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Students attitudes towards technology

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Abstract Technology is more present than ever. Young people are interested in technological products, but their opinions on education and careers in technology are not particularly positive (Johansson in Mathematics, science & technology education report. European Round Table of Industrials, Brussel, 2009). If we want to stimulate students' attitudes towards technology we need to have a better understanding of the factors which determine attitudes. Different studies (e.g. Volk and Yip in Int J Technol Des Educ 9:57–71, 1999; Jones et al. in Sci Educ 84(2):180–192, 2000; George in Int J Sci Educ 28(6):571–589, 2006; Salminen-Karlsson in Int J Sci Educ 29(8):1019–1033, 2007) have proven that students' characteristics correlate with their attitudes towards technology. As these studies often focus on effects on a specific aspect of attitude; the total effect cannot be interpreted correctly because attitude is a multi-dimensional concept (Osborne et al. in Int J Sci Educ 23(5):441–467, 2003). This study focuses upon six aspects of attitude namely: interest, career aspirations, boredom, consequences, difficulty and gender issues. Therefore a multivariate model has been set up. This allows us to answer the main research question: What is the predictive power of students' characteristics with regard to aspects of their attitudes towards technology? The revalidated version of the Pupils Attitude Towards Technology instrument (Ardies et al. in Des Technol Educ 18(1):8–19, 2013) was used in a large (n = 2,973) scale investigation of 12–14 year old students (Grade 1 and Grade 2 of secondary education). Given the multilevel nature of the data and that students are allocated to specific teachers, we analysed the data with a multivariate multilevel approach. The results of the study show a decline in interest in technology from the first to the second grade of secondary education. This finding appears to be stronger for girls. Interest in technology is significantly positively related to the amount of time that technology is

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taught for, as well as to the teacher. Parents have a positive influence on several aspects of attitude to technology when mothers and/or fathers have a profession related to technology. Equally, the presence of technological toys at home is a significantly positive characteristic. As the results confirmed previous, fragmented studies in related disciplines like science education, this study contributes to the wider body of knowledge concerning students' attitudes towards technology and how this can be investigated.

Keywords Technology education · Attitude · Secondary education · Multilevel analysis

Introduction

Technology is more present than ever. Young people are interested in technological products, but their opinions about education and careers in technology are not particularly positive (Johansson 2009). In a recent study on students' interest in Science and Technology Studies (2008), the Organisation for Economic Cooperation and Development (OECD), concluded that although absolute numbers of Science and Technology students have been increasing, the relative share of these students has been decreasing during the last decades. According to the Relevance of Science Education (ROSE) study (Schreiner and Sjøberg 2004), if students are asked why they didn't choose a STEM oriented subject it appears that many were not interested in science and technology at school. This research also found that students in western countries are more sceptical about technology than adults.

When Osborne, Simon and Collins (2003) write that students' attitudes towards studying science suggest there is an "urgent agenda for research", we assume that this is also the case for technology because science and technology are related and have a number of similarities. Research into students' interest in technology is apparently even smaller than in science (Van den Berghe and De Martelaere 2012). Similar findings are described in a report from the Round Table of Industrials (Johansson 2009), stating that although technology education is more relevant today than ever before, the public's attitude to studying technology or having a technical job is not positive. Often, this lack of enthusiasm is a result of experiences of science and technology at school, since these experiences shape the publics' conceptions of science and technology (de Vries 2005; Osborne and Collins 2000; Stein and McRobbie 1997). This was confirmed by the study of Lindahl (2007), who found that future interests in science and a technology related careers are generally formed before the age of 14.

Given the growing attention to the role that attitudes can play, and given the fact that future interest is formed before the age of 14, knowing which factors influence students' attitudes towards technology between the age of 12 and 14 is important to enable a better understanding of how the attitudes are formed.

Moreover, insight into factors influencing the attitudes of students towards technology may inform future programs on how the number of students in technology related study programmes and consequently in these jobs can be increased. When interrogating the relevant literature on this topic, we found that a number of studies are extant (see theoretical background section) but they are often fragmented and focus on one aspect of attitude at a time (e.g. Mammes 2004; Mawson 2010). Attitudes towards technology, however, consist of different sub-aspects (Osborne et al. 2003) and research focussing on these different aspects in an integrated manner is needed in order to provide insights into how attitudes are formed. Research looking at a broad scope of attitudes to technology is nevertheless lacking. In the present study we aim to provide better insights into the importance of different student characteristics on different aspects of attitude towards technology. This with respect to the differences between students and different groups of students. Regarding the different problems suggested above, a literature overview is given in the following paragraph.

Theoretical background

First, a brief background will be provided on the concept of 'attitude'. Next, we will look more deeply into aspects of attitude specific to technology education. We will give an overview of up-to-date research on these topics and we describe the need for additional studies in this field.

Different sub-factors of attitude

Reviews of studies of attitudes towards science (Osborne et al. 2003; van Aalderen-Smeets and Walma van der Molen 2013) and towards science and technology (van Aalderen-Smeets et al. 2012) note that the concept of attitude towards science and technology cannot be conceptualized as a single unitary construct as it is multidimensional. This multidimensionality can be found when putting together a number of studies of the last 20 years. A broad variety of aspects of attitude can be described.

