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Monitoring a gender gap in interest and social aspects of technology in different age groups

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Abstract Although technology determines our everyday life, many of us still have neither special knowledge nor interest. Our study focused on a reliable and valid empirical monitoring of interest in and social implications of technology by applying an existing scale to 610 participants. First, we confirmed the factor structure for the school student subsample which was the age-group of the originally applied scale (n = 369). Second, we were able to extract the same structure for both other subsamples: university freshmen (n = 125) and in-service teachers (n = 116). Interestingly a gender gap occurred in all age-groups for both factors (interest in technology and social aspects of technology). Not surprisingly, male participants showed significantly higher interest and social adjustment to technology. Only in the social context for male and female in-service teachers did no gender difference appeared. Consequently, technology in schools needs an introduction at young ages, where interest in both technology and its social aspects develops and needs support.

Keywords Interest in technology · Social aspects of technology · University freshman · Gender gap · Technology in school · STEM

Introduction

Technology learning in school

There are many definitions of technology in the literature. Mc Robbie et al. (2000) summarized the different views by pointing to the main dimensions of technology, a human dimension (inspired by inventors), a social dimension (used by society), technology as

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a process (working with materials), a situated dimension (executed in relations) and an artefacts dimension (progress of production). In our case, the social dimension of technology and general interest in technology are of interest. Most people regard technology as boring, hard to learn and also often associated with risks (Ardies et al. 2013). However, learning technology increasingly turned into a key condition to achieve this goal (Petrina et al. 2008). Self-regulated learning efforts might offer one way to improve students' self-efficacy in technology and to promote well-being and positive social interaction (Barak 2010). When beginning technology education, students have to feel positive, confident and enjoy favorable experiences in technology so that later they are more successful in their careers in school and university. Building positive attitudes towards technology is therefore of great importance (Akpınar et al. 2009). Although technology education is more important than ever, public views are still negative (Ardies et al. 2015). Ardies et al. (2015) showed that interest in technology decreased from the first to the second level of secondary education, especially for girls. Time devoted to teaching correlates in this study positively with interest in technology, while parents also influence students (as parents with technology occupations for example have a positive influence on attitudes and interest in technology). Young students in particular show more positive attitudes towards technology (Mawson 2010). Finally technological toys at home have a positive influence on attitudes (Ardies et al. 2015).

STEM and its negative image

Negative experiences are often described for Science, Technology, Engineering and Math (STEM) (Dasgupta and Stout 2014). Such bad experiences in science lessons may lead to negative attitudes towards science which are later difficult to change and may remain for the rest of students' lives (Simpson and Oliver 1990). In general, positive attitudes towards science tend to decrease during school life, although students' frequency of positive thoughts about the utility of science increase correspondingly (George 2006). Students regard science as useful and important although negative attitudes towards science prevent students from participating in science courses (George 2006).

Gender gap

Famous scientists, technologists or inventors often named are Einstein, Newton, Bohr or Pasteur (Otto 1991). These personalities produce the typical perception of science and technology as a "male-dominated profession" (NSF 1988). Famous women like Curie, Hodgkin or Herschel are rarely mentioned (Otto 1991). These differences are also seen in the STEM sector, women are in the minority in both STEM jobs and STEM degrees (Beede et al. 2011). Males achieve better test results and proceed to better careers (Miyake et al. 2010). This gender difference occurs in all age-groups and is perhaps already established in school, where girls have more negative attitudes towards science (Weinburgh 1995; Cannon and Simpson 1985). Males often show more positive attitudes towards enjoyment of and motivation in science, females on the other hand show more positive attitudes towards society, and prefer to please teachers, parents and society (Weinburgh 2000).

