nature of outdoor school activities. However, it seems that learning gains and positive attitude development are not always evident when compared to usual learning settings at school (Davidson et al. 2010; DeWitt and Osborne 2007; Griffin and Symington 1997; Rohaan et al. 2010). While it is agreed upon that cognitive as well as non-cognitive learning outcomes should be taken into account to fully capture the effect of outdoor school activities on children's learning, researchers are challenged with assessing the multiplicity of possible learning outcomes that school visits potentially have to offer (Anderson et al. 2000; Rennie and Johnston 2004).

In review, most research on school visits to science exhibits has been invested in deriving and developing practical guidelines that help teachers and on-site educators to organize improved outdoor school activities that effectively engage children in learning about a certain topic. Heimlich et al. (2011) have identified seven *field day components* that comprise 'best practices' based on evaluations and peer reviewed articles on school visits that seem to largely moderate the effective implementation of school visits. We believe that these seven components can be summarized according to the following three main recommendations that we will describe in more detail below: (1) increasing children's level of familiarity with the physical features of the environment to be visited prior to the visit, (2) the extent to which learning activities during the visit are connected to the classroom curriculum, and (3) the degree to which teachers actively participate and stimulate children before, during and after their visit to ensure that children connect their on-site learning experiences with the classroom curriculum.

With regard to familiarity, several studies have shown that before children are able to fully attend to any planned tasks of learning during their visit, they first need to become familiar with the physical features of the environment that they are soon to visit (Anderson and Lucas 1997; Falk and Bailing 1982; Kubota and Olstad 1991; Martin et al. 1981).

When children experience high levels of perceived novelty during their outdoor visit, this leads them to develop increased levels of curiosity to explore and become familiar with the physical out-of-school-environment. Although curiosity is a desired effect of these visits, too much curiosity for the physical environment may distract children from the desired on-task behavior. Alternatively, when children experience a slightly lower level of perceived novelty with regard to the physical on-site environment, their level of curiosity to explore the on-site tasks is likely to be higher, which makes it easier for teachers and on-site educators to effectively engage children in planned learning activities. As such, it is recommended that teachers allow children to work on specific pre-orientation activities in class prior to the visit. Such activities may involve studying photographs or short videos of the physical features of the site and vividly rehearsing the planned activities of the visit as part of other preparations.

Most researchers seem to agree that learning activities conducted during school visits should also be connected to the classroom curriculum. Short educational interventions that are not rooted in the topics being studied in class nor adequately embedded in the curriculum with preparatory and follow-up activities are unlikely to have much effect. Adequately connecting school visits to the classroom curriculum helps children to develop the necessary concepts relevant to the planned learning activities during the visit, making them more able to construct new learning experiences that are related to their prior knowledge and interests, while follow-up activities allow children to reflect on their gained learning experiences after the visit in order to turn short-term learning into long-term memories (Knapp 2000; Kolb 1984). Therefore, it is recommended to situate school visits early on in the school year in order to ensure for sufficient time to organize pre- and follow-up activities. Surprisingly, many school visits are organized near the summer break, often as part of a fun conclusion to the school year with little intention to be part of the classroom curriculum or any follow-up lessons (Orion and Hofstein 1994).

Lastly, teachers play an integral role in ensuring that children are prepared for the visit, engaged during the visit, and, once they return from the visit, reflect upon and apply their acquired knowledge and skills in future classroom activities. Although teachers' intentions are consistent with what research findings show to be necessary actions for ensuring effective school visits (e.g., connecting to curricular goals, preparatory assignments, addressing both cognitive and affective learning, etc.), teachers' actual behavior when conducting school visits is often quite the opposite: teachers seem to behave passively and limit themselves to the logistical issues of the visit (DeWitt and Osborne 2007; Griffin and Symington 1997). Furthermore, teachers tend to impose traditional top–down learning strategies on outdoor learning settings and feel unable to make use of the unique opportunities for learning that school visits to exhibits or nature have to offer. To maximize the potential of cognitive and attitudinal gains, teachers should actively participate during the visit by challenging and inspiring children to relate their prior knowledge, experiences and interests with the particular learning activities covered during the visit (Anderson et al. 2006; Jarvis and Pell 2005; Price and Hein 1991).

The present study

Considering the context of technology education in the Netherlands today, we are under the impression that Dutch schools are (1) generally employing company visits as a relatively easy way to outsource technology lessons, (2) largely unaware of the guidelines that may improve the effects of school visits, and (3) typically select technical companies for the children to visit that are too narrow-oriented and stereotypical (e.g., heavy machinery, male dominancy, etc.). Based on these impressions, at the onset of this study, we questioned whether the current practice of company visits would broaden and improve children's images of and attitudes toward technology and technical professions. Since the present study was the first to investigate if and to what extent children's images of and attitudes toward technology and technical professions are affected by technology-oriented company visits in their natural setting, our study was predominantly explorative. Previously validated measurement instruments were used to measure children's images and attitudes prior to and after their company visits and these images and attitudes were compared to children who did not take part in the visits. In order to explore the particular organization of the company visits and study the potential effects of the level of in-school preparation, teachers' level of participation during the visits, and follow-up activities on children's images and attitudes, structured interviews were carried out with all responsible teachers prior to the visits.

Methods

Participants

Thirteen primary schools from a rural area in the Netherlands were selected to participate in the study. From these schools, a total of 511 children from Grades 5 ($n = 247$) and 6 ($n = 263$) with a mean age of 11 years and 1 month participated as respondents. There were 255 boys and 256 girls. Six of the thirteen participating schools were selected because they took part in an annual local project on technology that included school visits to various technology-oriented companies in the area. The children in these schools ($n = 276$) formed the experimental group. The remaining seven schools constituted the control group of children ($n = 235$) that did not attend the company visits and were selected based upon background characteristics that matched the schools from the experimental group.

Design

A quasi-experimental pretest–posttest control group design was used for the study to investigate the effects of the company visits in their natural context. As described above, based on their participation in the local project, schools fitted into either one of two conditions: (1) an experimental condition for children that attended the company visits ($n = 276$), and (2) a control condition for children that did not attend any visits ($n = 235$). Children were not made aware of the fact that they were assigned to a particular condition.

Company visits

In total, 14 technology-oriented companies in the area volunteered to take part in the company visit event. Teachers organized and prepared the visits in collaboration with representatives from the participating companies. For each class, two company visits were planned and teachers prepared some learning activities to do in class prior to the company visits.

Preparatory assignments

To prepare for the company visits, children took part in a school competition by completing two assignments at school: (1) designing and constructing the most effective (miniature) windmill, and (2) creating the best computer model drawing. All final designs were displayed at a local exposition center to be viewed by the children, their teachers and parents at the end of the company visits. For each assignment, one school was rewarded as a winner.

Company visits

Each class visited two different companies that had prepared a guided tour (i.e., providing information about the company's history, explaining the process by which their products are made and sold, showing products, demonstrating the use of technical devices and machinery, etc.) and an authentic design activity that the children worked on individually at the company workplace under supervision and with help of specialists (e.g., welding various materials together to create more durable constructions, calculating the volume of water that could be transported through specialized pipelines that children connected, or assessing the performance of a motorcycle's engine power after having tweaked with various features of the engine). All company tours allowed the children to take home miniature designs that they worked on during their visit, to show to their family at home. In the evening, parents were invited to visit the same companies their children visited earlier that day and to attend the public announcement of the winning windmill and computer model drawing in the local exhibition center.

Procedure

One month before the company visits, a paper-and-pencil questionnaire that measured children's attitudes toward technology and toward technical professions was administered to all children (both in the experimental and the control group) in their own classroom. After a brief introduction by the principal researcher, each child was provided the time needed to complete the questionnaire. If a child did not understand a particular item, the researcher provided feedback individually.

