Scientific understanding of students in the picture

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Chapter 5

Attitudes towards teaching and learning science and technology

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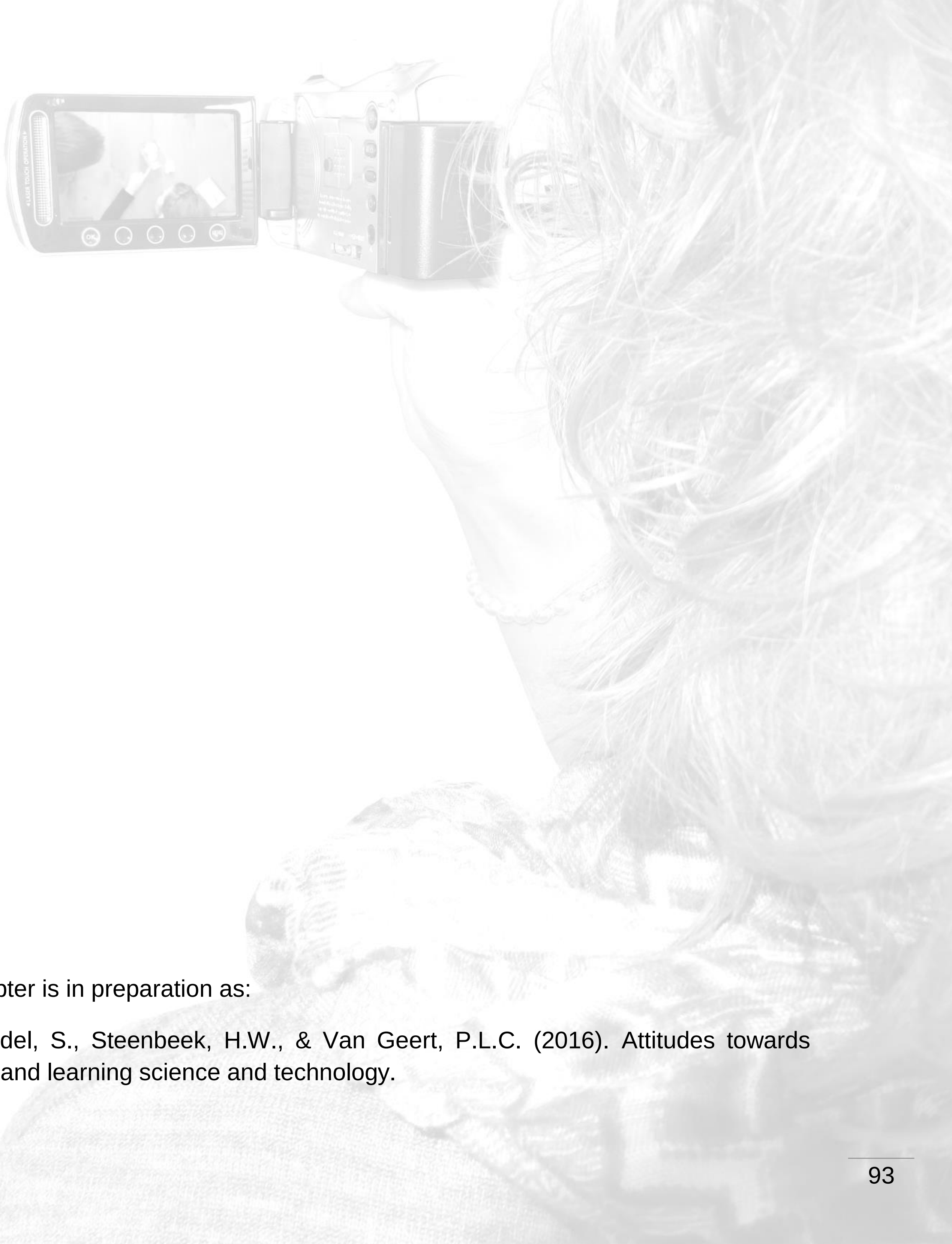

This chapter is in preparation as:

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Children’s natural curiosity towards science and technology seems to strongly decline during the period of primary education (see Engel, 2009; Steenbeek & Uittenbogaard, 2009). Such a decline in interest is harmful as it may endanger the development of science and technology skills in children and reduce future career choices in science and technology. The introduction of science and technology education in elementary education is important to evoke students’ natural curiosity, for the development of positive attitudes, and increased understanding (Eshach & Fried, 2005). On a political level, this concern is reflected in the acknowledgment that science and technology should be a part of the curriculum from an early age on in order to be able to meet the demands of a rapidly, highly technological and science-dominated society (Jorde & Dillon, 2013, p. 10).

Several countries have invested in allocating science and technology as part of curriculum goals and have supported teachers by providing tools to teach science and technology education in an inspiring way. One such initiative is Curious Minds (Post, 2009; Van Benthem, Dijkgraaf, & De Lange, 2005). Curious Minds is a Dutch national research program focusing on children’s knowledge and skills in science, technology, engineering, and mathematics disciplines. The program aims at gaining insight into how children’s abilities in these fields can be optimally advanced making use of environmental factors such as teachers, parents and activities. The program aims at professionalizing science and technology education. The starting point is that each child is naturally curious in science and technology, and therefore potentially skilled in these fields, and that teachers play a crucial role in stimulating these skills. These skilled behaviors reveal themselves in questioning, exploring, critical thinking, reasoning and problem solving, which are common behaviors in young children as well as skills that are necessary to become a researcher.

Within the Curious Minds program, the current study concentrated on gaining insight into the attitudes of teachers and upper grade students in regular elementary education. We aimed to study whether the Video Feedback Coaching program for upper grade teachers (VFCt) resulted in changes in attitudes towards teaching and learning science and technology. The VFCt was implemented in order to stimulate teachers to increase the quality level of students’ scientific understanding, spontaneity, exploration and initiative (Appendix C). One of the aims of the VFCt intervention was to diminish teachers’ negative concerns by helping them to see – by means of their own videotaped lessons – that they have, or can develop capabilities to teach science and technology in such a way that it improves students’ scientific understanding and students’ motivation to learn science. The question of the present study is: to what extent do teachers and students change in their attitudes towards science and technology under influence of the VFCt and how does this compare to eventual changes in the control condition?