Chance to bridge the gap

de Klerk Wolters (1989) described technology education as a chance to build attitudes towards technology, and to bridge gender gaps at a young age. The role of teachers is important to generate positive attitudes in students. In particular, primary school teachers seem to have no real concept of technology or technology education, which points to the need to provide more information about technology in pre-service teacher education (Mc Robbie et al. 2000). Furthermore, many secondary school teachers associate technology with subject specialization rather than as an extra curriculum subject. When asked what students should learn, teachers favored technology within their own subject area, and regarded education in technology as an implementation of science in general (Alister and Carr 1992). The pre-service teacher education and the professional development of in-service teacher may produce benefits such as passing their own positive attitudes on to students. Students should be taught that technology is everywhere and may substantially support everyday life (de Klerk Wolters 1989). In Germany there is no separate technology subject in schools, therefore introducing technology into established curricula is needed (ISB 2004). Such an approach was introduced into the Bavarian curriculum more than a decade ago, when a new subject called "Nature and Technology" was introduced (ISB 2004). However, to date no study has monitored the effects of more technology education in Bavarian schools. If a gender gap still exists or if we know when these gender differences arise, we can take early action. For that, it is important to measure the status-quo of technology attitudes in different age groups.

Development of the questionnaire

Studies monitoring interest in technology have been rare, especially regarding gender differences. To measure interest in technology and its social aspects we used a subscale of the Technology Questionnaire of Harding and Rennie (1992): Part B (*What do you think about technology?)*. The content of Part A (*What is technology?)* had been changed enormously in the decades since the development of the questionnaire, so we just applied Part B. However, other attempts to monitor the technology contexts have been undertaken. The PATT Questionnaire, for instance, monitoring pupils' attitudes towards technology, consisted of 10 sub-scales measuring the attitudes and cognitive components of technology (de Klerk Wolters 1989). The reliability and validity of that scale has repeatedly been confirmed, although its applicability to classrooms was low due to its length. The results of 13- and 14-year olds showed that most of them associate electricity, transport and computers with technology (Rennie and Jarvis 1995). Subsequently, a follow-up questionnaire (APAT: Attitudes and Perceptions About Technology) reduced the number of sub-scales to seven (interest, career in technology, technology is easy, importance of technology, technology as a design process, diversity of technology and technology as problem-solving) (Rennie and Treagust 1989). Later, a further reduction employed only four sub-scales (diversity, design, interest and social aspects). In our present study, we applied a short version of the Technology Questionnaire (TQ), the sTQ (short Technology Questionnaire), to answer four research questions.

Research questions

1. Is the Technology Questionnaire suitable in a German language context?
2. Does a two-factor solution of the shortened TQ (sTQ) apply to samples of different age groups?
3. Are there age differences?
4. Are there gender differences?

Procedures and methods

Subjects were 610 participants divided into three sub-samples (1) 6th graders from urban and non-urban areas, (2) university students from different science and non-science faculties and (3) in-service science teachers (see Table 1). The teachers were science teachers of "Nature and Technology".

Scale

We applied the short Version of the Technology Questionnaire (sTQ) (Harding and Rennie 1992) using Part B: "What do you think about technology?" with the sub-scales "interest in technology" and "social aspects or implications of technology". Participants were required to complete the 10-item questionnaire: "interest in technology" (5 items) and "social aspects or implications of technology" (5 items). In order to hide the scale's structure, items were randomly mixed. The items followed a five point Likert scale (1 = strongly disagree, 2 = disagree, 3 = can`t decide, 4 = agree, 5 = strongly agree). In contrast to Rennie and Jarvis (1995), we assigned low response numbers to indicate low preferences (1 = low preference) and high ones high (5 = high preference) as Bogner and Wiseman (2002) did.

Statistics

For statistical analyses, SPSS (Version 22.0) was used. First we repeated the factor analysis of Rennie and Jarvis (1995) by using the principal axis factoring method and Varimax rotation. The factor analysis was completed for each age group separately. Items with cross-loadings and factor loadings below .3 were removed (Stevens 2009; Nunnally and Bernstein 1994).

The central limit theorem supports accepting a normal distribution if the sample size exceeds 30 (Field 2013), permitting the use of parametric statistical methods. To measure the significance of differences between the groups, we used univariate ANOVA with Bonferroni post hoc tests. We used mean scores, subsequently splitting the groups by gender. T-tests were used to analyze gender differences within groups.