In addition to the child-questionnaires, structured interviews were carried out with all responsible teachers prior to the company visits. By means of these interviews we investigated potential differences between schools with regard to technology education in general (i.e., number of technology classes, kind of technical classroom activities, didactical approaches, etc.). In addition, for the schools that constituted the experimental condition, we investigated possible differences in the manner in which the teachers had planned the preparatory assignments or activities that preceded the company visits.

At the beginning of the day of the company visits, the teachers told their pupils that they were free to pose questions to the teacher and company host at any time during the visit, including questions that dealt with any specific topic related to the guided tour or the design activity.

To monitor the company visits, one class was randomly selected for observation during their company visits. Notes were taken by the principal researcher during the visits, concerning (1) the particular activities that the class engaged in during the day, and (2) any affective comments or expressions that were made by the children and teacher about how they generally felt about various parts of the visit.

One month after the visit, a post-test was administered to all children in the experimental and control group classes. This test concerned the same attitude questionnaire that was administered during the pre-test phase. In addition, children in the experimental group were asked to fill out a structured form that gathered information about their personal experiences during the company visits.

Measurements

At the beginning of the questionnaire, each child was asked to provide some personal information about age and gender. The remaining part of the questionnaire measured children's *Images of technology*, their *Attitudes toward technology*, their *Images of technical competencies,* and *Images of technical professions*. The instrument was based in part on a previously developed and validated test that investigated children's images of technology and their attitudes toward five specified components that relate to children's thoughts and feelings about technology (Walma van der Molen 2007). Responses to all attitude statements were scored on a four-point scale (1 strongly disagree, 2 disagree, 3 agree, 4 strongly agree). Each attitude component was measured with a set of statements. Weighted sum-scores for each attitude component were constructed by averaging a child's score on each set of items that defined the attitude component. The complete questionnaire is listed in "Appendix".

Images of technology

Based on the previously developed measurement instrument by Walma van der Molen (2007), the first part of the test consisted of seven statements that assessed children's personal view on what technology relates to. Statements were based upon two components: (1) *Narrow images of technology*, where children indicated to what extent they thought that, for example, technology is related to the craft of various materials or the skills needed to handle heavy machinery (factor loadings ranged between .67 and .79; Cronbach's alpha of .70), and (2) more *Broad images of technology*, including some scientific elements, where children were, among other statements, asked to indicate the extent to which technology is related to problem solving or coming up with new ideas (factor loadings ranged between .44 and .79; Cronbach's alpha of .65). The two factors explained 52.61 % of the variance in children's scores.

Attitudes toward technology

In the second part of the questionnaire, 23 statements assessed children's personal attitude toward various facets of technology. As was done with the items on children's images of technology, the attitude statements were taken from the previously developed and validated questionnaire by Walma van der Molen (2007). Statements were based on the tripartite model of attitudes (see for example Eagly and Chaiken 1993) that describes three underlying dimensions of attitude; *Cognition*, *Affect* and *Behavior* that may each consist of various subcomponents. As described by Walma van der Molen (2007), factor analysis showed that the attitude instrument consisted of five factors with an Eigenvalue >1, with an explained variance of 51.17 %.

For the dimension of *Cognition* three subcomponents were specified: (1) *Relevance*, the child's view on the relevance of technology for society and the effects of technology on economic welfare (e.g., "Technology is important for our economy"), where factor loadings ranged between .43 and .63 and the internal consistency was indicated by a Cronbach's alpha of .73; (2) *Difficulty*, to what extent the child attributes difficulty to the subject of technology (e.g., "Technology is a difficult topic"), where factor loadings ranged between .47 and .87 with a Cronbach's alpha of .50; (3) *Gender beliefs*, which measured the stereotypical views that children may hold with regard to gender differences in the context of technology (e.g., "Boys know more about the subject of technology than girls do"), where factor loadings ranged between .78 and .87 with a Cronbach's alpha of .85.

For the dimension of *Affect*, the attitude component of *Enjoyment* measured the extent to which children enjoy to engage in technology related activities (e.g., "I enjoy learning more about technology"). Factor loadings ranged between .52 and .81, with a Cronbach's alpha of .78.

Lastly, the dimension of *Behavior* measured a component that was labeled *Future,* to indicate the extent to which a child aspires to pursue a technical oriented career in the future (e.g., "I would like to have a technical job someday"). Factor loadings ranged between .79 and .88, with a Cronbach's alpha of .92.

Images of technical competencies

In the present study, a third and fourth part were added to the previously developed questionnaire, to generate additional data on children's attitudes toward the *professional* context of technology, because in case of the company visits, children would be explicitly exposed to various technical professions. To measure children's images of technical competencies, eight statements were added that aimed to measure children's images of the kind of domain-specific competencies required to be a professional technical worker. As was done for children's images of technology, these statements were designed according to two attitude components: (1) *Narrow images of technical competencies* (e.g., "Technical engineers need to be able to do repairs") and (2) more *Broad images of technical competencies* (e.g., "Technical workers need to be able to do inventions"). A confirmatory principal axis factor analysis with direct oblimin rotation was conducted. Based on the distinction between narrow and broad images, we expected the outcome of the factor analysis to be a two-dimensional scale. After having excluded two items that showed cross loadings higher than .30, a two-factor solution indeed provided the best fit of the data, explaining 54.29 % of the variance. Both factors corresponded to the hypothesized image components, where factor loadings on the *Narrow images of technical competencies* ranged between .47 and .59 (Cronbach's alpha of .55), and factor loadings on the more *Broad images of technical competencies* ranged between .47 and .66 (Cronbach's alpha of .59).

Images of technical professions

The last part of the questionnaire contained eight attitude statements that aimed to assess children's attitudes toward technical professions or toward working in a technical profession. Statements were constructed on the basis of two presumed attitude components: (1) *Positive images of technical professions* (e.g., "The technical professions offer much opportunity to earn money") and (2) *Negative images of technical professions* (e.g., "The technical sector mostly offers jobs that are boring"). A confirmatory factor analysis (principal axis factoring with direct oblimin rotation) showed the hypothesized two-factor solution to be the best fit of the data, explaining 47.25 % of the variance. Factor loadings for the component *Positive images of technical professions* ranged between .31 and .76 (Cronbach's alpha of .54) and for the component *Negative images of technical professions* ranged between .39 and .76 (Cronbach's alpha of .52).

Teacher interviews

One month before the company visits, structured interviews were carried out with the teachers of all participating classes (both in the experimental and control condition) ($n = 22$). Potential differences between schools were investigated with regard to (1) schools' technology teaching in general and (2) teachers' planned in-school, on-site, and follow-up activities for the children who participated in the company visits. A preplanned agenda of open-ended questions was used to consistently cover each question in the same sequential order. The interviewer provided minimal encouragement or confirmation to teachers' responses, only posing follow-up questions to summarize and clarify what was being said or to introduce a new topic. The length of the interviews varied from 20 to 30 min and the interviewer ended the interview when teachers brought up no new information related to the topic.

Schools' general technology teaching

This first part of the interview was structured according to the following five topics that aimed to measure the degree to which technology education was embedded in the school program: (1) *Evaluations*, whether technology education was structurally evaluated by school members to ensure that the school would meet quality standards, (2) *Technology classes*, the kind, number, and length of technology classes held each month, (3) *Technical resources*, the availability of technical materials, devices and other related resources for teachers to use at school to support their technology classes, (4) *Management*, whether particular members of the school were given the responsibility of ensuring the sustainability and further development of technology education at school, and (5) *Professionalization*, whether one or more teachers at school had followed or planned to follow any specialized in-service course on technology teaching.

