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Contact details: The Editor, AJTE, pj.williams@waikato.ac.nz

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The effect of classroom activities on students' interest and career aspirations towards technology

Jan Ardies, Sven De Maeyer & David Gijbels

Abstract

Many countries implement mandatory technology classes in the secondary education curriculum in the hope of stimulating students' interest and career aspirations in the field of technology However, there is still a need for empirical studies on how teachers and their classroom activities could enhance interest in technological vocations. This paper focusses on the different effects of classroom activities on boys' and girls' interest and career aspirations towards technology. Students (n = 2228) from 20 different schools participated in this study. The effects of different classroom activities were explored: interaction, hands-on activities, student investigations, and applications in technology. A factor analysis of the items enhanced the composition of the four factors. The results of the multi-level analyses indicate that some activities are more effective than others, and this effect is different for boys and girls.

Keywords: *classroom activities, attitudes, interest, technology education, secondary*

Introduction

In many countries, researchers and policy makers are concerned that society might fail to meet the demands of industry by neglecting to educate a sufficient number of students in the domain of STEM (Science, Technology, Engineering and Mathematics) (e.g. Fadigan & Hammrich, 2004; Gilbert & Calvert, 2003; OECD, 2008; Scantlebury & Baker, 2007; Xue, 2014). To tackle this challenge, several countries have turned their attention to mandatory science and technology classes in the primary and/or secondary education curriculum. It is seen as vital that STEM education contributes to fostering students' attitudes, specifically interest and career aspirations, as these are most related to students' future career orientation. Increasing students' interest and career aspirations should result in an increased number of students with ambitions to study or work in this domain (Hayden, Ouyang, Scinski, Olszewski & Bielefeldt, 2011; Osborne & Dillon, 2008). Several studies (e.g. Borko, 2004; Hampden-Thompson & Bennett, 2013; Lumpe, Czerniak, Haney & Beltyukova, 2012) have indicated that teachers can have an impact on students' attitudes towards science. Nevertheless, Buccheri, Gürber and Brühwiler (2011) argue there is still a need for empirical findings on how teachers and their classroom activities could enhance interest in scientific and technological vocations. This seems even more urgent for technology education as less research has been carried out on this field in comparison to students' interest in science (Osborne, Simon & Collins, 2003; Van den Berghe & De Martelaere, 2012). Moreover, a recent study by Ardies, De Maeyer, Gijbels, and van Keulen (2014) found that teachers differ in how they influence students' attitudes towards technology. This raises the question of how teachers' classroom activities influence students' interest and career aspirations in the field of technology.

Previous research in the domain of science and technology education found that certain classroom activities have a positive impact on attitudes towards science (Gibson & Van Strat, 2001; Liang & Gabel, 2005) and are more likely to encourage and motivate students to pursue

science at higher levels of study (DeWitt & Osborne, 2008). These activities are characterized by a large amount of autonomous self-directed learning, collaboration with classmates, activities that are active and hands-on, and are extended beyond the scope of a single lesson. Analysing the PISA 2006 data for the United Kingdom, Hampden-Thompson and Bennett (2013) confirm this positive effect of hands-on activities together with a positive effect of making use of applications on students' attitudes. However, also analysing the PISA 2006 data, Hampden-Thompson and Bennett find that an increase in the frequency of students' investigations results in lower student enjoyment. A similar pattern was found for students' future orientation towards science.

This raises the question as to whether these classroom activities also influence attitudes towards technology and, more specifically, interest in technology and related career aspirations. Knowledge of effective classroom activities, from the perspective of developing students' positive attitudes towards technology, is important in order to guide educational practice towards stimulating students' interest in technology and career aspirations. Nevertheless, there is, to the best of our knowledge, no scientific literature on this topic (Rohaan et al., 2010). Therefore the present study aimed to discover to what extent different classroom activities have an effect on students' interest in technology and technological careers. Given the continuing under-representation of girls in the field of technology (e.g. Fadigan & Hammrich, 2004; Gilbert & Calvert, 2003; Scantlebury & Baker, 2007) this paper will focus specifically on the different effect of classroom activities on boys' and girls' interest and career aspirations in this field.

Before introducing the specific research questions driving this study, classroom activity research is outlined, the differences between boys' and girls' interests and career aspirations are identified, and the relevant contextual parameters when researching students' attitudes are defined.