Teachers’ attitudes towards teaching science and technology

Attitudes towards science and technology teaching influence teacher’s participation, thinking and achievement (Alexander & Winne, 2012; Hong & Lin, 2013). Several studies show the challenges teachers experience when they teach science, or when they reflect on the possibility of starting to do so (Van Aalderen-Smeets, Walma van der Molen, & Asma, 2012; Wetzels, Steenbeek, & Van Geert, 2015). Most teachers find science and technology difficult, as they experience it as being far removed from their knowledge and skills. A common teaching strategy is using teacher- and textbook-dominated instruction, while students experience inquiry-based learning as more interesting (Furtak, Seidel, Iverson, & Brigg, 2012; Gibson, 1998; Guthrie, Wigfield, & VonSecker, 2000) and this approach yields improved attitudes towards science and increases in students' achievement (Parker & Gerber, 2000). Hence, as inquiry-based learning is hardly taught in elementary education (De Vries, Van Keulen, Peters, & Walma van der Molen, 2011), negative attitudes about science and competencies for this field are rigid.

Teachers' attitude towards teaching science highly contributes to teachers' intention to use inquiry-based teaching methods (Haney, Czerniak, & Lumpe, 1996; Van Aalderen-Smeets et al., 2013) and is considered to be predictive of their classroom practices (Haney, Lumpe, Czerniak, & Egan, 2002; Van Aalderen-Smeets & Walma van der Molen, 2015). Van Aalderen-Smeets and colleagues (2012) state that the behavioural intention, i.e. the extent to which a person is willing to try to perform certain behaviour, is the direct outcome of cognitive and affective attitude and the feelings of perceived control. Teachers who feel more capable seem more willing to provide science and technology education (Van Aalderen-Smeets & Walma van der Molen, 2013) and capable teachers are better equipped to stimulate scientific reasoning skills of students (Davies, 2000). Improvement in feelings of perceived control and affect are related to longer periods of science related teaching in the classroom (Van Aalderen-Smeets & Walma van der Molen, 2015).

How does attitude, for instance teacher's attitude towards science and technology develop? Attitude develops from daily activities and is constructed in interaction with the context. We follow the theoretical explanation of De Ruiter, Van Geert, and Kunnen (submitted) about three nested levels of self-esteem. In terms of its developmental mechanisms, attitude as described in the current chapter is similar to self-esteem. Self-esteem trait is the macro level, which is bi-directionally connected with the meso-level of state self-esteem, and this meso-level is bidirectional connected to the micro-level of self-experiences. For the present study, attitude (i.e. macro level) self-organizes out of iterations of the real-time experiences (i.e. micro level). We hypothesize that by actively perturbing the teacher-students interactions (at the micro level) towards more positive interactions during science and technology education, and in particular by increasing teaching quality, changes in teacher's attitude can be established.

An intervention that effectively increases the quality of teaching science and technology is expected to yield positive change in teachers' attitudes (hypothesis 1). We expect no change in the control condition, as no intervention is taking place, and as a result no change in teacher behavior is expected.

Students' attitudes towards learning science and technology

In Dutch elementary education, students spent on average 3 % of their time on science and technology related subjects (Verkenningscommissie W&T PO, 2013). This percentage should at least be doubled to be able to prepare students to become capable 21st century citizens. Especially because the rapid changes in society demand a highly educated workforce consisting of people who are capable of critical thinking, creative problem solving and are curious about the world and possibilities to develop (Van Graft, Tank, & Beker, 2014). However, if students are not familiarized with skills necessary for science and technology, their ideas about what professionals in this workforce should have in terms of skills, attitudes and knowledge, will not be in line with what is expected from 21st-century professionals. Students' attitude towards science and technology is important as a positive attitude might inspire students to progress in this field of work.

Several studies show that young students have positive attitudes toward science, but this positive attitude decreases and a negative attitude increases toward secondary education (Bae et al., 2000; Hong & Lin, 2013; Reid & Skryabina, 2003; Sorge, 2007). Young students state for instance, that they like science, find it an interesting course, and that it is useful in everyday life. Especially around the transition between elementary and secondary education, a shift concerning interest in science and technology appears (Murphy & Beggs, 2005). More specifically, although in general students have a positive attitude towards science, between the age 10 and 11 a significant drop takes place in their interest and enjoyment towards science and technology and between 11 and 12 in science attitude (Sorge, 2007).

Repeated positive experience with science and technology might fuel a more positive attitude. Both Guthrie and colleagues (2000) and Parker and Gerber (2000) state that real-world interaction in the form of hands-on experiences makes an important contribution to the emergence of a positive attitude towards science and technology, and in addition supports the students' competence and autonomy in these fields. Parker and Gerber (2000) for instance found that a 5 week academic enrichment program, i.e. using inquiry-based teaching in which students learn best by manipulation of materials and engagement in inquiries that are interesting and meaningful to them, was able to increase positive attitudes towards science. Post and Walma van der Molen (2014), however, did not find a positive change in attitudes after a single visit.

As stated above, an intervention that effectively increases the quality of teaching science and technology is expected to yield positive change in teachers' attitudes. As teachers' attitude is reflected upon their own behavior (Van Aalderen-Smeets & Walma van der Molen, 2013) we reason that teachers will model a more positive attitude toward their students. This means that it is expected that teachers' attitude is also reflected on their students' behavior (Jarvis & Pell, 2004). Therefore, we expect that through modeling (Bandura, 1971) and increased (positive) experiences a more positive student attitude will be found (hypothesis 2). Again, we expect no change in the control condition, as no intervention is taking place, and as a result no change in teacher and student behavior is expected.