Curricular embedding of company visits program

The last part of the interview was only targeted at teachers who were part of the experimental group that were to visit the companies, in order to examine to what extent the company visit program was embedded into the class curriculum. This part of the interview was structured according to the three main theoretical recommendations of organizing effective school visits as previously described in the introduction: (1) *Familiarity,* whether children would be familiarized with the physical features of the companies prior to the visits, (2) *Curricular connectivity*, the extent to which learning activities during the visit would be connected to the classroom curriculum, and (3) *Teacher participation*, the degree to which teachers would actively participate and stimulate children before, during and after their visit to ensure for intended student reflection.

For each component, responses were scored according to a qualitative evaluation by the researchers. One point was given for each component that was prevalent, amounting to a maximum score of five points that each school could earn for their current state of general technology teaching at school and an additional three points for schools in the experimental condition, for adequately embedding the company visit program into the classroom curriculum. For purposes of analysis, the median (general technology teaching = 2.00; curricular embedding = 1.00) was used as a cutoff score, to assign schools to either one of the two following groups: a higher-score group or a lower-score group, based on a relatively high or low prevalence of satisfactory components for each theme. In the case of general technology teaching, high and low score schools were almost evenly distributed across the experimental (three high and three low score schools) and the control group (three high and four low score schools).

Results

Initial data checks showed that there were no differences between children from different grade levels nor between different expected high school entry levels on any of the dependent variables. Therefore, in subsequent analyses these group variables were disregarded.

Images of technology

To investigate the effects of the company visits on children's images of technology, a 2 (experimental vs. control group) × 2 (boys vs. girls) × 2 (time 1 vs. time 2) × 2 (narrow vs. broad images) repeated measures MANOVA was conducted with condition and gender as between-subjects factors, time as a within-subjects factor, and the two image components (narrow and broad images) as multivariate dependent variables. Tests of within-subjects effects revealed a significant main effect of time, $F(1, 432) = 41.93$, $p = .000$, $\eta^2 = .088$. However, the analysis did not reveal a statistically significant interaction effect between time and condition ($p > .93$). These results suggest that, irrespective of condition, across both image components, children scored somewhat higher on the posttest than on the pretest (see Table 1 for boys' and girls' narrow and broad image scores).

As for gender, a significant between-subjects main effect was found, $F(1, 432) = 10.13$, $p = .002$, $\eta^2 = .023$, indicating that overall boys scored somewhat higher than girls did. However, this main effect was qualified by a significant interaction between time and gender that showed that during the pretest the difference between boys ($M = 2.98$,

Table 1 Mean scores with standard deviations of boys and girls on narrow and broad images of technology

	Experimental		Control	
	Pretest	Posttest	Pretest	Posttest
Narrow				
Boys	3.25 (.49)	3.16 (.52)	3.23 (.51)	3.19 (.47)
Girls	3.02 (.57)	3.25 (.50)	3.08 (.46)	3.19 (.50)
Total	3.13 (.55)	3.21 (.51)	3.16 (.49)	3.19 (.49)
Broad				
Boys	2.74 (.64)	3.00 (.57)	2.67 (.64)	2.84 (.60)
Girls	2.65 (.59)	2.77 (.54)	2.50 (.63)	2.77 (.61)
Total	2.69 (.61)	2.88 (.56)	2.59 (.64)	2.81 (.60)

Mean scores (with SDs in parentheses) could range from 1 (strongly disagree) to 4 (strongly agree)

$SD = .40$) and girls ($M = 2.81$, $SD = .41$) was larger than at the time of the posttest; boys ($M = 3.05$, $SD = .40$) and girls ($M = 2.98$, $SD = .40$), $F(1, 432) = 7.87$, $p = .005$, $\eta^2 = .018$. No three-way interaction effect was found between time, gender and condition ($p > .63$).

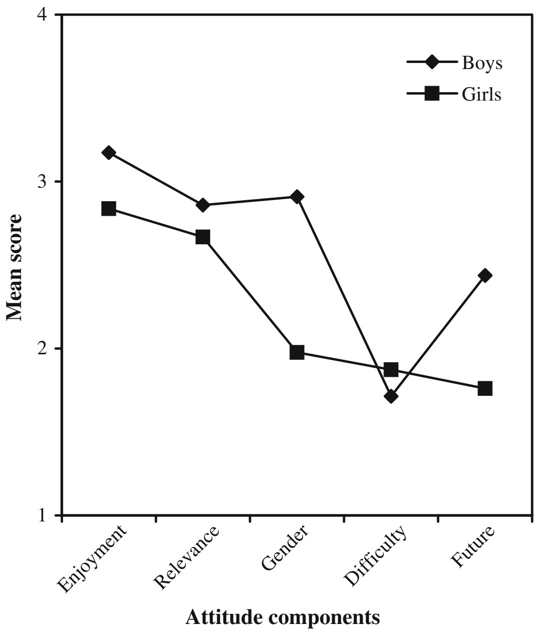
Tests of within-subjects effects also revealed a significant main effect of type of image, $F(1, 432) = 187.80$, $p = .000$, $\eta^2 = .303$, indicating that overall children scored higher on narrow images of technology ($M = 3.17$, $SD = .44$) than on more broad images of technology ($M = 2.75$, $SD = .52$). However, this main effect was qualified by a significant interaction between time and type of image that showed that during the pretest the difference between narrow ($M = 3.16$, $SD = .52$) and broad images ($M = 2.65$, $SD = .63$) of technology was larger than at the time of the posttest; narrow ($M = 3.20$, $SD = .50$) and broad ($M = 2.85$, $SD = .58$), $F(1, 432) = 17.34$, $p = .000$, $\eta^2 = .039$. However, an additional three-way interaction effect between time, type of image and gender, $F(1, 432) = 11.27$, $p = .001$, $\eta^2 = .025$, indicated that for girls both narrow and broad images increased over time, while boys' narrow images slightly decreased and their broad images of technology increased. As listed in Table 1, the above-described results were found in almost a similar manner in both the experimental and the control conditions and could thus not be ascribed to the company visits.

Attitude toward technology

To investigate the effects of the company visits on children's attitude toward technology, a 2 (experimental vs. control group) × 2 (boys vs. girls) × 2 (time 1 vs. time 2) × 5 (relevance vs. difficulty vs. gender beliefs vs. enjoyment vs. future) repeated measures MANOVA was conducted with condition and gender as between-subjects factors, time as a within-subjects factor, and the five attitude components as multivariate dependent variables. Tests of within-subjects effects revealed a significant main effect of time, $F(1, 320) = 7.66$, $p = .006$, $\eta^2 = .023$. The analysis did not reveal, however, a statistically significant interaction effect between time and condition ($p > .32$). Thus, irrespective of condition, across all attitude components, children scored somewhat higher on the pretest than on the posttest. However, a significant two-way interaction effect between time and attitudes toward technology, $F(4, 1280) = 5.34$, $p = .000$, $\eta^2 = .016$, indicated that the effect of time only occurred in the case of the attitude components of enjoyment and gender beliefs. In the case of enjoyment, univariate F tests showed that children displayed somewhat higher scores at the time of the pretest ($M = 3.09$, $SD = 2.92$) in comparison to the posttest ($M = 2.92$, $SD = .71$), $F(1, 412) = 32.80$, $p = .000$, $\eta^2 = .074$. Additionally, with regard to gender beliefs, children scored higher on the pretest ($M = 2.52$, $SD = .90$) than on the posttest ($M = 2.39$, $SD = .94$), $F(1, 438) = 13.62$, $p = .000$, $\eta^2 = .030$. No statistically significant effects of time were found for the attitude components of relevance ($p > .36$), difficulty ($p > .85$) and future ($p > .11$). Furthermore, no subsequent statistically significant three- or four-way interaction effects with time were found.