Classroom activity research

Different studies have shown that when teachers are more supportive and caring, students tend to have higher levels of achievement (Brown, Anfara & Roney, 2004; Klem & Connell, 2004) and motivation (Klem & Connell; Marks, 2000). In terms of instructional factors, the emphasis on science inquiry improves students' scientific achievement (Lee, Deaktor, Hart, Cuevas & Enders, 2005). Lesson characteristics influence learning processes in general and are thus relevant (Scheerens, 2005; Seidel & Prenzel, 2006; Seidel & Shavelson, 2007). A well-known international study in which classroom activities are investigated is the PISA 2006 study (PISA, 2009). This study describes classroom activities from the perspective of the students and is about the frequency at which activities occur. In particular, the questions refer to observable events, which make it easier for students to evaluate lesson characteristics in a way that is independent of subjective comparison. They ask about the frequency with which clearly definable teaching and learning activities occur in science lessons. As PISA 2006 investigates classroom activities on a large scale and focuses on science education, it aims to provide reliable, valid internationally comparative data about secondary school students. To do this most effectively, an age-based sample is at the core of the design. This does, however, impose some restrictions. For example, PISA does not include sampling at the classroom level. Therefore, the reports from students cannot be aggregated at that level, making it difficult to provide a complete description of science teaching (Wittwer & Renkl, 2008). Moreover, it must be kept in mind that PISA asks about features of science teaching in the current school year, while student performance in PISA is the result of many years of cumulative learning. This is also the case for interest in technology because it develops slowly and persists over time (Hidi, 1990). When connections between instructional practices and students' test performances are analysed and interpreted, all of these aspects indicate the need for caution when drawing conclusions (Kobarg, Prenzel, & Seidel, 2011). Therefore, when analysing the effect of the frequency of

classroom activities, it is more appropriate to make use of pre-test scores (e.g. an extra measurement occasion at the beginning of the research) in order to allow for the aggregating of students at the teacher level. In this way, it is possible to collect a more objective image of the frequency with which the different classroom activities occur with each teacher.

Gender differences in technology education

One of the key problems confronting educators in STEM disciplines is the disproportionate lack of involvement of women. Hence, when increasing the number of students in STEM, girls are the most likely targets (Fadigan & Hammrich, 2004; Gilbert & Calvert, 2003; Scantlebury & Baker, 2007). Many studies compare the differences in attitudes of girls and boys towards science and technology (Bybee, & McCrae, 2011; Grigg, Lauko & Brockway, 2006; Hill, Corbett & St Rose, 2010; National Center for Education Statistics, 2007; Schreiner & Sjøberg, 2004; Volk & Yip, 1999). Conclusions are always that boys are generally more interested in science and technology than girls (e.g. Ardies, De Maeyer & Gijbels, 2015; de Vries, 2005; Gardner, 1998; Mawson, 2010; Weinburgh, 1995). Research on attitudes towards a career in science and technology reports a similar pattern; girls tend to have less ambition in a STEM oriented future (Fadigan & Hammrich, 2004; Gilbert & Calvert, 2003; Jenkins & Nelson, 2010; Jones, Howe, & Rua, 2000; Scantlebury & Baker, 2007; Taskinen, Asseburg & Walter, 2008).

Brotman and Moore (2008) conclude in their review study that increasing girls' and boys' positive attitudes, influencing the education that students receive, and concerning both contextual and societal issues involved in understanding, teaching, and learning science are important. Girls' lack of participation is attributed to curriculum content that is biased toward boys' interests (Sanders, Koch, & Urso, 1997). Shroyer, Backe, and Powell (1995) attribute girls' lack of interest to pedagogical approaches rather than to the inherent nature of the subject. Appropriate teaching methods, such as a gender-neutral teaching style that integrates girls' needs, but equally fosters boys', are essential (Labudde, Herzog, Neuenschwander, Violi, & Gerber, 2000). This is especially so in secondary education where female interests in science are experiencing a decline (Gardner, 1985; Ardies et al., 2014). Archer, DeWitt and Dillon (2014) conclude that for STEM programmes, a one size fits all approach might be inappropriate. As an example, inquiry-based science laboratory activities are found to be differentially effective for male and female students. Whereas boys benefit more from inquiry methods, girls seem to benefit more from non-inquiry approaches (Wolf & Fraser, 2008).