Enthusiasm, *enjoyment* or its antagonist *boredom* has been studied in various empirical investigations (e.g. Bame et al. 1993; Hauttekeete 2007; Kind et al. 2007; Pell and Jarvis 2001). Also *interest* in the subject is a common aspect that appears in research in this field (e.g. Becker and Maunsaiyat 2002; Lyons and Quinn 2010; Murphy and Beggs 2005; van den Broek et al. 2010; Yu et al. 2005). Currently, internationally there is a decreasing workforce in the technological domain. Students' *career aspirations* and future intentions with regard to technology and science have become part of the research agenda (Francis and Greer 1999; Lindahl 2007; Venkatesh and Davis 2000; Yu et al. 2012). Other factors that appear in different studies are perceived *difficulty* of science and technology (e.g. van den Broek et al. 2010; Angell et al. 2004; Osborne and Collins 2001; Tytler et al. 2008) and the beliefs one has regarding the *consequences* of science and technology (e.g. Bame et al. 1993; Schreiner and Sjøberg 2004).

All these aspects or dimensions of attitude are also present in the framework made by de Vries (1988) specifically about attitudes towards technology. De Vries defined five different dimensions based on his own research and parallel international research (Raat et al. 1988):

- aspirations for a technological career as a measure of the extent to which a student has the ambition to start a study with a technological component in it, or wants to have a future job related to technology.
- interest in technology as a measure for ones feeling of wanting to know or learn about technology.
- perceived difficulty of technology is a measure that indicates how difficult a student finds technology as a subject at school.
- perceived consequences of technology is a measure for ones feelings about the positive (or negative) effects on the environment and society.

- technology as a subject for both genders indicates the measure to which students find both boys and girls capable to study and/or work in a technological domain compared to technology as a subject for only boys.

Predictive characteristics

As research on the dimensions of attitudes towards technology is not very extensive, we will also take a look at similar research in the domain of science and in the broader field of STEM. Research on the different sub-factors of attitudes toward technology reveals a number of characteristics that can have a significant influence. The different studies found on these topics are summarized in Table 1. This includes the different dimensions of attitude as described by de Vries (1988): interest in technology, aspirations for a technological career, perceived consequences of technology, perceived difficulty of technology and the students' perception of technology as a subject suitable to both genders. Table 1 is set up with the different attitudes as the rows and the predictive characteristics found in the literature as the columns. The studies, presented in the cells, focused on Technology (T), Science (S) or the broader domain of Science Technology Engineering and Mathematics (STEM).

Subsequently, a more detailed description is given on each of the predictive characteristics, including interaction effects where and when present.

Differences between boys and girls, at different ages

Because the differences in attitude towards technology between boys and girls often correlate with their age, research focussing on both these factors will be described. Many studies compare the attitude of girls and boys towards science and technology (e.g., Schreiner and Sjøberg 2004; Volk and Yip 1999). In this research it is shown that in general boys are more interested in science than girls (Beinke and Richter 1993; Gardner 1998). Research on attitudes towards a career in science finds the same pattern: girls tend to have a less positive attitude towards a career in science (e.g. Cannon and Simpson 1985; Simpson and Oliver 1985; Weinburgh 1995) and girls also tend to regard science as a difficult subject (e.g. Jones et al. 2000). For technology the same pattern is seen, girls are more negative toward technology (de Vries 2005 and Mawson 2010). Rees and Noyes (2007) also mentioned in their study that male students especially have positive attitudes towards technology. More specifically, Kotte (1992) and Catsambis (1995) show that the differences between boys and girls are related to age. They show that there is an increase in the perceived utility of technology, for boys between the ages of 10 and 14 years old, resulting in differences between boys and girls from the age of 14. This is concordant with findings reported in recent research from Murphy and Beggs (2005), Pell and Jarvis (2001) and Haworth et al. (2008). They concluded that at the age of 10 interest in STEM does not differ between boys and girls and is rather high. From that age on the interest starts to decline, especially for girls (Hoffman 2002). Barmby et al. (2008) reviewed the relationship between age and attitudes towards science and technology. Based on this review they concluded that there is consensus on the steady decline in students' attitude towards science over time, particularly in secondary education. This is consistent with the findings of Georg (2006) and Simpson and Oliver (1990). In the review of Barmby et al. (2008) boys are generally found to be more positive than girls and with a less negative trend in the

Table 1 Overview of studies on the five dimensions of students' attitudes towards science and technology

	Boys versus girls	Age	Toys	Parents
Career aspirations	(T) Cannon and Simpson (1985) (T) Simpson and Oliver (1985) (T) Weinburgh (1995) (T) Rasinen et al. (2009) (T) Volk and Yip (1999)			
Interest in technology at school	(S) Beinke and Richter (1993) (S) Gardner (1998) (T) de Vries (2005) (T) Mawson (2010) (STEM) Hoffman (2002) (S) Otto (1991) (T) Rasinen et al. (2009) (T) Mammes (2004) (T) Rees and Noyens (2007)	(STEM) Murphy and Beggs (2005) (STEM) Pell and Jarvis (2001) (STEM) Haworth et al. (2008) (STEM) Hoffman (2002) (S) Barmby et al. (2008) (S) George (2006) (S) Simpson and Oliver (1990)	(T) Mammes (2004) (T) Baumert and Geiser (1996) (T) Bame et al. (1993)	(S) George (2006) (S) Schibeci (1989) (S) Talton and Simpson (1987) (S) George and Kaplan (1998) (S) Otto (1991) (S) Beaton et al. (1996)
Perceived consequences of technology	(T) Kotte (1992) (T) Catsambis (1995) (STEM) Barkatsas et al. (2009)	(T) Kotte (1992) (T) Catsambis (1995)		
Perceived difficulty	(T) Jones et al. (2000)			
Technology as a subject for both genders	(T) Rasinen et al. (2009) (T) Salminen-Karlsson (2007)		(T) Rasinen et al. (2009) (T) Salminen-Karlsson (2007)	

T technology, *S* science, *STEM* science, technology, engineering and mathematics development of their attitude. However, as Mullis et al. (2004) point out, these findings cannot be generalized without caution, since results differ from country to country.