With regard to gender, a significant between-subjects main effect was found, $F(1, 320) = 137.40$, $p = .000$, $\eta^2 = .30$, indicating that across all attitude components, mean scores of boys differed substantially from girls' scores. Also, a significant main effect was found on the five attitude components, $F(4, 1280) = 221.98$, $p = .000$, $\eta^2 = .41$. However, these two main effects were qualified by a significant interaction between the different attitudes toward technology and gender, $F(4, 1280) = 39.01$, $p = .000$, $\eta^2 = .11$. As can been seen in Fig. 1, on average, boys scored higher than girls did, but these differences varied across attitude components.

Fig. 1 Mean scores of boys and girls across the five attitude components



Boys ($M = 3.17$, $SD = .58$) indicated to enjoy technology related activities somewhat more than girls did ($M = 2.83$, $SD = .61$), $F(1, 411) = 32.95$, $p = .000$, $\eta^2 = .074$. Boys ($M = 2.43$, $SD = .84$) seemed to be more willing than girls ($M = 1.76$, $SD = .60$) to consider a technology-oriented career, $F(1, 404) = 88{,}34$, $p = .000$, $\eta^2 = .18$. The societal relevance of technology was valued more by boys ($M = 2.86$, $SD = .49$) than by girls ($M = 2.67$, $SD = .47$), $F(1, 413) = 16.56$, $p = .000$, $\eta^2 = .039$. Boys ($M = 1.71$, $SD = .45$) indicated technology to be a more easy subject to understand than girls indicated it to be ($M = 1.87$, $SD = .47$), $F(1, 423) = 12.86$, $p = .000$, $\eta^2 = .029$. Boys ($M = 2.91$, $SD = .80$) held stronger stereotypical beliefs than girls did ($M = 1.97$, $SD = .67$), $F(1, 437) = 176.17$, $p = .000$, $\eta^2 = .29$. No two-way interaction effect was found between time and gender ($p > .95$), nor did a three-way interaction between time, gender and condition reveal significant results ($p > .64$). The two-way interaction between attitudes toward technology and gender was not qualified by any other higher-order interactions with time or condition. In other words, the results presented in Fig. 1 were statistically similar across both conditions and measurement times (see Table 2).

Images of technical competencies

To investigate the effects of the company visits on children's images of technical competencies, a 2 (experimental vs. control group) × 2 (boys vs. girls) × 2 (time 1 vs. time 2) × 2 (narrow vs. broad images) repeated measures MANOVA was conducted with condition and gender as between-subjects factors, time as a within-subjects factor, and the two image components (narrow and broad images) as multivariate dependent variables. Tests of within-subjects effects revealed a significant main effect of time, $F(1, 422) = 8.09$, $p = .005$, $\eta^2 = .19$. The analysis did not reveal, however, a statistically significant interaction effect between time and condition ($p > .21$). These results suggest

Table 2 Mean scores with SDs of boys and girls on their attitudes toward technology

	Experimental		Control	
	Pretest	Posttest	Pretest	Posttest
Relevance				
Boys	2.92 (.50)	2.86 (.58)	2.81 (.49)	2.88 (.56)
Girls	2.70 (.49)	2.67 (.51)	2.71 (.68)	2.63 (.41)
Total	2.80 (.51)	2.76 (.55)	2.76 (.59)	2.75 (.53)
Difficulty				
Boys	1.63 (.52)	1.67 (.49)	1.73 (.47)	1.67 (.45)
Girls	1.97 (.57)	1.97 (.54)	1.78 (.46)	1.76 (.42)
Total	1.80 (.57)	1.82 (.54)	1.75 (.46)	1.71 (.43)
Gender beliefs				
Boys	2.87 (.88)	2.84 (.89)	2.94 (.79)	2.90 (.88)
Girls	2.05 (.77)	1.93 (.78)	2.02 (.71)	1.97 (.73)
Total	2.44 (.92)	2.36 (.95)	2.46 (.88)	2.42 (.93)
Enjoyment				
Boys	3.35 (.54)	3.14 (.69)	3.18 (.61)	3.12 (.66)
Girls	2.93 (.59)	2.73 (.72)	2.89 (.60)	2.79 (.66)
Total	3.13 (.60)	2.93 (.73)	3.03 (.61)	2.95 (.68)
Future				
Boys	2.57 (.95)	2.54 (.98)	2.32 (.79)	2.32 (.84)
Girls	1.70 (.63)	1.82 (.71)	1.81 (.64)	1.88 (.70)
Total	2.12 (.91)	2.16 (.92)	2.05 (.76)	2.09 (.80)

Mean scores (with SDs in parentheses) could range from 1 (strongly disagree) to 4 (strongly agree)

Table 3 Mean scores with standard deviations of boys and girls on narrow and broad images of technical competencies

	Experimental		Control	
	Pretest	Posttest	Pretest	Posttest
Narrow				
Boys	3.12 (.55)	3.05 (.49)	3.11 (.54)	3.07 (.62)
Girls	2.97 (.51)	2.90 (.56)	2.87 (.53)	2.85 (.53)
Total	3.05 (.53)	2.98 (.54)	2.99 (.52)	2.96 (.58)
Broad				
Boys	2.95 (.58)	2.89 (.59)	2.85 (.67)	2.84 (.71)
Girls	2.94 (.50)	2.78 (.52)	2.86 (.59)	2.78 (.58)
Total	2.95 (.53)	2.83 (.56)	2.85 (.63)	2.81 (.65)

Mean scores (with SDs in parentheses) could range from 1 (strongly disagree) to 4 (strongly agree)

that, irrespective of condition, children scored somewhat higher on the pretest than on the posttest (see Table 3 for boys' and girls' narrow and broad image scores). In addition, the main effect of time was not qualified by any other higher-order interactions, indicating that the effect was statistically similar across both conditions, both image types, and gender.

With regard to gender, a significant between-subjects main effect was found, $F(1, 422) = 6.14$, $p = .002$, $\eta^2 = .022$, revealing that boys ($M = 2.99$, $SD = .42$) scored somewhat higher than girls did ($M = 2.87$, $SD = .38$). Tests of within-subjects effects also revealed a significant main effect of type of image, $F(1, 422) = 23.87$, $p = .000$, $\eta^2 = .054$, indicating that children scored somewhat higher on narrow images ($M = 2.99$, $SD = .48$) than on broad images ($M = 2.85$, $SD = .50$). However, these two main effects were qualified by a significant interaction between gender and type of image that showed that for boys the difference between narrow ($M = 3.09$, $SD = .47$) and broad images ($M = 2.89$, $SD = .53$) was somewhat larger than was the case for girls, ($M = 2.90$, $SD = .47$ and $M = 2.82$, $SD = .47$) for girls' narrow and broad images respectively, $F(1, 422) = 7.17$, $p = .008$, $\eta^2 = .017$. No two-way interaction effect was found between condition and type of image ($p > .68$), nor a three-way interaction effect between gender, condition and type of image ($p > .30$).