Given that both boys and girls often feel that course content often lacks relevance to their lives (Jacobs & Becker, 1997; Markert, 2003; Sanders et al., 1997), teachers should be encouraged to construct knowledge from students' experiences (Belenky, Clinchy, Goldberger & Tarule, 1986; Jacobs & Becker, 1997). However, relevant real life content is not necessarily the same for boys and girls (Wills, 2001). Since both girls and boys often have negative attitudes and minimal interest in science (Dawson, 2000; Stark & Gray, 1999), linking the lessons on students' real life experiences is important to all students. However, when focussing on increasing the inflow of girls in the domain of STEM it is particularly important that teachers and curriculum designers attend to the experience base of female students (Weber & Custer, 2005) and take into account that, in general, girls, in contrast to boys, prefer collaboration over competition (Chapman, 2000; Fiore, 1999; Jacobs & Becker, 1997; Sanders et al., 1997). Curriculum developers in technology education need to be informed by research and theory designed to comprehend 'women's ways of knowing' if they hope to be effective in recruiting and retaining women and girls in the study of technology (e.g. Belenky et al., 1986; Bybee & McCrae, 2011; Welty, 1996; Welty & Puck 2001). Pedagogical considerations are critical to sound gender-balanced curriculum design. Research indicates that there are instructional methods, patterns of interactions, and interests that can be characterised as distinctively female (Brunner, 1997; Chetcuti & Kioko, 2012; Jacobs & Becker, 1997; Little & Leon de la Barra, 2009; Liu, Hu,

Jiannong & Adey, 2010). Therefore curriculum materials need to connect in meaningful ways with all students' prior experiences and the world in which they live (Weber & Custer, 2005).

Research Questions

The available research indicates that specific classroom activities are likely to have a positive effect on students' interest and career aspirations in the field of technology and that the impact of certain activities may differ for girls and boys. This study focuses on technology education and aims to examine the effect of classroom activities on students' interest and career aspirations. This includes all four classroom activities from the PISA 2006 survey (PISA, 2009): interaction, hands-on activities, student investigations, and the use of applications. Hence, the following research questions have been derived:

1. What is the effect of the occurrence of different classroom activities on students' interest? Is the effect similar for boys and girls?
2. What is the single effect of the occurrence of different classroom activities on students' career ambitions? Is the effect similar for boys and girls?

Methodology and design

First the context and data collection of the study are described, followed by an outline of the variables of students' interest and career aspirations. Then the composition of the variables measuring classroom activities is given, and the independent control variables included in the research are outlined. Finally, the method of analysis is explained.

Context and data collection

For this study the focus is on the first two grades of secondary non-vocational education in the northern region of Belgium, namely, Flanders. Flanders can be considered as a relevant context to study the research questions as Flemish students take a mandatory curriculum of 27 hours a week including two hours of technology classes. Technology attainment goals stated by the government are to be achieved by all students. However, technology teachers have a large amount of autonomy in how to reach these goals. Therefore the focus on classroom activities in technology classes is relevant and variation can be expected in these classroom activities.

A two-stage sampling technique was used for this study. In the first stage, 20 geographically distant schools of different sizes were selected, including both public and private schools with technological and non-technological orientation in the higher grades. In these schools all technology teachers in the first and second grades were asked whether they were willing to participate in a survey study about technology education. Once teachers had agreed, the second sampling stage was conducted by including all students in the first and second grade of secondary education who were taught technology by the teachers in the sample. Data were collected with an online survey using Qualtrics software, of the Qualtrics Research Suite (Copyright © 2011) and students (n = 2228) logged in during the technology lesson at school. A pre-test/post-test design was used to investigate both the effect of the classroom activities on students' interest and career aspirations at the end of a grade and also to control for prior differences. Students completed the questionnaire at both the beginning and the end of the grade.

Measurement of interest and career aspirations

Students' interest and career aspirations were measured by making use of the revalidated PATT (Pupils' Attitude Towards Technology) instrument as described in Ardies, De Maeyer and Gijbels (2013). Four items measure the concept 'interest in technology'. The scale 'Interest' shows an excellent reliability (Cronbach's alpha = .92) and the scale career aspirations, a good reliability (.84) (see Table 1) (Cortina, 1993).