Table 1 Sample description

	N	Age		Gender (%)	
		M	*SD*	Female	Male
School students	369	12.14	0.573	47.43	52.57
University freshmen	125	22.53	2.828	76	24
In-service teachers	116	42.47	10.914	60.34	39.66

Results

German context

The Kaiser–Meyer–Olkin (KMO) test showed reasonable sampling with scores ranging between .74 and .82. (Kaiser 1970). Kaiser (1974) regarded scores exceeding .8 as sufficient. The sTQ is generally suitable for the German language context. Three principal factor analyses were computed for our three sub-samples (students, freshmen and teachers).

Factor solution

We used the KMO test separately for the different groups (see Table 1). Only the KMO of the university freshmen was below .8. The total explained variance of the factor solution was acceptable (Lienert and Raatz 1998). Cronbach`s alpha of the whole scale (interest and social aspect) and the different sub-scales [interest (I) and social aspects (S)] showed good overall reliability (Kline 1993) (see Table 2).

The explorative factor analysis extracted two factors for each age group as suggested by Rennie and Jarvis (1995). The re-checking of the factor analysis in different age groups was concordant. All three age-groups produced the same structure of the two factors although some differences appeared. One cross-loading in the students' sample (item I2) and one loading in the teachers sample solution was below .3 (item S3). The factor loadings of the two factors were high (see Table 3). Consequently, part B of the TQ Questionnaire showed the same structure for different groups.

Implementation of the Technology Questionnaire in different age-groups

The results showed significant differences between students and university freshmen as well as between students and teachers in both sub-scales (interest in technology and social aspects of technology). No significant differences between teachers and university freshman were observed.

The variance homogeneity test shows that the data are not optimal for analysis with ANOVA ($p = .119$ (social aspects); $p = .031$ (interest). However the inadequate test of homogeneity did not invalidate the ANOVA, that is why we raised the level of significance from $p = .05$ to $p = .01$ (Zöfel 2001). A univariate ANOVA showed differences for all three age-groups in "interest" and "social aspects", for "interest" $F(2, 598) = 23{,}406$, $p < .001$, omega = .263 and for "social aspects" $F(2, 606) = 18{,}602$, $p < .001$, omega = .228 (see Fig. 1). The Bonferroni post hoc tests showed significant differences between the different age groups. In "interest" there is a significant difference between students (M = 2.85,

Table 2 Total scale and sub-scales: KMO-test, total variance and reliabilities of the whole scale and the sub-scales

	Students	University freshman	Teacher
KMO	.82	.74	.80
Total variance (%)	35.66	42.30	40.72
Reliability I&S	.77	.78	.81
Reliability I	.78	.83	.81
Reliability S	.67	.62	.71

Table 3 Loading pattern of the short Technology Questionnaire

Item		Factor loadings							
		Original scale		Students scale		University freshmen scale		Teacher scale	
		1	2	1	2	1	2	1	2
I1	I am interested in technology	0.69		0.83		0.95		0.80	
I2	I would like to learn more about technology	0.75		0.72	0.46	0.90		0.69	
I3	I would like a career in technology later on	0.74		0.68		0.64		0.57	
I4	I like to read books and magazines about technology	0.76		0.72		0.67		0.88	
I5	I would like to join a hobby club about technology	0.73		0.85		0.33		0.47	
S1	Technology makes the world a better place to live in		0.73		0.68		0.35		0.42
S2	Technology has brought more good things than bad things		0.68		0.39		0.46		0.72
S3	It is worth spending money on technology		0.57		0.58		0.35		–
S4	Inventions in technology are doing more good than harm		0.60		0.47		0.42		0.73
S5	Technology is needed by everybody		0.67		0.47		0.30		0.32

Only factor loadings > 0.30 are reported, original factor loading (see Rennie and Jarvis (1995)
I sub-scale interest, *S* sub-scale social aspects