Images of technical professions

To investigate the effects of the company visits on children's images of technical professions, a 2 (experimental vs. control group) $\times$ 2 (boys vs. girls) $\times$ 2 (time 1 vs. time 2) $\times$ 2 (positive vs. negative images) repeated measures MANOVA was conducted with condition and gender as between-subjects factors, time as a within-subjects factor, and the two image components (positive and negative images) as multivariate dependent variables. Tests of within-subjects effects revealed no significant main effect of time ($p > .06$), suggesting that scores of children did not differ over time (see Table 4 for boys' and girls' positive and negative image scores). In addition, the analysis did not reveal statistically significant interaction effects between time and gender ($p > .09$) nor between time and condition ($p > .54$). However, a statistically significant interaction effect was found between time and type of image, $F(1, 399) = 385.66$, $p = .000$, $\eta^2 = .49$; indicating that, irrespective of condition or gender, children perceived technical professions to be less positive ($M = 2.46$, $SD = .56$) and more negative ($M = 3.11$, $SD = .51$) at the time of the posttest than at the time when the pretest was administered; positive image ($M = 3.16$, $SD = .47$) and negative image ($M = 2.49$, $SD = .59$). This interaction effect was further qualified by a significant three-way interaction between time, type of image and gender, revealing that boys showed somewhat more higher scores in comparison to girls in this regard; $F(1, 399) = 5.59$, $p = .019$, $\eta^2 = .014$. The two-way interaction between time and type of image was not qualified by any other statistically significant three- or four-way interaction effects.

As for gender, a significant between-subjects main effect was found, $F(1, 399) = 24.03$, $p = .000$, $\eta^2 = .057$, indicating that boys ($M = 2.88$, $SD = .34$) scored somewhat higher than girls did ($M = 2.73$, $SD = .30$). Tests of within-subjects effects revealed no significant main effect of type of image ($p > .74$) and did not yield any statistically significant interaction effects. These results indicated that children's scores on type of image did not statistically differ, irrespective of gender and condition.

Influence of technology teaching

Our above-described analyses of the quantitative data gathered from the child-questionnaires showed marginal effects of the company visits on children's images of and attitudes toward technology. In addition, qualitative data were collected through structured interviews with all teachers to investigate potential effects of differences between schools

Table 4 Mean scores with standard deviations of boys and girls on positive and negative images of technical professions

	Experimental		Control	
	Pretest	Posttest	Pretest	Posttest
Positive				
Boys	3.33 (.42)	2.54 (.62)	3.22 (.44)	2.38 (.49)
Girls	3.05 (.42)	2.47 (.53)	3.00 (.53)	2.40 (.58)
Total	3.18 (.44)	2.50 (.57)	3.12 (.50)	2.39 (.54)
Negative				
Boys	2.57 (.62)	3.29 (.47)	2.53 (.61)	3.18 (.48)
Girls	2.47 (.57)	3.02 (.47)	2.38 (.57)	3.00 (.56)
Total	2.51 (.59)	3.15 (.49)	2.46 (.59)	3.09 (.53)

Mean scores (with SDs in parentheses) could range from 1 (strongly disagree) to 4 (strongly agree)

concerning their general technology teaching. In doing so, previous analyses were repeated, including the general level of technology teaching as an extra between-subjects factor. The analysis only revealed only some statistically significant main effects of general technology teaching on the dependent variables and a limited number of interaction effects between technology teaching and the image and attitude components. Due to space constraints, below, we only report on the observed additional statistically significant effects.

Images of technology

To investigate potential additional effects of general technology teaching on children's images of technology, a 2 (experimental vs. control group) × 2 (time 1 vs. time 2) × 2 (boys vs. girls) × 2 (high performing vs. low performing technology teaching) × 2 (narrow vs. broad images) repeated measures MANOVA was conducted with condition, gender and technology teaching as a between-subjects factor, time as a within-subjects factor, and the two image components (narrow and broad images) as multivariate dependent variables. With regard to general technology teaching performance, no significant between-subjects main effect was found ($p > .26$). However, a statistically significant three-way interaction between technology teaching performance, image components and condition was found, $F(1, 428) = 5.52$, $p = .019$, $\eta^2 = .013$. These results revealed that for the experimental condition in particular, across both measurement times, children from high performing schools showed significantly higher scores on the broad image component ($M = 2.85$, $SD = .49$) in comparison to children's scores on the broad image component of low performing schools ($M = 2.69$, $SD = .48$). This score difference was not found for children in the control condition (see Table 5 for the mean scores of children from high and low performing schools on their images of technology).

Attitudes toward technology

To investigate the potential additional effect of general technology teaching on children's attitudes toward technology, a 2 (experimental vs. control group) × 2 (time 1 vs. time 2) × 2 (boys vs. girls) × 2 (high performing vs. low performing technology teaching) × 5 (relevance vs. difficulty vs. gender beliefs vs. enjoyment vs. future) repeated measures MANOVA was conducted with condition, gender, and general technology teaching as a between-

Table 5 Mean scores with standard deviations of children from high and low performing technology teaching schools on their Narrow and Broad images of technology

	Experimental		Control	
	High	Low	High	Low
Narrow	3.12 (.46)	3.22 (.44)	3.20 (.41)	3.15 (.42)
Broad	2.85 (.49)	2.69 (.48)	2.70 (.59)	2.68 (.49)

Mean scores (with SDs in parentheses) could range from 1 (strongly disagree) to 4 (strongly agree)

subjects factor, time as a within-subjects factor, and the five attitude components as multivariate dependent variables. With regard to technology teaching performance, a significant between-subjects main effect was found, $F(1, 316) = 5.88, p = .016, \eta^2 = .018$. However, this main effect was qualified by a significant interaction effect between technology teaching performance and the five attitude components, $F(4, 1264) = 4.082$, $p = .003$, $\eta^2 = .013$, revealing that the effect only occurred in the case of the attitude components of enjoyment, relevance and future (see Table 6). In the case of enjoyment, univariate *F* tests showed that children from high performing schools ($M = 3.07$, $SD = .63$) displayed somewhat higher scores in comparison to children from low performing schools ($M = 2.92$, $SD = .59$), $F(1, 405) = 5.096$, $p = .025$, $\eta^2 = .012$. Additionally, with regard to relevance, children from high performing schools ($M = 2.86$, $SD = .49$) scored higher than children from low performing schools ($M = 2.66$, $SD = .47$), $F(1, 407) = 14.84$, $p = .000$, $\eta^2 = .035$. Concerning future, children from high performing schools ($M = 2.19$, $SD = .85$) scored higher than children from low performing schools ($M = 1.97$, $SD = .72$), $F(1, 398) = 8.16$, $p = .005$, $\eta^2 = .020$. No statistically significant effects of technology teaching performance were found for the attitude components of gender beliefs ($p > .34$) and difficulty ($p > .11$).

Images of technical competencies

To investigate the potential effects of general technology teaching on children's images of technical competencies, a 2 (experimental vs. control group) × 2 (time 1 vs. time 2) × 2 (boys vs. girls) × 2 (high performing vs. low performing technology teaching) × 2 (narrow vs. broad) repeated measures MANOVA was conducted with condition, gender and technology teaching as a between-subjects factor, time as a within-subjects factor, and the two image components as multivariate dependent variables. With regard to technology teaching performance, a significant between-subjects main effect was found, $F(1, 418) = 4.56$, $p = .033$, $\eta^2 = .011$, revealing that children from high performing schools ($M = 2.97$, $SD = .41$) showed a higher average score on both image components compared to children from low performing schools ($M = 2.88$, $SD = .39$). No other statistically significant (interaction) effects were found (see Table 7 for the mean scores of children from high and low performing schools on their images of technical competencies).