Table 1: 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

Measurement of classroom activities

Classroom activities in technology education were measured making use of a questionnaire based on the PISA 2006 survey of science classes (PISA, 2009). This instrument was used as there was a great number of resemblances between science classes and technology classes in the first grade of secondary education. Nevertheless, we are aware that a few aspects have to be taken into account when using this survey in the context of technology education. In their discussion of the PISA 2006 data, Hampden-Thompson and Bennett (2013) note that the classroom activities are self-reported by the students. This gives the students' perspective on the activities that they perceive to be taking place during science lessons. Aggregating students' perspectives on classroom activities on the teacher level, creates a more objective image of the frequency at which each teacher presents the different classroom activities .

The research started with the 14 original items from PISA 2006, referring to the four different classroom activities: interaction, hands-on activities, student investigations, and applications in technology. All references in the items to science are adapted to technology. A four-point scale, with the response categories 'in all lessons', 'in most lessons', 'in some lessons', and 'never or hardly ever', was used for all the technology teaching and learning activity measures.

Before using the resulting scores, the validity and reliability scores based on this instrument were tested, as there are some changes made to the instrument of the PISA protocol. First, the age of the respondents, in the first cycle of secondary education where the instrument is employed, is no longer strictly 15 but can vary between 11 and 15. A second change is that of 'science' in the questions to 'technology' to cope with the aim of this study to investigate the precise effect of technology classes on students' attitudes.

Therefore, the model fit of the theoretical expected four factors model by making use of confirmative factor analysis (CFA) was tested. This model showed a relatively low Comparative Fit Index (CFI) of 0.889, which is below the .90 critical value for a reasonable model fit (Hu & Bentler, 1999). The model fit according to the Root Mean Square Error of Approximation (RMSEA) is 0.093, which is above the 0.08 critical value (MacCallum, Browne & Sugawara, 1996) for a mediocre fit. Concluding that the model does not sufficiently fit the data, further analyses were necessary. The scales were analysed again with an Explorative Factor Analysis (EFA) resulting in four almost identical scales. Only one item (Item 6: 'Students are required to design how a technology question could be investigated') showed an a priori unexpected high factor loading on the scale 'investigations', rather than a factor loading on the original scale 'hands-on'. This is not surprising as the content of this item covers the investigation of a topic by students. Implementing this adaptation in the measurement model resulted in a good fitting CFA model (CFI = 0.93 and RMSEA = 0.073). As the model significantly improved the model fit, the latter model was retained as being best suited for this study. The four classroom activities are all positively correlated (r between 0.506 and 0.726), but none of these correlations are extremely high. All scales have acceptable (Cortina, 1993) Cronbach's alpha coefficients (see Table 2). Hence, the analyses are continued with all four classroom activities as displayed in Table 2.

Table 2: Factors of Classroom activities

Factor	Cronbach's alpha	Items
Interactions (INTACT)	.78	(1) Students are given opportunities to explain their ideas,
		(2) the lessons involve students' opinions about the topics,
		(3) there is class debate or discussion,
		(4) the students have discussions about the topics.
Hands-on activities (HANDSON)	.64	(5) Students spend time doing practical experiments,
		(7) students are asked to draw conclusions from an experiment they have conducted,
		(8) students do experiments by following the instructions of the teachers.
Student investigations (INVEST)	.86	(9) Students are allowed to design their own experiments,
		(10) students are given the chance to choose their own investigations,
		(11) students are asked to do an investigation to test out their own ideas,
		(6) students are required to design how a technology question could be investigated.
Use of applications (APPLY)	.71	(12) The teacher explains how a school technology idea can be applied to a number of different phenomena,
		(13) the teacher clearly explains the relevance of technology in our lives,
		(14) the teacher uses examples of technological application to show the relevance of the topic at school.

Using all students as observers, and aggregating their perceptions of the frequency in which the different classroom activities occur, provides the best possible view on what actually happens in all classrooms over a longer period. Due to the large respondent numbers at the lowest level, scale measurement error is also reduced and reliability increased when aggregating the data (Snijders & Bosker, 1999). Moreover, when concepts measured at the individual level are nearly identical to concepts aggregated at the higher level (e.g. quality of instruction), the reliability can be assumed to be greater (Griffith, 2002). Therefore, the mean of each of the four classroom activities was calculated for each teacher and standardised. A positive score on, for example, hands-on learning, indicates that, according to the students, hands-on activities occur more frequently in their class than in a class of the average teacher.

Control variables

When examining the effect of classroom activities, a number of aspects have to be taken into account in order to exclude bias of intermediate effects from different related characteristics. In this section, the control variables included in this research are described.