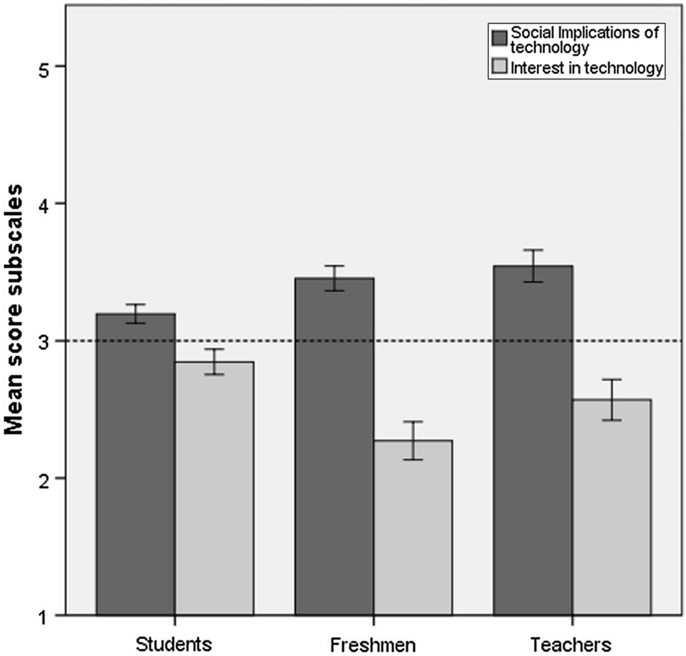

Fig. 1 "Interest in technology" and "social implications in technology" split by different group. Bars are 95% intervals

SE = .046) and university freshman (M = 2.26, SE = .069) ($p < .001$) as well as a significant difference between students and science teachers (M = 2.58, SE = .072) ($p = .008$). The "interest" mean scores of the university freshman and the science teachers were not significantly different ($p = .014$).The second part of the TQ "social aspects" produced similar results. There is a significant difference between students (M = 3.20, SE = .034) and university freshmen (M = 3.46, SE = .045) ($p < .001$) as well as between student and science teacher (M = 3.54, SE = .025) ($p < .001$). Here too there is no significant difference between university freshman and science teachers ($p = .943$).

Further analysis comparing the age-groups with respect to gender and sub-scale as shown in Fig. 2a, b.

Gender

Social

The social sub-scale showed significant differences between male and female participants in the students and in the university freshmen group. The teachers group was not significantly different (see Fig. 2a). The disparity − .26, 95% CI [− .39, − .13] between the female students (M = 3.06, SE = .044) and the male students (M = 3.32, SE = .04) was significant [t (368) = − 4.00, $p < .001$, d = .205]. As well the difference − .45, 95% CI [− .66, − .23] between the female university freshman (M = 3.35, SE = 0.05) and the male university freshman (M = 3.80, SE = .09) was significant [t (123) = − 4.23, $p < .001$, d = .541]. The difference − .09, 95% CI [− .32, − .13] between the female teachers (M = 3.49, SE = .07) and the male teachers (M = 3.58, SE = .09) was not significant [t (113) = − .85, $p = .396$, d = .087]. These differences are significant only in two groups (students, university freshmen). In the teachers group, there is no significant difference between female and male participants.

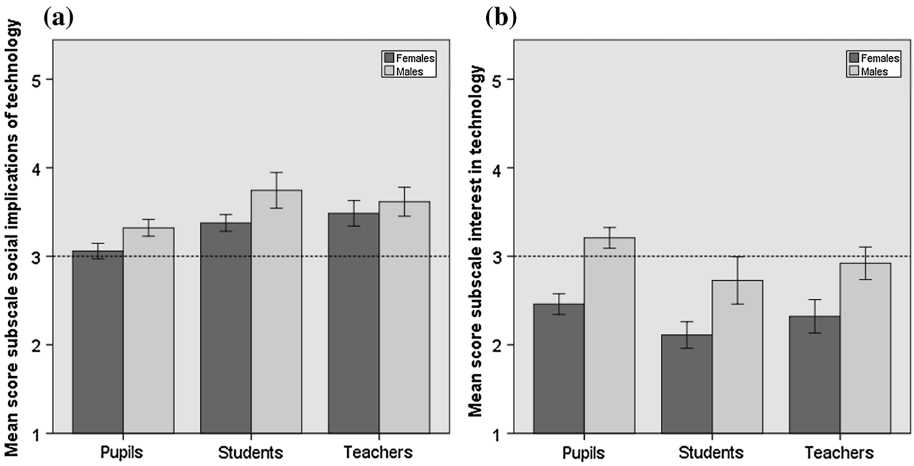

Fig. 2 Scores of "Social implications of technology" (**a**) and "interest in technology" (**b**) scores, split by different group and gender. Bars are 95% intervals