Images of technical professions

To investigate the effects of general technology teaching on children's images of technical professions, a 2 (experimental vs. control group) × 2 (time 1 vs. time 2) × 2 (boys vs. girls) × 2 (high performing vs. low performing technology teaching) × 2 (positive vs. negative) repeated measures MANOVA was conducted with condition, gender and

Table 6 Mean scores with standard deviations of children from high and low performing technology teaching schools on their Attitudes toward technology

	Experimental		Control	
	High	Low	High	Low
Relevance	2.89 (.48)	2.66 (.47)	2.81 (.50)	2.66 (.46)
Difficulty	1.80 (.47)	1.83 (.52)	1.70 (.43)	1.84 (.41)
Gender beliefs	2.46 (.86)	2.43 (.88)	2.40 (.99)	2.47 (.74)
Enjoyment	3.11 (.61)	2.97 (.60)	3.02 (.65)	2.87 (.59)
Future	2.23 (.91)	2.02 (.79)	2.13 (.76)	1.92 (.63)

Mean scores (with SDs in parentheses) could range from 1 (strongly disagree) to 4 (strongly agree)

Table 7 Mean scores with standard deviations of children from high and low performing technology teaching schools on their Narrow and Broad images of technical competencies

	Experimental		Control	
	High	Low	High	Low
Narrow	3.06 (.46)	2.94 (.47)	2.96 (.54)	2.99 (.44)
Broad	2.96 (.48)	2.79 (.44)	2.86 (.54)	2.78 (.58)

Mean scores (with SDs in parentheses) could range from 1 (strongly disagree) to 4 (strongly agree)

technology teaching as a between-subjects factor, time as a within-subjects factor, and the two image components as multivariate dependent variables. With regard to technology teaching performance, a significant between-subjects main effect was found, $F(1, 395) = 4.81$, $p = .029$, $\eta^2 = .012$, indicating that children from high performing schools ($M = 2.84$, $SD = .35$) showed a higher average score on both image components in comparison to children from low performing schools ($M = 2.77$, $SD = .30$). No other statistically significant (interaction) effects were found (see Table 8 for the mean scores of children from high and low performing schools on their images of technical professions).

Curricular embedding of the company visits program

Prior to the company visits, teacher interviews were conducted to examine the possible differences between teachers' planned in-school preparations, on-site involvement during the company visits, and their intended follow-up activities after the visits. Unfortunately, however, none of the teachers in the experimental condition met our criteria of satisfactory curriculum embedment. Although this finding corroborates our initial impression of the relatively low commitment and knowledge of teachers with regard to effective company visits, the consistency of the finding was a surprise to us. Based on this finding, we did not perform additional quantitative analyses with level of curricular embedment of the company visits as a grouping variable.

Discussion

The present study was the first to explore whether children's images of and attitudes toward technology, technical competencies and technical professions are affected by

Table 8 Mean scores with standard deviations of children from high and low performing technology teaching schools on their positive and negative images of technical professions

	Experimental		Control	
	High	Low	High	Low
Positive	2.87 (.35)	2.82 (.32)	2.80 (.35)	2.70 (.29)
Negative	2.86 (.40)	2.77 (.39)	2.81 (.42)	2.73 (.37)

Mean scores (with SDs in parentheses) could range from 1 (strongly disagree) to 4 (strongly agree)

technology-oriented company visits as they are presently conducted in their natural context in the Netherlands. A partially previously validated measurement instrument was used to measure children's images and attitudes prior to and after the visits and results were compared to similar measurements of children who did not take part in the visits. Although factor analyses confirmed the hypothesized factor structures with satisfactory factor loadings, some levels of internal consistency for certain subscales of images and attitudes would require improvement in future studies. Nevertheless, we believe the measurement instrument even in its present form may serve as a valuable tool for (1) educators to evaluate and outdoor school programs and (2) researchers, to investigate the effects of similar kinds of company visits and examine possible organizational differences. In addition to the survey instrument, structured interviews were carried out with all teachers prior to the company visits to establish the level of in-school preparation, follow-up activities and teachers' level of involvement during the visits.

As indicated before, at the onset of the study, we were somewhat skeptical about the level of involvement of teachers and the curricular embedment of the company visits–two features that could affect the potential influence of company visits on children's images of and attitudes toward technology and technical professions. The qualitative results of our study showed that our initial reservations were indeed correct and our quantitative results indicated that children's images and attitudes remained mostly unaffected by the company visits. Only a marginal effect of the visits was found in the case of boys who adopted slightly less narrow images and slightly more broad images of technology after the visits. No interaction effects were found with respect to differences in gender, grade level, expected high school entry levels or general technology teaching performance at schools on any of the dependent variables. While we did find that, on average, children from schools that scored higher on general technology teaching held relatively more broad images of and somewhat higher attitudes toward technology in comparison to children from low performing schools, the company visits did not significantly improve upon these scores.

Irrespective of whether children took part in the company visits, results did reveal a slightly *negative* effect of time on children's images and attitudes. This effect was particularly prominent in the case of children's images of technical professions, which showed significantly less positive and more negative images of technical professions over time. A tentative line of reasoning might be that our measurement instrument functioned as a reflection tool that fostered children's typically negative images of technical professions during the time after the pretest. Another tentative explanation could be that all children received their high school entry-level recommendations in the time period between the pretest and posttest. As Dutch teachers and parents generally recommend children to pursue non-technical study paths (because these are believed to hold more promising future career options), these considerations could have unintentionally set children up to depreciate technical professions at the time of the posttest. However, these explanations are speculative and further research should establish whether these effects would be found again in follow-up studies.

In review, our results seem to complement findings of earlier studies that investigated the effects of school visits to science exhibits. Our results confirm the notion that while teachers and on-site educators often advocate the motivating nature of outdoor school activities, the effects of these visits on children's image and attitude development are not necessarily evident (Rohaan et al. 2010; DeWitt and Osborne 2007). Therefore, it is relevant to further examine the particular implementation of the present company visits, especially in light of the theoretical guidelines proposed by Heimlich et al. (2011), in order to arrive at some important recommendations that could enhance the effects of visits to technical companies. As outlined in the introduction of this article, we summarized the guidelines by Heimlich et al. into: (1) familiarizing children with the physical features of the on-site environment prior to their visit, (2) connecting the school visit to the classroom curriculum with preparatory and follow-up activities, and (3) making sure that teachers actively participate during the visit to ensure for ongoing student reflection with regard to the subject matter. In the paragraphs below, we will review the extent to which the present company visits met these guidelines and how this may have prevented positive image and attitude development to take place.

Pre-orientating students

No pre-orientating activities were implemented by any of the participating schools to familiarize children with the physical environment of the companies prior to the visits. Still, since the company visits were part of an annual school project, this year's sixth graders had already participated in the company visits last year and thus were at some level already familiar with most of the companies' facilities. One might expect that differences in grade level would thus have interacted with children's test scores, i.e., that sixth graders had benefitted more from the company visits than the fifth graders who were new to the companies. However, results showed no interaction effects between children's grade level and their image and attitude development over time. Please note that this finding does not exclude the potential value of pre-orientating children before their visit, as it might well be that such preparations would only show to affect children's behavior when implemented just before and not a year prior to the visits.

Connection to curriculum

Prior to this study, the school boards and company representatives stated that the company visits were primarily aimed at (1) improving children's images of and attitudes toward technology, technical professions and their roles as future technology-literate citizens, and (2) inspiring at least some children to pursue technical study paths later on. However, there seemed little connection between these program goals and the actual learning activities that children were engaged in before, during, and after the program. Teachers primarily asked children to create their designs for the school competition and the subsequent exhibition that was organized for parents. While this design assignment may have been valuable in fostering some cognitive learning related to various aspects of design-based inquiry, it does not challenge children's existing images and attitudes about technology or technical professions. In addition, the companies that children visited predominantly featured a stereotypical image of technical work that may have only reinforced children's images and attitudes. Most of the companies in the program appeared to be relatively traditional businesses that promote heavy-duty, repetitious, and male dominant work and it seems unlikely that such companies could improve children's images of and attitudes toward technology and technical professions. The current disconnection between the program goals and children's actual in-school preparations and on-site activities, as well as the absence of any follow-up activities, may well explain to a large extent why the company visits failed to effectively improve children's images and attitudes. We believe that a better connection to the curriculum and program goals could be obtained by (1) selecting companies that represent a broad range of technical professional work, including the development of new technologies that children can relate to, such as modern communication technology or sustainable energy, and (2) consciously discussing, explicating and tackling children's misconceptions and stereotypical beliefs about technology and technical professions during lessons prior to and after the company visits.