Research on the effects of the teachers' level of experience provides mixed results. Some indicate that students were more successful in science when their teachers had more years of teaching experience (Fetler, 2001; Greenwald, Hedges & Laine, 1996), while some report no correlation between student achievement and teachers' experience (Ferguson & Ladd, 1996; Goldhaber & Brewer, 2000; Monk, 1994). However, given the lack of clarity on this aspect, it is advisable to include the level of teacher experience in the research design when possible. In order to be certain that the effects of different classroom activities are due to the actual activity,

and not possible differences in approach between novice and experienced teacher, the numbers of years teaching technology are taken into account.

As technology and attitudes are gender sensitive aspects (Little & Leon de la Barra, 2009; Chetcuti & Kioko, 2012; Liu et al., 2010; Talbot-Smith, Abell, Appleton & Hanuscin, 2013), it is also necessary to control for teacher gender. It is not unthinkable that male or female teachers have a different impact on their male or female students' attitudes towards technology.

The choice of curriculum can also be important as students in Flanders have to choose, in addition to the mandatory two hours of technology in the standard curriculum, five hours of elective classes a week. They can choose from 15 packages, such as Latin, Modern Science, Mechanics and Electricity, Industrial Science and Construction and Woodwork. We hypothesize that a students' choice between a technological or a non-technological package may correlate with their attitudes towards technology. Therefore, in our analyses we control for the package students have and use the non-technological packages as the reference group.

The educational level of the mother is also taken into account and the differentiation between mothers with and without a degree in tertiary (or higher) education, as prior research has indicated that children with highly educated mothers are more likely to enjoy science and technology and to have a positive orientation towards a future in science (Hampden-Thompson & Bennett, 2013; Ardies et al., [1]2014). Students with at least one parent working in a technology related career report higher levels of enjoyment and future orientation (Ardies et al., 2014). Including parents' professions and educational levels is therefore necessary when researching students' attitudes. Two categories are included for both mothers and fathers: those with jobs that have either no or very few technological aspects (reference category), and those that have a fair to large connection with technology. The presence of technological toys at home can also be a predictor for students' career aspirations (Bame, Dugger, de Vries, & McBee, 1993; Ardies et al., 2014) and interest in technology (Sanders et al., 1997). All variables are either dichotomous or standardised to facilitate the interpretation.

Method of analysis

Given that the data has a nested structure (students are allocated to particular teachers) it is most appropriate to rely on multilevel analysis rather than simple regression analysis (Goldstein, 2011; Hox, 2010). In a multilevel model it is possible to model the variation between individual students and the variances between groups of students (e.g. classes, teachers). The analyses distinguish two levels: the first level is the student level and the second is the teacher level. The variances at the first level allow a description of the size of the differences between the individual students. Variances at the second level give an impression of the impact of teachers on students' individual attitudes.

The multilevel analyses were set up in five steps (see Table 3). All models, for interest and career aspirations in technology, are built in a parallel manner. Each step is analogue, in order to be able to compare the effect of the classroom activities on interest and career aspirations. First, in a null model, the variances between both individual students and between teachers is explored. If both levels demonstrate a significant variance estimate, the multilevel structure is retained. This is done by implementing the interest and career aspirations that students have at the start of the research; this allows the specification of the differences in interest at the end of the year as being due to aspects other than the interest at the beginning. In the second step, the main effects of the student characteristics were added (Model 1): technological or non-technological options in the students' curriculum, grade, gender; the presence of technological toys at home; and the educational level and job characteristics of father and mother. This model

[1] Et al. is short for et alia, so the full stop is always used, and is placed after the 'l' only

allows conclusions to be drawn as to the main effects of the students' characteristics. Subsequently, teacher characteristics of experience and gender are added (Model 2). In Model 3 the classroom activities, as perceived by the students, are included. In the final models the main effects of the standardised classroom activities on boys and girls are included. The final step is the addition of interaction effects between student gender and classroom activities. This is done with one interaction at a time, so four different models (4A, 4B, 4C, and 4D) are built. This final model provides an answer to the second research question, whether the effect of the activities is equal for both genders. The models are compared based on the Akaike's Information Criterion) (AIC) and the model with the smallest AIC is the best fitting model (Bozdogan, 1987).