METHOD

Participants

531 (N_{VFCt} = 270; $N_{Control}$ = 261) students and 23 teachers (N_{VFCt} = 11; $N_{Control}$ = 12) from grade 4 to 6 of elementary education participated in this study. Four teachers of the intervention condition and three of the control condition only filled out the questionnaire during either pre measure or post-measure and were therefore excluded for analysis. The average age of the remaining 7 teachers in the intervention condition was 39.6 (range 23-54), with an average teaching experience of 13 years (range 1 – 32). The 270 students had an average age of 10.7 (range 8.4 – 13.2; 51% boys). The 9 teachers in the control condition were comparable to the teachers in the intervention condition on the basis of age (M = 37 years; range 24 – 54), teaching experience (M = 13 years; range 1 – 30), and the grades they taught (see table 1). In the control condition, the 261 students' average age was 10.6 (range 7.3 – 13.2; 53% boys). All participants were volunteers, who had a personal goal with regard to improving their science and technology education.

Each teacher in the intervention condition was observed during eight science and technology lessons, within a period of approximately three to four months. The first two lessons were pre-intervention lessons. Next, the intervention, as described in 5.2.2.1, was implemented. The final two lessons were post intervention and were videotaped approximately two months after the last video feedback coaching session.

The control condition teachers were observed during four science and technology lessons that were taught as usual. The teachers taught two lessons at the beginning of the trajectory, termed as premeasures, and two lessons approximately 2.5 months later, termed as post-measures. The teachers were not given any teaching instructions in the period between the premeasures and post-measures. This means that they were free to choose whether or not they continued to provide science and technology lessons. Therefore, this condition was considered representative of teaching-as-usual practices.

Procedure

A quasi-experimental pretest–posttest control condition design was used for the study to investigate the effects of the intervention in their natural context.

Teachers and students from both the intervention condition and control condition completed the same paper-and-pencil questionnaires just before the premeasure and post-measure in order to be able to grasp changes in teachers' and students' science and technology attitudes. We contacted the teachers and all teachers agreed to personally supervise the administration of the questionnaires by the students in their classes, this was decided to reduce the demands on the classes as much as possible. Teachers received the questionnaires via surface mail approximately 2 weeks before the researcher visited the school. The questionnaires were accompanied by a letter specifying how to fill out the questionnaires, for instance by stressing that each student had to fill it out individually and that there were no right or wrong answers. If a student did not understand a particular item, the teacher was allowed to help the student individually.

Rationale for the teaching intervention

The Video Feedback Coaching program for upper grade teachers is a professionalization program designed to support teachers in improving the quality of science and technology education in their classroom. It was developed to stimulate change in teacher-students interactions, i.e. changing the discourse from mostly teacher-centered into inquiry-based teaching (Wetzels et al., 2016). By doing so, teachers enhance the quality of students' scientific understanding by establishing a series of teachable science moments (Bentley, 1995; Hyun & Marshall, 2003). The way teachers interact with students was regarded as a key to quality of the lessons. The intervention contained the following evidence-based key elements (Appendix C): (1) improving teachers' knowledge about teaching science and scientific skills, (2) establishing behavioral change by improving teachers' instructional skills by means of (a) VFCt and (b) articulating personal learning goals.

The intervention consisted of an educational session between the coach and the teacher of approximately 2 hours after which the teacher formulated a learning goal. This learning goal was explicitly aimed at the teacher's skill with regard to providing effective and interesting science and technology lessons. Next 4 science and technology lessons were filmed and critically reflected upon by means of video feedback coaching. During these individual coaching sessions, immediately after each lesson, micro moments were selected from the recorded lesson and discussed. These fragments were used to prompt teachers to become aware of their own pedagogical-didactical strategies: i.e. asking the right questions, giving students time to think, respond and argument and experience what type of instruction suits the topic/students best. Each professionalization training was based on the same evidence-based pedagogical-didactical practices, while at the same time a highly idiosyncratic approach was adopted to be able to support teachers in their personal learning goals. For an elaborate description, see appendix C.

Measures and variables

At the first page of the questionnaire, teachers were asked to provide information about their age, gender, and teaching experience. Students were asked to provide information about age, gender, and grade.

Teachers

To assess teacher's attitudes towards teaching science and technology, a validated attitude scale was used (Van Aalderen-Smeets & Walma van der Molen, 2013). This questionnaire consisted of 28 items using a 5-point-likert scale ranging from strongly disagree to strongly agree. The teacher questionnaire items were grouped into three dimensions: *cognition*, *affect* and *perceived control. Cognition* was composed of three sub dimensions: 1. Difficulty, representing teacher's general beliefs about the difficulty of teaching science and technology ('I think that most teachers believe that teaching science is more difficult than teaching other subjects'); 2. Relevance of teaching science, referring to the extent to which the teacher finds it important and relevant to teach science for students' development; and 3. Gender-stereotypical beliefs regarding teaching science, referring to gender-related beliefs such as perceived differences between boys and girls in science. The second dimension, *affect*, concerned items encompassing positive (Enjoyment in teaching science) and negative feelings and emotions (Anxiety in teaching science) related to teaching science and technology ('I am nervous while teaching science'). The last dimension, *perceived control* dimension consisted of statements concerning: 1. Self-efficacy, referring to their own capabilities in teaching ('I think I am capable of answering student's questions appropriately'); and 2. Context dependency, referring to feelings of being dependent of contextual factors ('For me, the availability of a science teaching method is decisive for whether or not I will teach science in class'). Each sub dimension was measured with a set of statements. Weighted sum-scores for each dimension were constructed.

Students

To determine students' attitudes towards science and technology, a science attitude scale developed and validated by Walma van der Molen (2007) was used.[6] The test included 46 items using a 4-point-likert scale, ranging from 'strongly disagree' to 'strongly agree'. Half of the items specifically concerned students' attitudes towards technology, while the other half focused on attitudes towards science. The items of both the technology and the science attitude scale were grouped into three underlying dimensions of attitude: *cognition*, *affect* and *behavior* (Post & Walma van der Molen, 2014). *Cognition* was composed of three sub dimensions: 1. Difficulty, referring to the extent students find the subject of science and technology difficult; 2. Relevance, referring to the students' view on the relevance for science and technology for society and the effects of it on economic welfare; and 3. Gender beliefs, measuring the stereotypical views that students hold regarding gender differences in the context of science and technology. The second dimension, *affect*, comprised items regarding the extent to which students enjoy to engage in science and technology related activities. The last dimension, *behavior*, was intended to measure the extent to which students aspire a technology-or science-oriented career in the future. As with the teacher questionnaire, each dimension consisted of several items. Weighted sum-scores for each dimension were constructed by averaging a student's score on each set of items that defined the attitude dimension.