Interest

The Interest sub-scale showed significant differences between male and female participants in all age groups (see Fig. 2b). The difference −.75, 95% CI [−.91, −.58] between the female students (M = 2.46, SE = .06) and the male students (M = 3.20, SE = .06) was significant [t (366) = −8.92, $p < .001$, d = .424] Additionally the difference −0.79, 95% CI [−1.10, −.48] between the female university freshman (M = 2.08, SE = 0.07) and the male university freshman (M = 2.87, SE = .14) was significant [t (123) = −5.20, $p < .001$, d = .614]. The teacher sample also show a significant [t (105) = −4.38, $p < .001$, d = .408] gender gap −.61, 95% CI [−.89, −.33] as female teachers (M = 2.30, SE = .10) scored lower than males (M = 2.91, SE = .10). The gender gap appears in all age groups in the sub-scale interest.

Discussion

Scale application

The short version of the Rennie and Jarvis (1995) instrument is shown to be suitable for a Bavarian sample. In southern Germany technology is not a separate school subject, while the subject called "Nature and Technology" was established for 10–12 year olds in a new curriculum (ISB 2004), relatively the high scores in interest and social aspects of technology may therefore originate this curriculum adjustment. Earlier studies in England (Jarvis and Rennie 1998) and in Australia (Rennie and Jarvis 1995) had shown similar effects of the integration of technology into curricula.

Although our applied scale was developed 20 years ago, both sub-scales showed similar loading patterns yielding "interest in technology" (I) and "social aspects of technology" (S). This fact is surprising as technology has developed fast and new technology is affecting the lives of students (Subrahmanyam et al. 2001), for example, in the use of cell phones, portable computers or smart watches (Rawassizadeh et al. 2014). Additionally, social media are increasingly impacting our daily life (O'Keeffe and Clarke-Pearson 2011). Twenty years ago, when the scale was originally developed, it was still inconceivable that everybody, especially in the observed age group, would be using technology in this way. That was why our sample selection was extended to freshmen and in-service teachers in order to cover potential age-variations, in line with the study of Langheinrich et al. (2016), where an existing scale (quantifying computer self-concept) was extended to other age groups but showed the same structure. Another example of a successful application was the environmental value model published by Munoz et al. (2009), where a scale originally designed for adolescents (Bogner and Wiseman 1999, 2002) was successfully applied to pre- and in-service teachers and showed the same structure.

Age groups

The age-group with the highest interest scores were young school students, freshmen and in-service teachers scored significantly but only slightly lower. In-service teachers and freshmen did not differed significantly. Interest in technology is apparently high in school and drops later, with its lowest scores in university. A need to prevent the described drops is apparent, as career preferences are established at young ages (Lips 2004), although the problem of lowering interest across school years remains (Speering and Rennie 1996). Primarily for girls, the STEM (science, technology, engineering, and mathematics) subjects seem to fail to meet expectations, and to determine later career choices (Speering and Rennie 1996). This anti-technology preference in school seems at least partly ascribable to teachers, as primary school teachers often show less preference towards technology (Mc Robbie et al. 2000), and this alone may prevent the introduction of new technology issues into school. Stein et al. (2006) have pointed to many difficulties in real classrooms when teaching technology, but also showed ways to improve understanding technology. However, the sub-scale social aspects of technology showed the opposite pattern, as positive preferences increase with age. Freshmen and in-service teachers score substantially higher and recognize more social implications and social responsibilities than do school students. Teachers explain the importance of social aspects of technology with the process of technology development. Bouras and Albe (2008) described teachers' perception that society is dependent on technology because of change of life styles requiring more and more new inventions and technical processes. For that reason, continued interaction and connection between scientists and technology teachers is needed (Stein et al. 2006).