Presence of technological toys

Gender differences may correlate with the presence of and the amount of actual play with technological toys. Technical toys are in the present paper referred to as construction toys like LEGO© etc. Mammes (2004) suggests that girls cannot build a relationship with technology which can serve to promote their interest in technological careers and activities, because they have less experience than boys in playing with technological toys and are also significantly less often inclined to help to repair things or to engage with technology. Baumert and Geiser (1996) found that at the age of 10 a significantly different approach to technological objects is manifest. Bame et al. (1993) found that the presence of technological toys at home showed a significantly positive correlation with different dimensions of attitude. Rasinen et al. (2009) and Salminen-Karlsson (2007) point out that stereotypical ideas concerning technology—it is a male profession only for example—are already stimulated at primary school age by giving pupils gender-specific toys.

Parental characteristics

Some studies have shown that parental involvement and attitudes are often correlated with students' attitudes towards science (George 2000; Schibeci 1989; Talton and Simpson 1987; George and Kaplan 1998). Otto (1991) found that mothers in particular view science as unsuitable for females, thereby contributing to their daughters' negative attitude towards science. The opinions of eighth graders in the Third International Mathematics and Science Study (TIMSS) were found to correlate with their mother's opinions of the importance of doing well in science (Beaton et al. 1996). George (2006), however, found that the influence of the parent variable (pushing their children) on attitude was very small and statistically non-significant.

The importance of context

Educational research is far from easy because of the importance of context. Assuring that the myriad variables are well understood is harder than in studies which focus on the regularities of nature across contexts. Acknowledging that the context is of such importance in educational research because of the interactions that abound (Berliner 2002), we will give a detailed description of the educational context of our study.

A meaningful case

Flanders is the, mainly Dutch speaking, northern part of Belgium. It has a well-developed framework for technological literacy called TOS21 (Technology at School in the 21st century) (Moens 2008), which is based on and comparable to international standards and frameworks (e.g., the ITEEA Standards (ITEA 2003)). TOS21 defines standards for all students from pre-kindergarten to grade 12. We focus on the first two grades of general secondary education because in these grades, in Flanders, technology lessons have a substantial place in the curriculum: all students take technology lessons for 2 h a week. Teachers have ample autonomy with regard to what they teach and how they maintain standards. This emphasizes the importance of the role and the influence of the teacher.

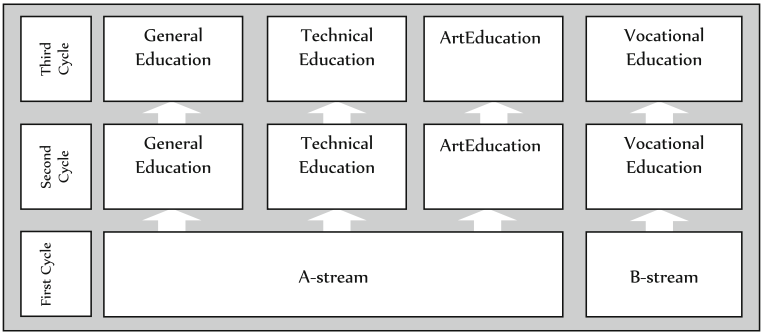


Fig. 1 Structure of secondary education in Flanders

Secondary education in Flanders has a uniform structure. Students enter the first of six grades in secondary education at the age of 12–13. The grades are grouped into three cycles of two grades, as shown in Fig. 1. The first cycle (ISCED-level 2) is comprehensive. In this cycle most students follow a general two-year track, called the A-stream. This stream is continued with two cycles where students can choose between comprehensive, technological or artistic education. The A-stream prepares students for higher education. There is also a B-stream that prepares students for vocational studies, with a different curriculum. Schools are relatively free in the way they organize the teaching and learning process at the classroom and school level.

This study focuses on both grades of the A-stream. Students take a mandatory curriculum of 27 h a week including 2 h of technology classes. Technology attainment goals are to be achieved by all students. Students also take elective classes for 5 h a week. They can choose from 15 packages, such as ‘Latin’, ‘Modern science’, ‘Mechanics and electricity’, ‘Industrial science’ and ‘Construction and Wood’. We hypothesise that students’ choice between a technological or a non-technological package may correlate with their attitude towards technology.

Research questions

The review of the literature on factors influencing attitudes towards science and technology demonstrates that the majority of the studies do not focus specifically on the different dimensions of attitudes towards technology. This is emphasized by de Vries (1988) in his conceptual definition of attitudes towards technology. Given that scholars agree that attitudes are formed between the ages of 12 and 14, we focus in this study on the attitudes towards technology of students of this age. Moreover, we investigate, in an integrated way, the relationships between the student’s characteristics and the dimensions that underlie the construct of attitude. The main research question driving our study is as follows:

1. What is the predictive power of students’ characteristics on all sub-factors of attitudes towards technology in the first grades of general secondary education?

As previous studies have shown some specific tendencies, we will also assess four specific questions about interaction effects. The first two concern aspects of students’ development during their progression through the educational system.

2ab. Do students who take technological or non-technological curriculum option classes differ with respect to their evolution in attitudes towards technology between the first and second grade?
2b. Is there a difference between boys and girls in first and second grade with respect to the evolution in attitudes towards technology?