[6] Note that although the teacher questionnaire and student questionnaire both focus on attitudes towards science and technology they do not measure similar constructs. The student questionnaire focuses on beliefs, thoughts and/or feelings towards science and technology in general, not specific to the lessons of the VFCt, while the teacher questionnaire takes into account specific behaviors about teaching science.

Data analysis

Teachers: Premeasure and post-measure

As the collected data of the teachers consisted of a small group of participants a non-parametric test, i.e. Monte Carlo analysis, was used to test differences in teachers' reports at premeasure and post-measure (Hood, 2004). To assess whether teachers in both conditions started with a similar attitude we first focused on the premeasure. First, the average score per condition per dimension was calculated. Next, the difference between conditions was calculated and tested against the difference of randomly shuffled scores. The null hypothesis was that no difference between the intervention and control condition could be found. After each shuffle the average of each condition was calculated. The random shuffling was permutated 10,000 times. The p value indicates the probability of finding the empirically found difference in the shuffled data. Second, a similar procedure was followed to assess the change within conditions, in that the null hypothesis was that no difference between premeasure and post-measure existed. The scores of the premeasure and post-measure per condition were randomly shuffled and the empirically found difference was tested against the shuffled data. The test-statistic is supplemented with a practical significance score (Sullivan & Feinn, 2012), namely the effect size Cohens *d*. Following Sullivan and Feinn, an effect size of .2 is considered small, .5 medium, .8 large and 1.3 or higher very large. A $p < .05$ and $d > .8$ is convincing evidence of differences between the measurements; $p < .1$ and $d = .5$ to .8 is less convincing evidence; $p > .1$ and $d < .5$ is unconvincing evidence, providing no support for differences between the measurements.

In addition, a profile pattern of teacher attitudes will be obtained by plotting data of sub dimensions from the same dimension. This will serve as an extension of the above described analysis of the seven attitude dimensions. In order to gain insight into individual differences, a visual representation will be used to provide a description of the attitude profiles pre and post intervention. Following Van Aalderen-Smeets and Walma van der Molen (2013), a scatterplot was made of enjoyment and anxiety (*affect* dimension) and from self-efficacy and context dependency (perce*ived control* dimension). Four quadrants represent how likely it is that teachers will teach science now and in the future, i.e. *high potentials*, *promising*, *reluctant*, and *indifferent*. High potentials referred to those teachers who report only positive feelings toward teaching science and those who do not experience anxiety when doing so. These teachers feel they are in control of their science teaching. The promising group referred to those teachers that enjoy teaching while at the same time feeling anxious about it. The third quadrant referred to teachers who do not report to enjoy science teaching and who feel anxious to teach science. The indifferent group referred to teachers whose answers show that they are indifferent and disinterested about teaching science.

Students: Premeasure and post-measure
Data obtained via the student questionnaires were analyzed using SPSS 22.00. To investigate the effects of the intervention on students' attitudes toward science and technology, a 2 (control vs. intervention condition) x 2 (pre measure vs. post-measure) x 5 (relevance vs. difficulty vs. gender beliefs vs. affect vs. behavior) repeated measures MANOVA was conducted with condition as between-subjects factor, time as a within-subjects factor, and the five attitude dimensions as multivariate dependent variables. The paired-sample t-test was conducted to study whether there were any significant differences between premeasure and post-measure score for each dimension.

RESULTS

Teachers' attitude towards science and technology teaching

Premeasure between conditions
To assess whether the teachers' attitude in both conditions could be compared we first examined whether teachers in the intervention condition were similar to those in the control condition.

Cognition: The Monte Carlo analyses showed that the probability that the difference found between conditions on Relevance was purely based on chance is rather low (M_{VFCt} = 4.18, SD = .54 *vs.* $M_{control}$ = 3.8, SD =.69, p < .05, d = .57). No differences were found between the conditions at premeasure on Difficulty and Gender (M_{VFCt} = 3.5, SD = 1.02 *vs.* $M_{control}$ = 3.56, SD = .69, p = .47, d = .06; M_{VFCt} = 2.5, SD = 1.26 *vs.* $M_{control}$ = 2.24, SD = .98, p = .17, d = .22).

Affect: No differences were found between the conditions at premeasure on the affect scale (Enjoyment: M_{VFCt} = 4, SD = 1.06 *vs.* $M_{control}$ = 3.57, SD = .70, p = .07, d = .46; Anxiety: M_{VFCt} = 2.38, SD = 1.18 *vs.* $M_{control}$ = 2.46, SD = .85, p =.41, d = .08).

Perceived control: The analysis showed that the probability that the differences found between conditions on Context Dependency was purely based on chance is rather low (M_{VFCt} = 3.04, SD = .86 *vs.* $M_{control}$ = 2.56, SD = 1.01, p = .05, d = .50). No difference was found between the conditions at premeasure on Self-Efficacy (M_{VFCt} = 2.78, SD = .95 *vs.* $M_{control}$ = 2.96, SD = 1.20, p =.25, d = .17).

This indicates that teachers in the intervention condition felt on average, more than teachers in the control condition, dependent on contexts factors and report to value science and technology as more important for students' development. Given the effect sizes these differences are considerable.

Premeasure and post-measure within conditions
Next, we examined whether the teachers in the intervention condition changed in their attitude from premeasure to post-measure (see Fig. 5.1).

Cognition: The evidence for a differences from premeasure to post-measure is unconvincing (Difficulty: p = .09, d = .33; Relevance: p = .17, d = .25; Gender: p = .44, d = .03).