Teacher participation

Based on our teacher interviews and on-site observations during the visits, we conclude that teachers were primarily concerned with the logistics of the visits, i.e., whether the visits would run smoothly. Most teachers were unable to clearly define the purpose of the company visits or to reflect on their own role as contributors to the program. Teachers merely provided us with the following generic goal statements: (1) that the company visits were intended to show children what technical professional work entails, (2) that the program should involve parents with children's learning at school, or (3) that the company visits were just part of a fun conclusion of a long and busy school year (similar findings were obtained by: Tal et al. 2005). It seems clear that most teachers were unaware of the actual purpose of the company visits and had no explicit intention to improve children's images of and attitudes toward technology and technical professions. While most teachers indicated to be generally positive about the company visits as a recurring annual school project, a few teachers mentioned to be skeptical about the extent to which the company visits could allow for attitudinal change in their present form. Based on their personal teaching experiences, the latter group of teachers believed that most children in the upper grades of primary school have already settled on their images of and future ambitions toward technology and technical professions. Therefore, the company visits would probably not change children's pre-existing images and attitudes, although they believed they could reaffirm the images and attitudes of those children who were already inclined to pursue a technical career (e.g., because of a favorable technical hobby, friend, parent, etc.). Although conclusive evidence is still lacking on this topic, a growing body of research does seem to suggest that paying attention to children's images of and attitudes toward technology at an earlier age (Grade 4) may have a larger influence on their future study choices than waiting until they have already settled on these attitudes by the end of primary school (e.g., Rohaan et al. 2010).

Practical recommendations

In order to improve the potential attitudinal effects of company visits, we conclude this paper with some practical recommendations. Our recommendations are based in part on the above-described guidelines for visits to science exhibits. However, they also provide some practical guidelines that are specifically tailored to the context of technical companies and they are based on the organizational issues that we identified in the present study.

First of all, we believe that school boards should make sure that children visit a balanced selection of technical oriented companies that includes both traditional and modern businesses of technology (e.g., bio-technology, computer engineering, communication technology, etc.). These businesses should appeal to children's diverse technical interests, talents and professional aspirations and they should aim to promote broad and positive images of technology and technical professions. Secondly, all parties involved in the company visits should be made aware of the goals of the visits and they should all share a commitment to improve children's images and attitudes. With all parties, we do not only mean the school boards and company representatives but also all participating teachers, on-site educators, and parents.

Schools should consider starting the company visits in Grade 4, rather than in Grade 5 or 6 when stereotypical images and attitudes may have already settled in. In addition, the company visits should be organized not near the end but around the middle or beginning of the school year. This will allow for sufficient opportunities to connect the visits to the classroom curriculum with preparatory and follow-up activities. In-school preparations should include (1) pre-orientation activities that aim to familiarize children with the physical environment of the companies (e.g., presenting a slide show with photos of the companies' facilities; showing a brief video tour made by one of the on-site workers, etc.) and (2) identifying and confronting children's misconceptions and stereotypical beliefs about technology and technical professions (e.g., group discussions to identify common misconceptions and stereotypical beliefs, inviting technical professionals from a few of the participating companies to visit the schools to discuss possible misconceptions and to share their personal considerations that led to their current technical professions, and informing children about available study options). As part of these preparations, it also seems important to improve parents' images of and attitudes toward technology and technical professions. Parents function as role models to primary school children and they are likely to have a strong influence children's image and attitude development (either intentionally or unintentionally) through often ill-informed conversations about the relevance of technology, the availability and range of modern day technical professions, and the child's (latent) technical talents and professional ambitions (see also, Ormerod et al. 1989). Parents could be invited to an evening group session at school organized by the teachers and company representatives prior to the visits, where they could be informed about the societal relevance of technology, the future promise of technical professions and the value of the upcoming company visits program to improve their child's images and attitudes.

Finally, teachers should actively evoke student reflection during the company visits by helping children to connect their on-site experiences to the classroom curriculum. The company tour could still include hands-on design activities for the children to work on. However, emphasis should ultimately be on connecting children's design work to nurturing their technical interests, talents and professional ambitions. Apart from a public exhibit of their designs, children could exhibit posters that demonstrate their personal image and attitude improvement with respect to technology and technical professions. These posters could also function as valuable input for follow-up activities at school when children are required to reflect upon their learning experiences.

In sum, the above-described guidelines illustrate an integrated curricular approach that is required to organize company visits that may effectively broaden children's images of and attitudes toward technology and technical professions. Although further research is necessary to test the effects of these guidelines, we believe that they may make children more aware of how their interests in certain societal issues or modern technology relate to technical professions and also to help children to see themselves as being part of a future technological workforce.

Appendix: Questionnaire instrument[1]

See Tables 9, 10, 11 and 12.

Table 9 Items for measuring images of technology

Component	Code	Item
Narrow	N1	Technology is related to computers
	N2	Technology is related to electricity
	N3	Technology is related to using machinery
	N4	Technology is related to using devices
Broad	B1	Technology is related to devising solutions
	B2	Technology is related to designing products
	B3	Technology is related to coming up with new ideas

Response options to the items were 1–4, with 1 labelled 'strongly disagree' and 4 labelled 'strongly agree'

Table 10 Items for measuring attitude toward technology

Subscale	Code	Item
Cognition		
Relevance	R1	Technology is important for our economy
	R2	The Dutch government should spend more money on technology
	R3	Technology has a big impact on people's lives
	R4	Everyone needs technology
	R5	If a nation invests in technology, that nation becomes richer
	R6	Technology makes our lives more comfortable
	R7	Technology adds to the income of the Netherlands
Difficulty	D1	Technology is for smart people only
	D2	I have trouble using technical devices
	D3	Technology is a difficult topic
	D4	I have trouble learning about technology
Gender	G1	Boys often know more about technology than girls
	G2	Boys are better car mechanics than girls
	G3	Boys are better at using computers than girls

[1] The items are translated from Dutch.

Table 10 continued

Subscale	Code	Item
Affect		
Enjoyment	E1	I find technology to be an interesting topic
	E2	It annoys me to repair something myself
	E3	I enjoy designing things
	E4	I enjoy putting things together
	E5	I enjoy learning more about technology
	E6	I enjoy repairing something myself
Behavior		
Future	F1	I would like to have a technical job someday
	F2	I would like to have a future job in engineering
	F3	I would like to pursue a technical study career

Response options to the items were 1–4, with 1 labelled ‘strongly disagree’ and 4 labelled ‘strongly agree’

Table 11 Items for measuring images of technical competencies

Component	Code	Item
Narrow	N1	Technical work requires using machinery
	N2	Technical work requires being handy
	N3	Technical work requires computer skills
Broad	B1	Technical work requires design
	B2	Technical work requires doing inventions
	B3	Technical work requires imagination

Response options to the items were 1–4, with 1 labelled ‘strongly disagree’ and 4 labelled ‘strongly agree’

Table 12 Items for measuring Images of technical professions

Component	Code	Item
Positive	P1	The technical sector offers plenty of jobs
	P2	The technical sector offers much opportunity to earn money
	P3	The technical sector offers much opportunity to become successful
Negative	N1	The technical sector involves work that quickly gets your clothes dirty
	N2	The technical sector involves heavy work
	N3	The technical sector is mostly dominated by men
	N4	The technical sector is not considered in high regard
	N5	The technical sector mostly offers jobs that are boring

Response options to the items were 1–4, with 1 labelled ‘strongly disagree’ and 4 labelled ‘strongly agree’

References

Anderson, D., & Lucas, K. B. (1997). The effectiveness of orienting students to the physical features of a science museum prior to visitation. *Research in Science Education, 27*, 485–495.