Students not only develop different through their education. Also other characteristics, like the presence of technological toys or the technological nature of the job of the mother can have a stimulating effect on students' attitudes as described in the theoretical background. Two questions concerning these specific interaction effects that occur are:

3a. Is the predictive power of the presence of technological toys at home the same for boys and girls concerning their attitudes towards technology?
3b. Is the predictive power of the technological nature of the job of the mother the same for boys and girls with respect to the sub-factor of attitudes toward technological career aspirations and the sub-factor on beliefs about gender differences?

Design and methodology

In this section we first describe the sample including a descriptive overview of the data. Secondly the questionnaire used [Pupils Attitude Towards Technology (PATT)] will be described. Then the methodology will be explained.

Sample

Flanders has approximately 200,000 students in the first two grades of secondary education. Based on the rules of thumb introduced in Cohen et al. (2007), a sample size of 1,826 respondents is required in order to reach a confidence level of 99 %. In order to achieve this we used a stage sampling method. First, a number of schools were contacted to invite their participation in this study. Schools were selected on the basis of their location, size, whether they are a public or a private school and whether they have a technological or non-technological orientation in the higher grades. Subsequently, in the selected schools, technology teachers were asked to participate and finally specific classes were selected to participate. Participating students were asked to fill in web-based questionnaire. Students completed the online questionnaire during class on school computers after the first trimester.

Seventeen Flemish secondary schools participated in this research. The total number of responding students was 2,973, more or less equally distributed over both genders and the first and second grade (Table 2). Two-thirds of all students stated that they had technological toys (e.g. Lego, Knex) at home; 56 % of these were boys.

Only a few parents had an International Standard Classification of Education (ISCED) level lower than 4 (no secondary education qualification). In order to have sufficient analytical power we used only two levels in the factor indicating parental educational level, capturing ISCED levels 1–4, non tertiary education, into one group and parents with a higher education degree (ISCED level 5 or higher) in a second group.

For the job description we used a scale with two options in which students could indicate to what extent their father's and mother's occupation has something to do with technology. A summary of these data can be found in Table 2.

Table 2 Description of the frequency of all student, parent and curriculum characteristics

Variable	Category	Absolute number (n)	Relative number (%)
Gender	Boys	1,370	46.1
	Girls	1,603	54.9
Grade	1st	1,439	48.4
	2nd	1,534	51.6
Curriculum options	Technology orientated	237	8
	Non-technology orientated	2,661	79.5
	Missing	75	2.5
Diploma Father	ISCED <5	1,301	43.8
	ISCED $\geq$5	1,502	50.5
	Missing	170	5.7
Diploma Mother	ISCED <5	1,171	39.4
	ISCED $\geq$5	1,654	55.6
	Missing	148	5.0
Job Father has something to do with technology	Nothing—a little	1,384	46.6
	Some—a lot	1,332	44.8
	Missing	257	8.6
Job Mother has something to do with technology	Nothing—a little	2,268	76.3
	Some—a lot	366	12.3
	Missing	339	11.4
Technological toys	Yes	1,044	35.1
	No	1,888	63.5
	Missing	41	1.4

Instrument

The questionnaire consisted of two groups of questions. The first part focused on the background variables of the student (gender, student grade, curriculum, the presence of technological toys at home, the educational level and professions of the parents). The second part was the revalidated PATT-SQ survey (Raat et al. 1988; Ardies et al. 2013), which contains 25 five point Likert-scale questions which measure six factors of attitude towards technology: interest in technology, boredom, perceived difficulty of technology, technological career aspirations, perceived consequences of technology and beliefs about gender differences. Table 3 contains the reliability estimates as reported by Ardies et al. (2013) and example items.

Analyses

In most studies, the factors involved are studied in isolation without taking into consideration the highly complex situation that occurs when they interact. Barmby et al. (2008) point out that it is important in attitude research to assess the combined effects of variables. Previous research (Ardies et al. 2013) indicated that the sub-factors career aspirations, interest and boredom are highly correlated. In order to take these correlations into account

Table 3 Factors of attitude towards technology

Sub-factor	α	# items	Example Item
Technological career aspirations	.92	4	I will probably choose a job in technology
Interest in technology	.84	6	If there was a school club about technology I would certainly join it
Boredom with technology	.81	4	I think machines are boring
Perceived consequences of technology	.72	4	Technology makes everything work better
Perceived difficulty of technology	.64	4	Technology is only for smart people
Beliefs about gender differences	.82	3	Boys are more capable of doing technological jobs than girls

when performing statistical analyses, scholars (e.g. De Maeyer et al. 2010) emphasize the necessity of using a multivariate analysis: a statistical model that allows analyses of multiple dependent variables in one analysis. Hence, a multivariate design in which all sub-factors are modeled simultaneously is essential to interpret the effects correctly. We will use a multivariate analysis in which all dependent variables are included in the model. Given that the data has a nested structure because students are allocated to particular teachers, it is most appropriate to rely on multilevel analysis rather than simple regression analysis (Hox 2010; Goldstein 2011). In a multilevel model it is possible to model the variation between students and the variances between groups of students (e.g. classes, teachers). In our analyses we distinguish between two levels: the first level is the student level and the second level is the teacher level. The variances at level one allow us to describe the amount of the differences between the individual students. Variances at the second level give an impression of the impact of teachers on individual attitudes of students.