Affect: The evidence that teachers scored at post-measure different on Enjoyment and Anxiety in teaching science is considered relatively convincing ($p < .05$, $d = .54$; $p < .05$, $d = .54$).

Perceived control: The evidence that teachers scored at post-measure different on Self-Efficacy and Context Dependency is considered convincing ($p < .01$, $d = 1.00$; $p < .05$, $d = .60$).

This indicates that teachers experienced more positive feelings and less negative feelings while teaching science and technology after the intervention. Teachers further reported that they felt more capable of teaching science and technology and felt less dependent of contextual factors at post-measure. Given the effect sizes these differences are considered considerable to large.

Furthermore, we examined whether the teachers in the control condition remained the same in their attitude from premeasure to post-measure.

Cognition: No differences were found from premeasure to post-measure on the cognitive dimension (Difficulty: $p = .09$, $d = .3$; Relevance: $p = .32$, $d = .13$; Gender: $p = .24$, $d = .18$).

Affect: No differences were found from premeasure to post-measure on Enjoyment and Anxiety in teaching science ($p = .26$, $d = .25$; $p = .06$, $d = .37$).

Perceived control: No differences were found from premeasure to post-measure on Self-Efficacy and Context Dependency ($p = .51$, $d = .00$; $p = .17$, $d = .30$).

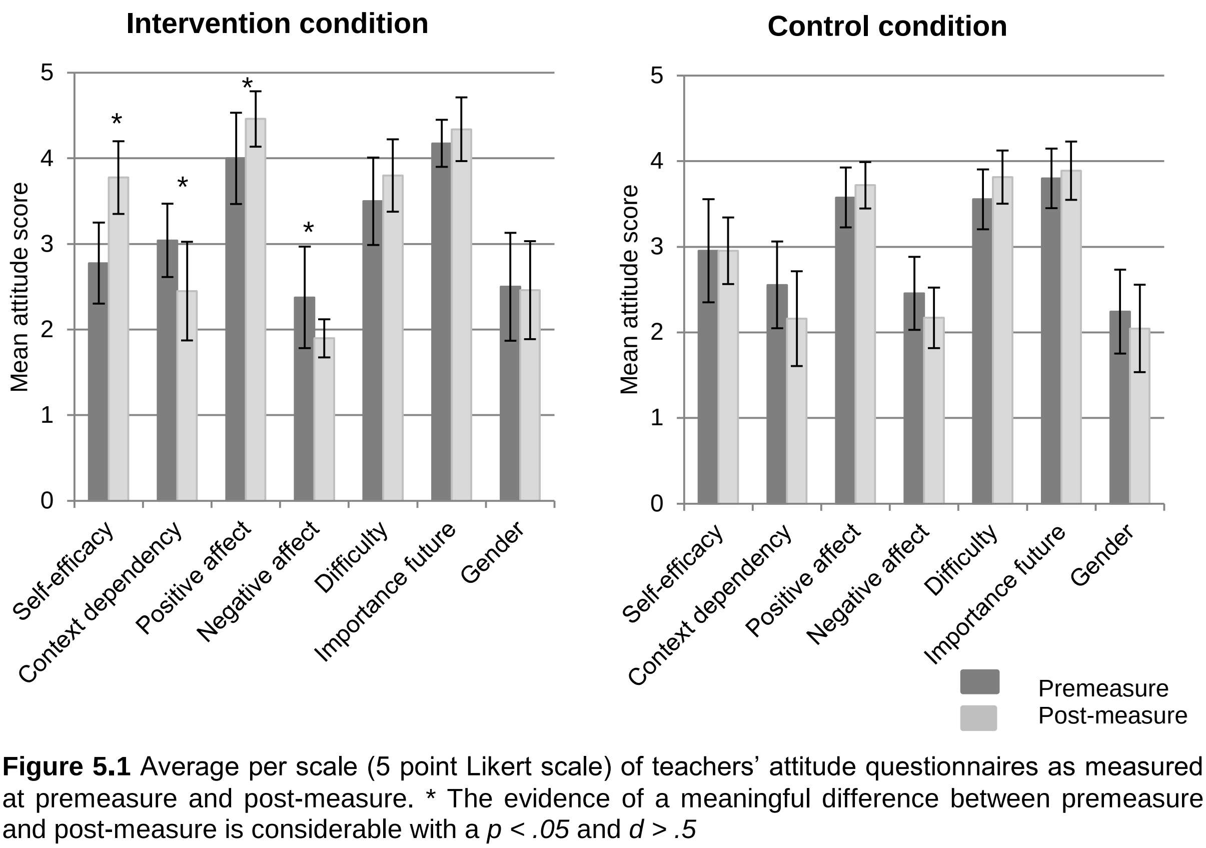

Figure 5.1 Average per scale (5 point Likert scale) of teachers' attitude questionnaires as measured at premeasure and post-measure. * The evidence of a meaningful difference between premeasure and post-measure is considerable with a $p < .05$ and $d > .5$

To summarize, for the intervention condition an expected change was found in four out of seven sub dimensions (see Fig. 5.1). These changes were in the *perceived control* and the *affect* dimension. Given the effect sizes this is a considerable effect. For the control condition no change was found in the dimensions. Therefore, hypothesis 1 is partly accepted. Hypothesis 1 is partly accepted, because no change was found in the *cognition* dimension.

Profile patterns of individual teachers

The scores on two related sub dimensions of each individual teacher are plotted in a grid (Fig. 5.2 and 5.3). The focus is on the dimensions were a change over time was found. For each dimension a short description will be provided over the group of teachers followed by a short description of teacher's attitude per condition.

Figure 5.2 depicts the *affect* dimension. In general, at premeasure most teachers in the control (circles) as well as in the intervention condition (diamonds) are in the promising quadrant which means that teachers view teaching science and technology as a challenge. At post-measure a shift towards the high potential quadrant appears. This means that most teachers view science and technology as enjoyable and hardly perceive teaching science and technology with feelings of anxiety.

Next, the focus will be on teachers in the intervention condition. At premeasure the inter-individual variability seems high among teachers. Some view science and technology teaching as enjoyable (high potentials), some view it as challenging (promising), and some appear reluctant to teach science. At post-measure all teachers view science and technology teaching rather similarly, i.e. all being labeled as high potentials.