Table 3: Different steps to build the final model

Model	0	1	2	3	4A	4B	4C	4D
Multilevel	x	x	x	x	x	x	x	x
Student characteristics		x	x	x	x	x	x	x
Teacher characteristics			x	x	x	x	x	x
Classroom activities				x	x	x	x	x
Interaction effects of Classroom activities								
Gender * Interaction					x			
Gender * Investigations						x		
Gender * Hands-On							x	
Gender * Applications								x

Results

First, the choice of the best fitting model is described and the estimates of these best fitting models are presented in an integrating table. Second, a closer examination is made of the teacher and background characteristics of students and their effects in order to conclude with an outline of the effect of all four classroom activities.

Best fitting model

When building the different models, each increasingly complex model was compared with the previous one (see Table 4). Model 2, including the teacher characteristics, is not significantly better fitting for the data when analysing students' interest. Nevertheless, we build further on this model for both career aspirations and interest in order to build analogue models for both attitudes so data can be compared. Models 4A to 4D were each compared with Model 3. As the preferred model to withhold, for both students' interest and career aspiration, Model 4C (Table 4). This model includes the interaction effect between students' gender and hands-on activities.

Table 4: Akaike's Information Criterion (AIC) and -2 Log Likelyhood (-2LL) for each model analysing students' interest and career aspirations.

Model		Interest			Career		
		AIC		-2LL	AIC		-2LL
0	Null model Multilevel	4998.5		4990.5	4717.0		4709.0
1	M0 + Student characteristics	3821.0	*	3799.0	3660.7	*	3638.7
2	M1 + Teacher characteristics	3822.0		3496.0	3658.6	*	3632.6
3	M2 + Classroom activities	3820.3	*	3786.3	3653.7	*	3619.7

Interaction effects Classroom activities							
4 A	M3 + Gender * Interaction	3818.9		3782.9	3654.8		3618.8
4 B	M3 + Gender * Investigations	3822.0		3789.0	3653.6	*	3617.6
4 C	M3 + Gender * Hands-On	3816.2	*	3780.2	3652.1	*	3616.1
4 D	M3 + Gender * Applications	3818.0		3782.0	3654.3		3618.3

* Significant improved model compared with previous model.

In order to make comparisons easier, the parameter estimates for both models are combined in one table (Table 5). For both interest and career aspirations the null model shows that 3 percent of the variance is explained at the teacher level. When including the classroom activities and interaction effect, in the latter model 4B less than 0.001 percent of the variance explained at the teacher level was found. It can be concluded that a very large proportion of the variance between groups of students is due to what actually happens in the classroom, combined with teacher background characteristics (see Table 5).

Table 5: Parameter estimates (est.) and standard errors (se) of the best fitting models for Interest and Career.

	Interest			Career Ambitions		
	est	se	p	est	se	p
Fixed Part						
(Intercept)	-0.077	0.075		-0.159	0.070	*
Pre-test scores (z-score)	0.226	0.025	*	0.373	0.027	*
Boys	0.138	0.052	*	0.313	0.049	*
Technological Curriculum	0.002	0.136		0.542	0.131	*
Technological Toys at home	0.079	0.052		0.119	0.048	*
Mother has a Tertiary education degree	-0.056	0.059		-0.015	0.054	
Father has a technological job	0.113	0.049	*	0.088	0.045	°
Mother has a technological job	-0.118	0,070	°	-0.144	0.065	*
Male teacher	0.024	0,052		-0.039	0.048	
Years' experience of teacher	0.002	0.004		0.001	0.004	
INTACT (standardised)	0.006	0.042		0.024	0.039	
INVEST (standardised)	-0.004	0.031		0.069	0.029	*
HANDSON (standardised)	0.044	0.041		0.019	0.038	
APPLY (standardised)	-0.081	0.040	*	-0.066	0.037	°
Interactions						
Boys: HANDSON (standardised)	0.117	0.048	*	0.084	0.044	°
Random Part						
Variance between teachers	< 0.001			< 0.001		
Variance between students	0.809			0.699		

Significance codes: * = p<0.05; ° = p<0.1

Describing the results, first the effects of the control variables are explained and then an answer to the research questions is provided.