Our multivariate multilevel analyses will be set up in three steps. First, in a null model, we explore the variances between both individual students and between teachers for all six factors of attitude measured with the PATT-SQ instrument (Ardies et al. 2013). If both levels demonstrate a significant part of the variance we retain the multilevel structure. In the second step, the main effects of the student characteristics were added (Model 1a): technological or non-technological options in the curriculum of students, grade, gender, the presence of technological toys at home, the educational level and job characteristics of father and mother. This model allows us to draw conclusions as to the main effects of the students' characteristics. Finally, we will model the interaction effects that are mentioned in the literature and research questions in separate models in order to answer the research question (2a, 2b, 3a, 3b).

- Model 2a: The interaction effects of technological or non-technological curriculum option and grade.
- Model 2b: The interaction effects of gender and grade.
- Model 3a: The interaction effects of technological toys and gender.
- Model 3b: The job of the mother (as a role-model) and gender.

Multilevel analyses were conducted with MLwiN Version 2.02 (Rasbash et al. 2005).

Table 4 Parameter estimates (Est.), standard errors (SE) and intraclass-correlations (ICC) for the variances in the random part of the null model

Sub factors of attitude	Variance between students		Variance between teachers		
	Est.	SE	Est.	SE	ICC
Career	0.781	0.023*	0.338	0.078*	0.30
Interest	0.837	0.025*	0.199	0.049*	0.19
Boredom	0.884	0.027*	0.106	0.028*	0.11
Consequences	0.904	0.027*	0.057	0.017*	0.06
Difficulty	0.969	0.029*	0.011	0.006*	0.01
Gender	0.936	0.028*	0.060	0.018*	0.06

* $p < .05$

Results

This section has three main parts. First, the null model is presented to emphasize the indications of the multilevel analysis. The second part shows the results of the multivariate analysis. To increase the readability the results on the attitudes are presented in Table 5. The interaction effects are measured in different models, as described above although displayed in Table 6. The interpretations of both these tables is comprehended by attitude to elucidate the results.

The third part of this section summarizes the significant effects of the characteristics on the six sub factors. This overview allows us to investigate the data for similarities.

Model 0

In the null model (Table 4) the necessity of the multilevel approach is tested. None of the independent variables are included, only the multilevel structure is present. All attitude variables are standardized.

For all six different sub factors of attitude towards technology significant variance at the teacher level is found. The smallest variance at teacher level is detected for the sub factor perception of difficulty in technology. For four factors 6–19 % of the total variance is due to teachers (see ICC). Without including any control variables, the variance with respect to career aspirations is for 30 % explained by the teacher level. Given the significant variances at the teacher level a multilevel model is justifiable and therefore we continue with the use of a multilevel analysis in the further analyses. The results of the complete model will be explained in the next section of the results.

The complete model and the interaction models

In Table 5 we primarily provide an answer to the first research question considering the predictive power of student characteristics' to all sub-factors of attitudes towards technology. The predictive power of each of the student characteristics is analysed in the complete model, which includes all variables.

The models M2a&b and 3a&b refer to the research questions about differential effects.

Table 5 Overall effects of the predictive characteristics on students attitudes

	Career	SE	Interest	SE	Boredom	SE	Conseq.	SE	Difficulty	SE	Gender	SE
Intercept	−.570	.062*	−.329	.069*	−.356	.060*	−.204	.069*	−.164	.066*	.343	.063*
Boy	.472	.041*	.479	.044*	.414	.045*	.014	.047	.074	.050	−.565	.048*
Techn. Opt.	.968	.088*	.538	.096*	.378	.089*	.356	.099*	.021	.097	−.045	.094
Toys at home	.347	.041*	.369	.043*	.281	.046*	.241	.047*	.175	.050*	.108	.048*
Grade_2	−.109	.045*	−.306	.049*	−.214	.045*	−.101	.051*	.004	.050	−.171	.048*
High edu Fa	.051	.045	.029	.048	.022	.050	.010	.052	.079	.055	−.063	.053
High edu Mo	−.111	.046*	−.112	.049*	−.041	.051	.013	.053	−.058	.056	−.020	.054
Tech Job Fa	.224	.039*	.122	.041*	.131	.043*	.143	.044*	.085	.047	−.057	.045
Tech Job Mo	.314	.054*	.181	.058*	.233	.061*	.031	.062	−.046	.066	.162	.064*

* $p < .05$

- M2a describes the effect of being a student in second grade taking technological curriculum option.
- M2b describes the effect of being a boy in second grade.
- M3a describes the effect of technological toys on boys.
- M3b describes the effect of mothers with a technological job on boys.

Student characteristics that do not have any significant influence in the first model (M1) are not included in the models. To determine whether these models are significant improvements, a model 1a (not displayed in the tables) was made. This model is equal to Model 1 without insignificant direct effects of variables. Models M2a&b and 3a&b were all significantly better than model 1 ($\chi^2 < .05$ for -2LL tests). This indicates that the inclusion of the interaction effects makes the model more concordant with the reality. The intercept of all models refers to a girl in the first grade of secondary education who has a non-technologically profiled curriculum and does not have technological toys at home.

The predictive power of students' characteristics on all six sub-factors of attitudes towards technology in secondary education is described in detail below, together with the interaction effects about the grade and the gender of the students for each sub-factor.