Teachers in the control condition view science and technology teaching as challenging or feel reluctant to teach science and technology at premeasure. At post-measure, most of the teachers are labelled as being high potentials and one third of the teachers are on the edge of being labeled as high potentials.

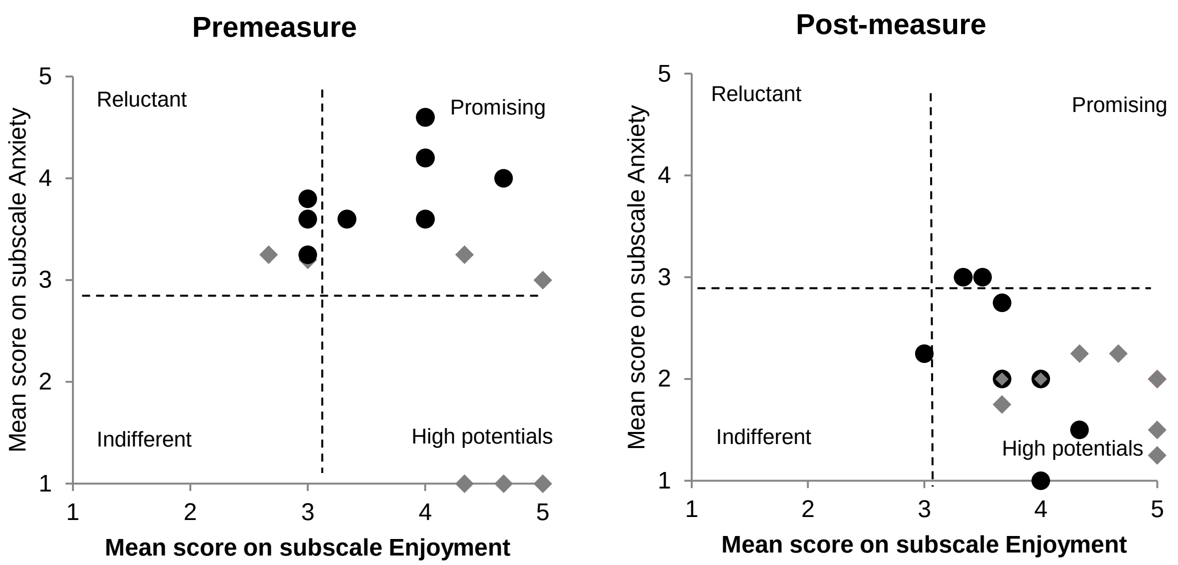

Figure 5.2 Profile patterns of individual teachers on the *affect* dimension. The diamonds represent the intervention condition, circles represent the control condition

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Figure 5.3 depicts the two related sub dimensions of each individual teacher for the *perceived control* dimension. In general, the views of the teachers at premeasure seem rather randomly scattered around the grid mainly occurring as high potentials, reluctant and indifferent. At post-measure these inter-individual differences remain, in that these quadrants are still prevalent.

For the intervention condition three teachers of the intervention condition report feelings of reluctance to teach science and technology at premeasure, two appear as indifferent, one as promising and one teacher feels self-efficacious to teach science and technology (high potentials). At post-measure most intervention teachers could be labelled as high potentials. However, individual differences were found in that some teachers still showed feelings of reluctance to teach science and technology.

Teachers in the control condition showed similar individual differences at premeasure. Some reported feeling dependent on context factors in combination with low feelings of self-efficacy (reluctant). Others reported a lack of perceived control (indifferent). A last group of teachers felt in control and did not feel dependent on context (high potentials). At post-measure, these individual differences remained in that teacher's view again appeared in three quadrants.

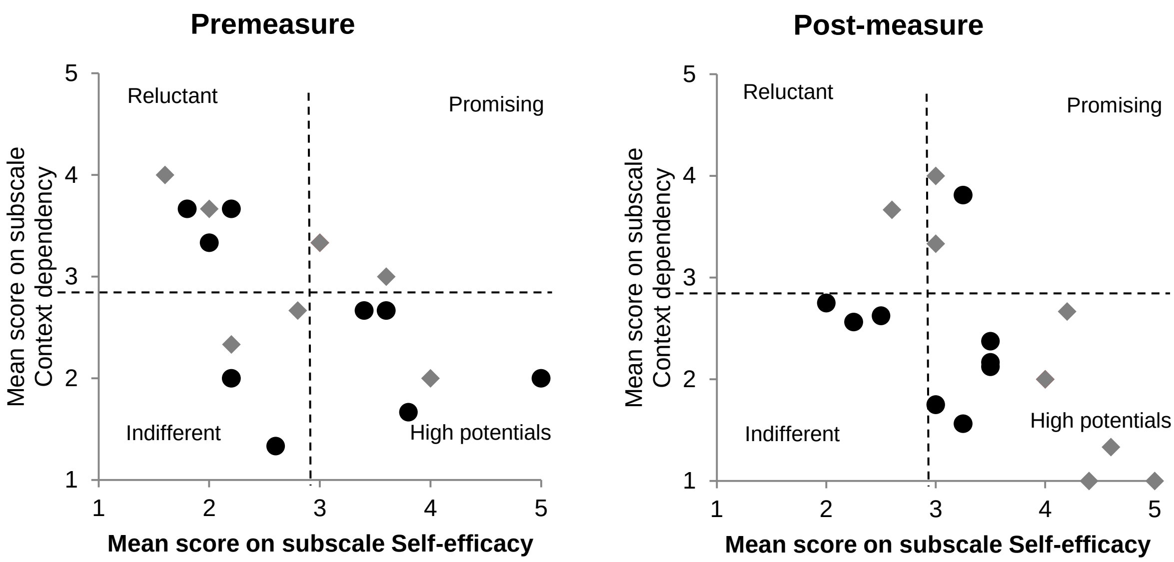

Figure 5.3 Profile patterns of individual teachers on the *perceived control* dimension. The diamonds represent the intervention condition, circles represent the control condition

Students' attitude towards science and technology

Initial data checks, using repeated measure MANOVAs, showed that there were no differences between students from different grade levels on the attitude variables.