A significantly large amount of the variation between students' interest and career aspiration is due to their attitude at the beginning of the research (Interest pre-test Est = 0.226; $p<0.05$; Career aspirations pre-test Est = 0.373; $p<0.05$). For interest, the effect of pre-test scores was estimated as 0.226, and for career as 0.373. So for interest this means that scoring one point higher on the pre-test co-relates with scoring 0.226 higher on the post-test. Boys also have more interest (Est = 0.138; $p<0.05$) and career ambition (Est = 0.313; $p<0.05$) than their female peers. Students with a more technologically oriented curriculum do not differ in interest towards this subject, but have more ambition (Est = 0.542; $p<0.05$). Students with technological toys at home have more ambition (Est = 0.119; $p<0.05$) than their peers without technological toys. The degree of education of the mother has an effect on their interest or ambition (interest Est = -0.056; $p>0.05$; Career aspirations Est = -0.015; $p>0.05$). Students with mothers who have a job that is somehow related to technology have less interest (Est = -0.118; $p<0.05$) and less ambition (Est = -0.144; p<0,05). For fathers this effect is the opposite, there is a positive effect on interest (Est = 0.113; $p<0.05$) and a small positive effect on students' ambitions (Est = 0.088; $p<0.05$).

A teacher's gender does not have a significant impact on students' interest and career aspiration. Furthermore, novice teachers are equally as effective as senior teachers when it comes to developing students' interest in technology or stimulating their career aspirations. What does matter is what happens in the classroom, as findings show that not all activities positively influence students' attitudes and not all activities have an equal effect on students' interest and career aspirations. Giving them more than the average number of opportunities to explain their ideas and organise class debates or discussions (INTACT) has no significant effect on students' interest in technology, nor does it influence their career aspirations, as can be seen in Table 5 (Est Interest = 0.006; $p>0.05$; Est Career = 0.024; $p > 0.05$). When students can design and investigate their own experiments (INVEST) more than the average students, interest in technology remains equal, but their career aspirations rise. Table 5 shows that, for teachers who score one standard deviation above the mean on the scale INVEST, their students' interest in technology increases with 0.069 SD ($p<0.05$), at the end of the grade. Teachers explaining technology and discussing its relevance outside school (APPLY) have a significant negative impact on both the interest (Est = -0.081; $p<0.05$), and ambitions (Est = -0.066; $p<0.05$) of students. Students' interest decreases with 0.081 SD when teachers score one SD higher than the average teacher. For career aspirations the effect is a little smaller, here students score 0.066 SD ($p<0.05$), which is lower than their peers with an average scoring teacher. This effect naturally also works in the other direction, which means that teachers who do not focus on the applications of technology during their lessons have a positive effect on students' interest and career aspirations. This type of classroom activity is the one of the four with most teacher interference. Teachers talking and students listening, regardless of the relevance of the subject, have a negative effect on students' interest or career aspirations. This effect is equal for boys and girls as no significant interaction effects with students' genders were found; this is indicated by Model 4D not fitting the data better. The only significant interaction effect was found between students' gender and the frequency with which hands-on activities occur as a classroom activity. The main effect of HANDSON is not significant, indicating that for girls (the reference category in these models) hands-on activities have no effect. For boys, however, there are significant effects. When male students can conduct practical experiments and do hands-on activities more than the average (Boys: HANDSON), they also have greater ambition for a career in technology (see Table 5). Boys' interest in technology increases with 0.117 SD ($p<0.05$), when hands-on activities occur one SD more than average. Boys' aspirations for a technological career increase with 0.084 SD ($p<0.05$), when the hands-on activities are one SD more than the average carried out in classrooms. This positive effect, however, only works for boys.

Conclusion and discussion

An insufficient number of students in the domain of STEM was the catalyst for this research. One possible solution, suggested by scholars, is to foster students' interest through education, which should result in a larger number of students with interests in, and ambitions for, further study or a job in this domain (Osborne & Dillon, 2008). One of the key aspects of this study was an under-representation of women in the domain of science and technology, and how education at school can increase this by means of different classroom activities. More specifically, two different aspects of students' attitude towards technology are measured. The first research question investigated the effect of the occurrence of different classroom activities on students' interest. The second research question specifically focussed on the single effect of the occurrence of different classroom activities on students' career ambitions.

Therefore, this analysis focussed on the effect of four common classroom activities in technology lessons at school, with a special interest in the different effects on male and female students. Interactions between teacher and students was the first activity. When this classroom activity occurred, students could explain their ideas, participate in debates or discussions, and express their opinions. After that, hands-on activities were included. Here, students were specifically asked about the frequency with which they could do practical experiments. The third classroom activity, investigations, entailed students being allowed to design and choose their own experiments and testing those ideas. The last activity studied the frequency with which teachers explained phenomena and the relevance of technology in the daily life. This activity was mainly the teacher who was giving a 'lecture' about the relevance and importance of technology.