Career aspirations

When it comes to the students and their career aspirations in the null model (Table 4), 30 % of the variance between students was situated on the teacher level. Including the technological or non-technological elective classes (Table 5), although <30 %, 6 % of the variance is still at the teacher level. This indicates that a large proportion of the explained variance at the teacher level is due to the optional curriculum package students choose, but not all of it. For the interaction effect between grade and curriculum, we notice a very strong positive effect: students who take technological curriculum options are more certain in their choice of a technological career in future than their peers in non-technological curriculum option. Students with a non-technological curriculum option are even less interested in a technological career after the second grade with mandatory technological education. All variables, except the educational level of the father, have a significant effect on students' career aspirations. Both the gender of the students and the presence of the elective technological option in their curriculum have a large significant correlation. When mothers have a technological job their children, both boys and girls, are more likely to aspire a technological career. This effect is not stronger for girls than for boys (Table 6). We also note that mother having obtained a higher education degree (ISCED 5 or 6) has a significant negative effect on students' technological career aspirations. The presence of technological toys at home is a good predictor for aspirations to a technological career, both for boys and girls, but the effect is significantly stronger for boys (Table 6).

Interest

There is a significant interaction effect between Grade and Technological Option (Table 5). Second grade students have a significantly lower interest in technology than first grade students. However, students who take technological curriculum option are more interested in technology than those who do not choose these classes and their interest increases from grade 1 to grade 2, as shown in Figs. 2 and 3. This positive effect, however, does not compensate for the overall decrease with time. The decline of interest is strongest for girls as shown in Table 5 and Fig. 4).

Table 6 Interaction effects on students attitudes

	Career	SE	Interest	SE	Boredom	SE	Conseq.	SE	Difficulty	SE	Gender	SE
Interaction effects												
G2 * Tech. Opt.	.777	.166*	.481	.182*	−.356	.060*	.448	.182*	.116	.128	−.150	.131
G2 * Boy	.056	.075	.211	.080*	.181	.083*	−.013	.058	−.106	.064	.058	.085
Toys * Boy	.151	.081*	.133	.086	.237	.091*	.023	.054	.220	.091*	−.066	.093
T Job Mo. * Boy	−.140	.110	−.086	.112	−.040	.118	.012	.088	−.109	.094	−.142	.119

* $p < .05$

Fig. 2 Difference between first and second grades in interest. The *solid line* represents a technological profile, the *dashed line* a non-technological curriculum option

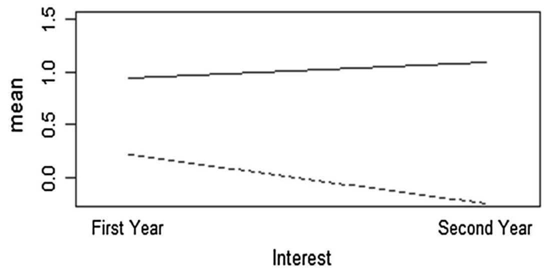
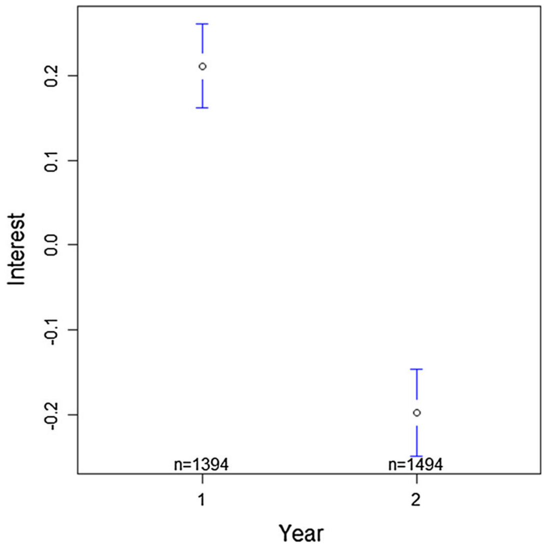


Fig. 3 Differences in interest between first grade and second grade, with a 95 % reliability interval



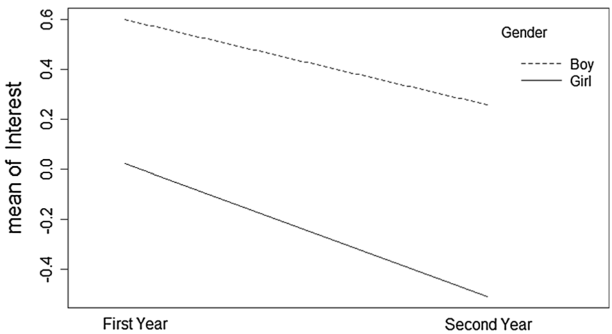
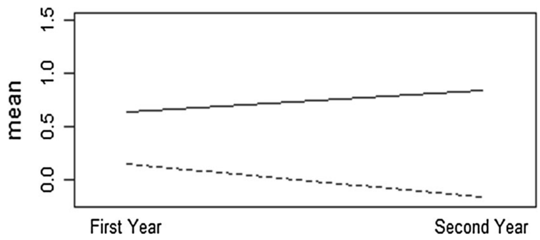


Fig. 4 Plot of the difference in interest between girls and boys in first and second grade

Toys have a significantly positive correlation with interest (Table 5). The effect of the presence of toys at home is the same for boys and girls (Table 6). Highly educated mothers have a small negative impact on interest in technology (Table 5). Students who indicate that their parents have a technology related job are a little more interested in technology than those who did not (Table 6). 7 % of the differences between students' interest in technology can be attributed to their teacher.

Fig. 5 Graphic of the difference in boredom level between students in a technological (*solid line*) and non-technological (*dashed line*) curriculum option of the first and second grade



Boredom

As boredom is a negative psychological tendency, all results are inverted from positive to negative and vice versa in order to facilitate the comparison with other sub factors. In the items on boredom, technology is presented as being dull, boring, tedious or nerve-wracking.