Tests of within-subjects effects showed a main effect of time for technology (F(1, 216) = 4.25, p = .04, ŋ = .2) and science (F(1, 211) = 12.9, p < .01). The analysis did not show, however, an interaction effect between time and condition (p = .74; p = .79). Thus, irrespective of condition, across all dimensions, students scored somewhat higher on the pretest than on the posttest. However, further analysis indicated that the effect of time only occurred in the case of some attitude dimensions.

Cognition: With regard to Gender beliefs, a paired sample test showed that students scored higher on the pretest (M = 2.31, SD = .93) than on the posttest (M = 2.09, SD = .84), p = .001 for technology and science (M_{pre} = 1.91, SD = .9 vs. M_{post} = 1.79, SD = .89, $p < .01$). Students scored higher on Difficulty at pretest than on posttest regarding the science items (M_{pre} = 2.05, SD = .66 vs. M_{post} = 1.84, SD = .66, $p < .01$), but not for technology (M_{pre} = 1.75, SD = .51 vs. M_{post} = 1.77, SD = .52; p = .64). No statistically significant effects of time were found for Relevance towards technology or science (resp.: M_{pre} = 2.71, SD = .54 vs. M_{post} = 2.74, SD = .56, p = .42; M_{pre} = 2.87, SD = .57 vs. M_{post} = 2.83, SD = .61, p = .25)

Affect: In the case of the affective dimension, students displayed higher scores at the time of the pretest in comparison to the posttest on the technology and science dimensions (resp.: M = 3.07, SD = .46 vs. M = 3.00, SD = .46, p = .02; M = 3.04, SD = .62 vs. M = 2.97, SD = .62, p = .04).

Behavior: For technology, students scored higher on the pretest (M = 2.23, SD = .9) than on the posttest (M = 2.11, SD = .8), p = .01, while no statistically significant effect of time was found for the attitude dimension of Behavior towards science (M_{pre} = 1.91, SD = .79 vs. M_{post} = 1.94, SD = .76, p = .46).

To summarize, hypothesis 2 is rejected as no difference was found between the intervention and control condition in neither the technology nor the science scale. However, there was an effect of time. For both conditions the findings indicate that students think that science is less difficult at post-measure, and they report less gender stereotypical beliefs at post-measure compared to premeasure for both technology and science. For the affective domain the significant findings indicate that the students experience science and technology related activities less positive at the time of the post-measure. The behavioral dimension shows that students report to be less willing to pursue a technology related activity at post-measure.

CONCLUSION AND DISCUSSION

The aim of the current study was to examine the effect of the VFCt on teachers' and students' attitudes towards science and technology. First, the results that confirmed our hypothesis will be discussed, followed by the results that were contrary to our expectations.

Conclusions

Teacher attitude: In line with our expectation, the results of the questionnaire indicated an intervention effect – with medium to large effect sizes – on teachers' attitudes towards teaching science and technology. Teachers who participated in the intervention reported to feel more in control and experienced more positive feelings, while feeling less stressed and nervous during teaching science and technology at post-measure compared to premeasure reports. For the control condition no change was found. Feelings of control combined with feelings of competence are considered essential to maintain intrinsic motivation for optimal functioning and is as well considered important for personal well-being (Ryan & Deci, 2000). The more positive feelings are towards teaching science and the higher the feelings of control, the more likely it will be that teachers continue teaching science and technology (Van Aalderen-Smeets & Walma van der Molen, 2013). In addition, the profile patterns of teachers' scores on *perceived control* and *affect* made variability between teachers and within teachers visible. The plot of the affect dimension showed that all teachers seem to become more positive towards teaching science and technology, while the rather scattered pattern in the perceived control grid underlines the idiosyncratic nature of change. These dimensions of attitude seem to follow a different pathway of change. Individual variability can be seen as a phenomenon of interest when studying differences in behavior (Van Geert & Van Dijk, 2002) and can be used to improve professionalization interventions tailored to individual needs.

Contrary to our expectation, no effect was found for the *cognition* dimension. The lack of effect for this dimension could reflect a ceiling effect. The mean pretest scores in the intervention condition, on 'importance for future' was M = 4.17 (on a scale from 1 to 5) and in the control condition M = 3.8 are already rather high, which might constrain improvement. Another explanation might be found in the characteristics of the study. The VFCt aimed at improving teachers' behavior. Teachers' feelings about teaching science and technology and their feelings regarding contextual factors (resp. *affect* and *perceived control*) might be more directly reflected in their actions, while teachers' thoughts and perception are less directly linked to their behavior and therefore more rigid. We conclude that actively changing practices can result in attitudinal changes as captured by the questionnaire used in this study.

Student attitude: Contrary to our expectations no intervention effect was found for students' attitude towards science and technology. This finding is in line with Walma van der Molen (2007), who found a negative change in attitude after company visits and in line with Simsek and Kapabinar (2010) who implemented an inquiry-based teaching intervention. We speculate that the negative effect of time on student's attitudes is a reflection of the general tendency of decreasing positive attitudes, as described above. An explanation for no change might be that a short intervention study might not have a large enough impact to change students' attitude, as attitudes are usually hard to change (Niederhauser, Salam, & Field, 1999). In addition, we speculate that especially in students who are not used to checking their own reflections about their own behavior, the connection between attitude reports on the one hand and reflection of attitudes in their commitment, enjoyment and so on with regard to particular activities, is still very weak. There might be a difference between decontextualized reported attitudes, i.e. attitudes that are the subject of explicit and decontextualized reflection, and attitudes that are expressed in the form of real behavior, real commitment, real effort and so forth during contextualized activities (see also Haney et al., 2002). There is more to attitudes than what people report about them, and maybe the most important indicator of attitudes is the actual behavior of people, in this particular case of students, whose enthusiasm, commitment to tasks and so forth changed during the intervention. So maybe an intrinsic weakness of studying attitudes by means of questionnaire reports, especially studying young students, is that questionnaires reflect *reported* attitudes, which might be quite different from the actual drives and motivation towards particular subjects, such as science. Results of previous studies showed that students did show changes in their classroom behavior in terms of increased active cognitive participation (chapter 3 and 4). Future research should help us understand how reported attitudes reflect contextualized (indicators of) attitudes.