The frequency with which these different classroom activities occurred did have an impact on students' attitudes. First, a negative effect of the teachers' focus on application was found. Second, a positive effect of doing investigations and experiments, hands-on activities was found. This classroom activity, however, only had a positive effect on boys. A possible explanation as to why drawing their own conclusions and conducting an experiment stimulated male students' interest can be found in research on boys' preference for more active forms of education (Wolf & Fraser, 2008). This is also opposite to the teachers' focus on applications and explaining the relevance of technology, which has a negative effect on students' interest and career aspirations. Therefore, this seems to be an activity that should be avoided if one wants to attain more interest and higher career aspirations. Similar effects were found in the research of Welty and Puck (2001) who found relatively low rankings of 'debate' and 'discussion' by the male students when students were asked which activity they preferred in science classes. Focussing on applications and holding class debates and discussions has an equal effect on boys and girls. This is a minor difference with Tillberg and Cohoon (2005) who argue that girls' prefer a contextualised curriculum in which technology is generally seen as a tool for solving humanity's problems and enriching humanity's experiences. Not only was the positive impact of hands-on activities for boys important in this research, even more interesting was the effect of investigations. It was found that this had a stimulating effect on students' career aspirations and the effects were not different for male and female students. This seems to be the key to stimulating girls without negatively effecting boys' attitudes. This is in line with Blum and Frieze's warning (2005) that curriculum changes based on commonly accepted gender differences can perpetuate stereotypes, and indeed the risk is obvious. By focussing on classroom activities that have a positive impact on both male and female students, like designing and doing investigations, curriculum designers and teachers seem to provide the tools to overcome this potential danger.

By including an extra measurement occasion at the beginning of the research, a pre-test to exclude the bias described by Kobarg et al. (2011), the results provide researchers with new insights into the effects of classroom activities on students' interest and career aspirations. Also, it was found that the scales designed for the PISA research lead to valid measures for the four

classroom activities, although it proved to be important to control the factor structure for the questionnaire. For the specific context of this research, a small adjustment in the composition of the scales was needed. The scales 'hand-on' and 'investigations' were composed a little differently, by switching one item from 'hands-on' to 'investigations'. Nevertheless, with the adaptation incorporated, all four classroom activities included in the PISA 2006 studies for science classes (PISA, 2009) could be measured with good reliability. The classroom activity was measured by aggregating students' perceptions of the frequency of the occurrence of the activities. This study did not investigate whether male and female students experience classroom activities in the same way, nor how the experiences of these students' correlate with teachers' intentions; more in-depth research might resolve this. When looking at the effects of the four different classroom activities, we like to emphasise again that the outcome variables in this research are interest and career aspirations. Although some researchers argue that students' interest can serve as a predictor for their literacy, it cannot be concluded from this study that equal effects of classroom activities would be found when measuring students' technological knowledge or skills.

Teacher professional development as a means toward developing quality teachers is cited as a significant variable in setting classroom practices and as positively influencing student learning (Borko, 2004; Desimone, Smith, Hayes & Frisvold, 2005). The results of this study are in line with Hampten-Thompson and Bennett (2013) that on the level of teacher education, continuing empirical research as to how to achieve gender equity in sciences and technology education should be incorporated in teacher training (e.g. attributional retraining), while ensuring the expertise of the teachers. This is also because the teacher characteristics included show that what happens in the classroom is of far larger importance than the teachers' experience when it comes to stimulating students' interest and career aspirations. This shows that young teachers are equally as effective as more experienced teachers when it comes to improving students' interest and career aspirations in technology, and the largest profit is made when teachers do not focus too greatly on the applications of technology and talk about its relevance, but let students do something in class.

Affiliations

Jan Ardies
Faculty of Social Sciences
Department of Training and Education Sciencs – EduBROn research group
University of Antwerp, Belgium
janardies@gmail.com

Sven De Maeyer
Faculty of Social Sciences
Department of Training and Education Sciencs – EduBROn research group
University of Antwerp, Belgium

David Gijbels
Faculty of Social Sciences
Department of Training and Education Sciencs – EduBROn research group
University of Antwerp, Belgium

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