The effects of different parameters are similar to their effects on interest but less explicit. Educational level of the mother has no significant influence (Table 5). Girls are more anxious about technology than boys and this aspect increases from grade 1 to grade 2 than for boys (Table 6, M1c). Overall, second graders are more anxious with technology than first graders, except for students engaged in technological study (Table 6, M1b; Fig. 5).

There is a curriculum effect: boys and girls who choose technological curriculum option are less bored by technology (Table 5). Girls without technological toys are far more anxious than boys (Table 6). Almost all (98.7 %) of this variance is explained on the student level.

Perception of consequences

There is no difference between boys and girls regarding the positive or negative assessment of the impact of technology (Table 5). Table 5 also shows that the educational level of the parents has a significant influence. There is a positive effect on perceptions of the consequences of technology on students' choices regarding a technological curriculum option (Table 5).

Second grade students who have chosen a non-technological curriculum option perceive the consequences of technology as significantly more negative (Table 5; Fig. 6). Students who have chosen technological curriculum option however show a more positive attitude. (Table 6, Fig. 6). The overall evolution of consequences from the first to the second year is slightly negative (Table 5). Technological toys on the other hand have a positive effect on perceptions of the consequences of technology (Table 5).

Perceived difficulty

The perceived difficulty of technology is equal for all students. Only students with technological toys at home find technology less difficult than their peers. When assessing the interaction effect (Table 5), this effect appears to be significantly stronger for boys than for girls (Table 6). When the interaction effect is included, the effects of gender and toys described previously disappears; only boys with technological toys find technology at school significantly less difficult. The level 'teacher' does not explain any variance in perceived difficulty of technology.

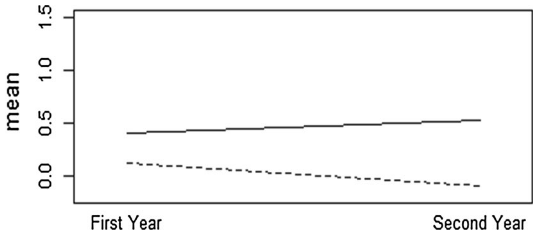


Fig. 6 Plot of the difference in positive attitude towards the consequences of technology between students in a technological (*solid line*) and non-technological (*dashed line*) option of the first and second grade

Beliefs about gender differences

Students' attitude towards technology and by extension towards technological careers as being equally suitable for both boys and girls is predetermined by the students' gender. Girls are more positive about the idea that technology is gender-neutral and this effect is strong (Table 5). According to the same Table 5 students in the second grade find technology less suitable for both genders than first graders. Apparently, an extra year with mandatory technology classes leads to a more stereotyped vision of technology and gender for both girls and boys (Table 6). Students who have technological toys at home and who have a mother who has a technological job have a more neutral opinion (Table 5). Boys' perceptions do not differ from those of girls if their mother has a job that involves technology (Table 6).

Overview of the results

Table 7 summarizes the significant positive and negative effects of different student characteristics are displayed for each of the sub-factors of attitude.

In conclusion, we see that the presence of technological toys at home has a significant positive correlation with all sub factors. When it comes to career aspirations and the perceived difficulty of technology the presence of technological toys in the home has a larger effect on boys than on girls. Students who choose the technological curriculum option tend to have more ambition towards a technological career or study. They are more interested in technology, are less anxious about it and have a more positive view on the consequences of technology. This effect becomes stronger for interest, ambitions, and perceived consequences when they are a year further in their education. Boys and girls are different when it comes to their interest and ambitions regarding technology. Boys find technology less boring than girls and regard technology to be a more masculine subject. The difference between boys and girls regarding interest in technology becomes even larger when they are in second grade, resulting in boys being more interested in technology. Nevertheless, second graders are overall less positive about technology than first graders, they are less interested, more anxious and have a less positive image of the consequences of technology. Moreover, second graders find technology to be a more gender-biased subject than their younger peers. This is the case for both boys and girls. Second graders who choose a technology-oriented program are, however, more positive than the first graders. The educational level of the father does not have any significant influence on the students' attitudes; the mothers' educational level has a negative correlation with both male and female students' career aspirations and level of interest in technology. Children of a father and/or mother with a technological profession have more ambitions regarding a technological job themselves, and are more interested in and less

Table 7 Summary of the different characteristics and interactions

	Career	Interest	Boredom	Consequences	Difficulty	Gender
Boy	+	+	+			–
Technological option	+	+	+	+		
Toys at home	+	+	+	+	+	+
Second grade	–	–	–	–		–
High edu Father						
High edu Mother	–	–				
Tech Job Father	+	+	+	+		
Tech Job Mother	+	+	+			+
Second grade * Tech. Option	+	+		+		
Second grade * Boy		+				
Toys at home * Boy	+				+	
Tech. Job Mother * Boy						

Only significant effects are illustrated. "+" for a positive effect, "–" for a negative effect

anxious about technology. If the mother has a technological profession, boys and girls both have a more positive attitude towards technology as a subject for both genders.

Conclusions, discussion and implications

This research elaborated upon the concerns regarding technology in education in relation to anticipated shortages within the labour market for technology. We assumed that attitudes towards technology play a significant role in this and should be related to other characteristics of both students and schools. The focus of this study was upon students in the first and second grade of general secondary education in Flanders. All of these students experience 2 h of obligatory technology classes per week. A certain number of these students take extra technology related classes, up to 5 h per week extra.