However, Parker and Gerber (2000) showed an attitudinal change after 5 weeks. The difference might be found in that these students followed a two hour lesson twice a week, i.e. an intensive course taught by an expert science teacher. In addition, the inquiry-based lessons were complemented with some unique features showing how the science concepts were important to local businesses. The relevance of the topics was thus made explicit to those students. In addition, the teacher in Parker and Gerber's study seemed specialized in teaching science courses. It might therefore be that the teacher modelled a more positive attitude towards students from the start. Both elements might have contributed to the difference in findings. An explanation might therefore be that the students in the current study were not aware how the science and technology lessons were related to the more general questionnaire items. The findings show that an intervention specifically focused at changing interactions in the classroom does not yield changes in students' domain general attitudes towards science and technology.

Future research

The results of this study demand further research to understand why results of teachers' and students' attitudes were not in line. The question is whether the findings of this study adequately reflect behavior in real-time settings, for instance did students' behavior during the science and technology lessons remain the same during the intervention? If not, this might indicate that the effectiveness of the intervention on attitude was assessed on a too general level to address actual dynamic change or that the timescale to assess change in attitude was too short. In addition, future study is recommended to study whether teacher's attitudinal change is visible in their behavior. The assumption that a change in teacher's attitude would cohere with a change in students' attitude was not confirmed. The results showed that the teacher's attitudinal change is convincing. We therefore speculate that teachers did not show their attitudinal change in their behavior towards students. Future study might provide insight into whether teachers started modelling different attitudes during the actual science and technology lessons and how this coheres with behavioral changes of students.

In general, for future research we propose that in order to gain a better understanding of the effect of interventions it is important to assess micro-level changes. In other words, we stress the importance of taking the starting point of development and change into account when assessing educational interventions: teacher-student interaction as the building blocks of learning. Iterations of real-time interactions between teacher and students are the engine of behavioral and attitudinal change. In addition, interaction patterns are an accurate reflection of the quality of teaching in the classroom (Barber & Mourshed, 2007) and might therefore more closely reflect effects of interventions. The interplay of results using different perspectives (questionnaires and observational data) yield insight into how and why an intervention is effective for which individuals (Boelhouwer, 2013). The combination of results supports the optimization of professionalization interventions.

Limitations

One issue concerns the difference between teachers in the intervention and control condition at the start of the intervention. Pre intervention, teachers in the intervention condition indicated a higher value of the importance of science and technology for the future of students' development compared to control teachers, while teachers in the control condition felt less dependent on context factors compared to intervention teachers. This might reflect a difference in intrinsic motivation to change practice; teachers in the intervention condition think that science and technology education is more important for students, but do not feel capable enough to teach science and technology and are therefore motivated to participate in the intervention. We speculate that teachers in the intervention condition were highly motivated as all of them volunteered to participate in an intervention in which they formulated their own goals for change, whereas we do not have information about how motivated those in the control condition eventually were if they would have been given the chance to participate in the intervention. Intrinsic motivation is considered essential for establishing behavioral change (Ryan & Deci, 2000). We took the difference at the start of the intervention into consideration by assessing within group differences only. If the analyses were focused on between group differences a gain-index might have been useful to counteract initial differences (Cox, Reimer, Verezen, Smitsman, Vervloed, & Boonstra, 2009).

In this study, the DAS (Dimensions of Attitude toward Science) instrument was mainly used as a tool to assess the changing attitude of the group of teachers, i.e. for purposes of scientific research. However, the profile pattern plot provides opportunities to characterize the attitude of teachers in a manner that is understandable and usable for teachers themselves, and might therefore be used beyond scientific research (Van Aalderen-Smeets & Walma van der Molen, 2013). The DAS might have been used for practical purposes, for instance as part of the VFCt to tailor the professionalization intervention further to the specific needs of an individual teacher. This might be relevant as the profile plots showed individual variability. Teachers in the reluctant quadrant might benefit more from general pedagogical-didactical strategies to be able to implement science and technology in their curriculum, while teachers in the high potential quadrant might benefit more from specific tools that enable them to increase the quality of the lessons.

Lastly, as the main question of the current article concerned the change in attitudes over the course of the intervention, no attempt has been made to include the gender of the participants as a source of information. The finding that students hold less stereotypical thoughts after the intervention might be an indication of experienced gender differences regarding science and technology. As gender differences are a hotly debated topic, especially in the field of science and technology (OECD, 2015), future study might show whether there are gender differences in students' attitude and whether this is a gender effect in the change over the course of the intervention or whether this is a gender effect in the pattern of the attitudes.

Practical implications

Our finding that by focusing on teacher's practice in the classroom a change in attitude can be triggered in a relatively short period might have wide-ranging practical meaning. That is, if teachers feel more capable to teach science and show enjoyment when teaching science, teachers are expected to continue teaching science and technology (Van Aalderen-Smeets et al., 2013). This is important as science and technology should be a part of the curriculum from an early age on (Jorde & Dillon, 2013, p. 10) to prepare students for the demands of the 21st century. In addition, a more positive attitude of teachers is expected to model students' future behaviors (in the long run). A more positive attitude for students is considered important for the development of science and technology skills in students and increase future career choices in science and technology.

In order to improve the potential attitudinal effects of intervention studies, we conclude that it is important to make students aware of what belongs to science and technology and how their interest fits in there. A more explicit focus on students' thoughts about science and technology might be beneficial. Teachers can support students by explicitly relating the science topic to daily practice or businesses, i.e. show the relevance of the newly acquired information. Teachers can do this by actively evoking students' reflection during science and technology activities by helping them to connect their real-time experiences to outside of school experiences and by modelling their positive attitude towards science and technology.