Gender

A stereotypical gender difference was observed in the social sub-scale. It is smaller than in the interest sub-scale but still significant. Only the in-service teacher age-cohort showed no gender difference on the social sub-scale. The social aspects of technology sub-scale scored positive for both sexes, although lower than in Rennie and Jarvis (1995). In adulthood, the social implications of technology scores are more balanced although males consistently showed higher in technical interest, an unsurprising result, as males always show higher interest in technology. This is in line with Rennie and Jarvis (1995) and Brown (1993), where the latter reported a gender difference in technology interest even at pre-school ages. Boys, for example, prefer to play with technical toys or computer games. If teachers don't pay attention to girls' performance in technical matters, this gender gap remains (Brown 1993). This stereotypical gender gap for technical matters appears also in other groups, for example in the labor market described by Beede et al. (2011), even women with a STEM degree are less likely prefer a STEM career, many of them moving to the educational or health sectors, leading to an under-representation of women in STEM careers.

Dasgupta and Stout (2014) discussed different stages in the gender gap development: (1) childhood and adolescence, (2) emerging adulthood, and (3) young-to-middle adulthood. During childhood children learn about general role stereotypes mainly from their parents (Eccles et al. 1990). Another major influence, particularly in adolescence, is the peer group, where young people learn their first social interactions (Eaton et al. 1991). Peer groups often choose their members from those in the same courses and those who share similar interests (Riegle-Crumb et al. 2006). The next step in the development of the gender gap is in emerging adulthood (Dasgupta and Stout 2014). Here the question is why girls with an interest in STEM do not proceed to a science career. Young woman are generally under-represented in the male-dominated science community, leading to a dominated feeling when meetings are not gender balanced (Murphy et al. 2007). Another cause may be the lack of role models in the STEM community (Dasgupta and Stout 2014). Female experts acting as role models may overcome this (Stout et al. 2011). In adulthood, women have to compete with male colleagues to demonstrate their equality. Finally, one must not forget the need to combine family and work (Mason and Goulden 2002).

Altogether, there are many reasons for the gender gap in technology and general in STEM related sciences, and many possibilities to bridge them. Baram-Tsabari and Yarden (2011) observed no emergence of typical stereotypes until the end of high school. Interest in technical topics needs to be formed in school in order to bring girls into a corresponding profession. With training in younger years, the gender gap may disappear. To reduce the gender gap there must be some methods like the interactive strategies of Lorenzo et al. (2006), who reported a reduction of the gender gap with these strategies.

Gender gaps need to be reduced. Improved teaching methods and closer inspection of girls' technical interest and skills in school are required to promote girls' interest in technical issues. Technical subjects may become increasingly relevant to girls when they find stimulation in younger classes long before their choice of academic study (Speering and Rennie 1996; Lips 2004). Women often tend to more social motivation, so one way to introduce technology in schools is to increase emphasis on social aspects of technology (Lips 2004). Reduction of those gaps may bring more young women into professions in technical fields or into research on technical issues (Beede et al. 2011).

Conclusion and outlook

Applying our questionnaire will only monitor and not solve the issue of a lack of interest in technology. It is simply a step towards illustrating the gender gap in different age groups, and perhaps point to necessary actions to reduce that gap. Frequent validity measures need to secure qualitative studies in the context of fast development in technology. The Bavarian curriculum reform was a step towards a new and innovative approach, but it is only one possibility among many to improve attitudes towards technology. The new curriculum may help as competencies beyond cognitive knowledge acquire a new role that may give technology a more positive image (ISB 2017). Further studies need to evaluate the effect of age development in increasing interest or emphasizing social aspects technology, perhaps showing the potential of integrating more technical issues into everyday lives.

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Compliances with the ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval Research involving Human Participants but the ethical standards are followed.

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