Anderson, D., Lucas, K., Ginns, I., & Dierking, L. (2000). Development of knowledge about electricity and magnetism during a visit to a science museum and related post-visit activities. *Science Education, 84*, 658–679.

Anderson, D., Kisiel, J., & Storksdieck, M. (2006). Understanding teachers' perspectives on field trips: Discovering common ground in three countries. *Curator: The Museum Journal, 49*, 365–386.

Bitgood, S. (1989). School field trips: An overview. *Visitor Behavior, 5*(2), 3–6.

Davidson, S. K., Passmore, C., & Anderson, D. (2010). Learning on zoo field trips: The interaction of the agendas and practices of students, teachers, and zoo educators. *Science Education, 94*, 122–141.

De Grip, A. en Smits, W. (red.) (2007). *Technotopics II*. Den Haag, The Netherlands: Platform Bèta Techniek.

de Vries, M. J., van Keulen, H., Peters, S., & Walma van der Molen, J. H. (Eds.). (2011). *Professional development for primary teachers in science and technology. The Dutch VTB-Pro project in an international perspective*. Rotterdam, Boston, Taipei: Sense Publishers.

Dekker, B., Krooneman, P. J., Walma van der Molen, J. H., & van der Wel, J. (2007). *Verbreding Techniek in het Basisonderwijs: Stand van Zaken 2007 (The expansion of technology in primary education: Progress report 2007)*. Amsterdam: Regioplan.

DeWitt, J., & Osborne, J. (2007). Supporting teachers on science-focused school trips: Towards an integrated framework of theory and practice. *International Journal of Science Education, 29*, 685–710.

DeWitt, J., & Storksdieck, M. (2008). A short review of school field trips: Key findings from the past and implications for the future. *Visitor Studies, 11*, 181–197.

Eagly, A., & Chaiken, S. (1993). *The psychology of attitudes*. Belmont, CA: Wadsworth group/Thomson Learning.

Falk, J. H., & Bailing, J. D. (1982). The field trip milieu: Learning and behavior as a function of contextual events. *Journal of Educational Research, 76*, 22–28.

Griffin, J., & Symington, D. (1997). Moving from task-oriented to learning-oriented strategies on school excursions to museums. *Science Education, 81*, 763–779.

Heimlich, J. E., Carlson, S. P., & Storksdieck, M. (2011). Building face, construct, and content validity through use of a modified Delphi: Adapting grounded theory to build an environmental field days observation tool. *Environmental Education Research, 17*, 287–305.

Jarvis, T., & Pell, A. (2002). Effect of the challenger experience on elementary children's attitudes to science. *Journal of Research in Science Teaching, 39*, 979–1000.

Jarvis, T., & Pell, A. (2005). Factors influencing elementary school children's attitudes toward science before, during, and after a visit to the UK National Space Centre. *Journal of Research in Science Teaching, 42*, 53–83.

Knapp, D. (2000). Memorable experiences of a science field trip. *School Science and Mathematics, 100*, 65–72.

Knapp, D. (2007). A longitudinal analysis of an out-of-school science experience. *School Science and Mathematics, 107*, 44–51.

Knapp, D., & Barrie, E. (2001). Content evaluation of an environmental science field trip. *Journal of Science Education and Technology, 10*, 351–357.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development* (Vol. 1). Englewood Cliffs, NJ: Prentice-Hall.

Kubota, C. A., & Olstad, R. G. (1991). Effects of novelty-reducing preparation on exploratory behavior and cognitive learning in a science museum setting. *Journal of Research in Science Teaching, 28*, 225–234.

Martin, W. W., Falk, J. H., & Bailing, J. D. (1981). Environmental effects on learning: The outdoor field trip. *Science Education, 65*, 301–309.

Morag, O., & Tal, T. (2011). Assessing learning in the outdoors with the field trip in natural environments assessing learning in the outdoors with the Field Trip in Natural Environments (FiNE) Framework. *International Journal of Science Education, 34*, 745–777.

OECD/PISA (2006). *Assessing scientific, reading, and mathematical literacy: A framework for PISA 2006*.

Orion, N., & Hofstein, A. (1994). Factors that influence learning during a scientific field trip in a natural environment. *Journal of Research in Science Teaching, 31*, 1097–1119.

Ormerod, M. B., Rutherford, M., & Wood, C. (1989). Relationships between attitudes to science and television viewing among pupils aged 10 to 13+. *Research in Science and Technological Education, 7*, 75–84.

Osborne, J., & Dillon, J. (2008). Science education in Europe: Critical reflections (a report to the Nuffield Foundation). London: the Nuffield Foundation. Retrieved from http://www.pollen-europa.net/pollen dev/ImagesEditor/Nuffieldreport.pdf.

Price, S., & Hein, G. E. (1991). More than a field trip: Science programs for elementary school groups at museums. *International Journal of Science Education, 13*, 505–519.

Ramey-Gassert, L. (1997). Learning science beyond the classroom. *The Elementary School Journal, 97*, 433–450.

Rennie, L. J., & Johnston, D. J. (2004). The nature of learning and its implications for research on learning from museums. *Science Education, 88*, S4–S16.

Rohaan, E. J., Taconis, R., & Jochems, W. M. G. (2010). Reviewing the relations between teachers' knowledge and pupils' attitude in the field of primary technology education. *International Journal of Technology and Design Education, 20*, 15–26.

Salmi, H. (2003). Science centres as learning laboratories: Experiences of Heureka, the Finish Science Centre. *International Journal of Technology Management, 25*, 460–476.

Tai, R. H., Liu, C. Q., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. *Science, 312*, 1143–1145.

Tal, R., Bamberger, Y., & Morag, O. (2005). Guided school visits to natural history museums in Israel: Teachers' roles. *Science Education, 89*, 920–935.

Turner, S., & Ireson, G. (2010). Fifteen pupils' positive approach to primary school science: When does it decline? *Educational Studies, 36*, 119–141.

van Aalderen-Smeets, S. I., Walma van der Molen, J. H., & Asma, L. J. (2012). Primary teachers' attitudes toward science: A new theoretical framework. *Science Education, 96*, 158–182.

van den Berg, E., & van Keulen, v. (2011). A science and technology base for primary teachers. In M. J. de Vries, H. van Keulen, S. Peters, & J. H. Walma van der Molen (Eds.), *Professional development for primary teachers in science and technology. The Dutch VTB-Pro project in an international perspective* (pp. 49–62). Rotterdam, Boston, Taipei: Sense Publishers.

Walma van der Molen, J. H. (2007). *Eindrapportage VTB Attitude Monitor. De ontwikkeling van een attitude-instrument op het gebied van wetenschap en techniek voor leerlingen in het basisonderwijs* (Final Report VTB Attitude Monitor. The development of an attitude measurement instrument in the field of science and technology for primary school children). Den Haag, The Netherlands: Platform Bèta Techniek.

Walma van der Molen, J. H., Aalderen-Smeets, van, S. I., & Asma, L. J. F. (2010). Teaching science and technology at primary school level: Theoretical and practical considerations for primary school teachers' professional training. In: *Proceedings of the IOSTE symposium on science and technology education* (Vol. 14).

Young, B. J., & Kellogg, T. (1993). Science attitudes and preparation of preservice elementary teachers. *Science Education, 77*, 279–291.

Zoldosova, K., & Prokop, P. (2006). Education in the field influences children's ideas and interest toward science. *Journal of Science Education and Technology, 15(3–4)*, 304–313.