With respect to the first research question concerning the predictive power of student characteristics we found some notable differences between first and second grade students. An extra grade, and thus an extra 2 h of technology education each week for a whole year, does not improve any of the sub-factors of attitude measured. On the contrary: students' attitude towards technology, despite the efforts taken, diminishes over time. This clearly highlights the problematic nature of the current situation regarding technology education.

In this study we did not investigate what causes these effects, so we do not suggest that this effect is caused by the content, pedagogy or delivery of the technology lessons. Research from Barmby et al. (2008) and George (2006) shows a similar decline in students' attitude towards science. Maturation as such may be an important factor. However, students who choose packages such as Industrial Science or Construction and Wood show more positive attitudes. In second grade, these students show an increased interest in technology and larger career aspirations than their peers in the first grade and they become less anxious about technology. They develop a more positive perception of the consequences of technology. We note that all differences are significant. Nevertheless, longitudinal research over a longer period of time could lead to valuable new insights.

Our research indicates that a larger amount of time spent on learning about technology correlates with a higher interest. The multivariate analysis reveals that extra technology related classes affects the various sub factors of attitude separately: it positively influences the level of interest, career aspirations, perceptions of technological consequences and it decreases the boredom towards technology. The question still is: what is cause and what is effect? More research is necessary. Is it purely due to student characteristics such as intrinsic interest, or are these classes taught with more competence and enthusiasm, or are they more challenging? There might be a significant difference between teachers who teach the regular 2 h of technology classes and the ones who teach the technological curriculum option. We do not know what the effects will be when the technological curriculum option are mandatory and it would be worthwhile to investigate this in an experimental setup with controlled conditions.

Our findings with respect to the effect of students' gender is similar to Mawson's (2010) findings: it affects levels of interest, boredom and perceived consequences. Mawsons' results were based on a qualitative study with a small group of primary school children. Our research reinforces these findings with substantial quantitative data.

Not only are girls less interested in technology and technological careers, this interest also declines faster than for boys. Hoffman (2002) found similar results. He concluded that from the age of 10 the level of interest starts to decline, and especially for girls. Our study expands these findings to the first grades of secondary education at ages 12–14. Boys are more positive about a future technological job or study. This difference between the genders has been found in a number of studies (Cannon and Simpson 1985; Simpson and Oliver 1985; Weinburgh 1995). We add extra insights based on the interaction effects. The very strong positive effect of the selection of technological curriculum option is a new finding as is the positive effect on career aspirations of technological toys for girls and, to an even greater extent, for boys. Our study does not confirm stereotypical ideas concerning gender differences (Rasinen et al. 2009; Salminen-Karlsson 2007) in all respects: the female students in our study do think they can study technology and have a technological career. The male students, however, still conform to the stereotype. This should motivate changes in education, in order not to waste future talent. If today's boys do not think that females can have a career in technology, will they, as adults, stimulate their daughters to become a mechanic or an engineer?

The educational level of the father has no significant impact on any of the attitudes in our study. Mothers' educational level, however, has a negative impact on the interest of their children in technology and their children are less inclined towards a technological career. Parents are especially influential as a role model when they have a technological job themselves. When one or both of the parents hold a job in technology, students are more inclined towards a technological career. The effect of the mothers' job is the same for boys and girls. The presence of technological toys at home stimulates aspirations for a technological career both for boys and girls, but the effect is significantly stronger for boys. An explanation for this can be found in the research of Elvstrand et al. (2012). They show that in kindergarten and primary school boys and girls play differently with technological products. For boys, the process of constructing things itself is often the goal whereas girls are users of technology and construct things to play with. Toys have a significantly positive effect on all other factors of attitude towards technology. When it comes to perceived difficulty of technology, toys are the only characteristic on the student level that explains variation. Volk and Yip (1999) found similar positive effect of toys on all aspects, but contrary to our findings, not for difficulty where the effect they found was insignificant. It is not clear what causes the difference between our studies. An important critical reflection needs to be made here. We use the term technological toys to define toys like Lego® and Knex®, like most other researchers do (e.g., Bame et al. 1993; Volk and Yip 1999;

Mammes 2004; Bast 1991). These toys represent creativity, construction, and various other concepts of the technological system but are is nevertheless a narrow conception of technology. Van Keulen (2010) summarized the contexts and contents that relate to technology, such as gardening, healthcare, safety, energy, music, sport, clothing, food and agriculture. These are not evoked by our items, which mainly focus on *construction* toys. Using another conception of technological toys and other examples might lead to other findings on attitude, especially for girls. It might have been better to define these toys as 'construction toys' rather than 'technological toys' in our study.

The multilevel analysis revealed that for all six attitudes the teacher explains a significant part of the variance, even after controlling for all independent student variables. This means that teachers are different and do not have the same effect on students. For some attitudes the explained variance at the teacher level is, although significant, rather small. This is the case for pupils' beliefs about gender differences, perceived difficulty of technology and boredom. The teacher explains a bigger part of the variance among students with regard to consequences of technology (4 %), ambitions for a technological career (5.7 %) and interest in technology (7.6 %).

It is important investigate the influence of the teacher further. Clearly, teaching technology classes for two hours a week should have an impact. George (2006) stated: 'When students see the practical utility of science, they are more likely to become interested in science and pursue science-related careers.' This is where the teacher can make the difference. Not all teachers are effective, not all teachers are experts and not all teachers have sizeable effects on students (Hattie 2008). Now that the importance and relevance of the teacher on students' attitudes towards technology is shown, the next step should be to take a closer look at the differences between successful and unsuccessful teachers.

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