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Does it matter if students enjoy learning science?

Exploring student attitudes towards science in South Africa

Prepared by TIMSS South Africa Authors

- Attitudes about science formed early in life may influence the relationship that adults have with science in general.
- How students experience science education at school plays an important role in shaping their attitudes towards school science and in influencing their views about science-related topics as an adult.
- The South African public shows signs of becoming more critically engaged with science and technology.
- South African students' enjoyment and value of science is far higher than the international average. In contrast, their belief in their ability to learn science (self-efficacy) is lower than the global average.
- Students with positive attitudes towards science tend to engage in desirable science behaviours e.g. reading about science.
- Students who engage in science activities at home tend to be more positive about school science.
- Positive experiences in the science classroom are linked to positive attitudes expressed by students.
- Girls tend to have less positive attitudes towards science, even when they achieve results that are at the same level as boys.

2000

National Science Week is introduced by the Department of Science and Technology (DST). This country-wide initiative aims to create awareness of science, and to encourage youth to develop an interest in studying science-related subjects.

2001

The Department of Education launches the National Strategy for Mathematics, Science and Technology Education in order to improve the quality of teaching and learning in mathematics and science.

2006

The Youth into Science Strategy is initiated by the DST to enhance participation and performance in, and awareness of, science and science-based careers of school-going youth and undergraduates in science, technology, engineering and mathematics.

2014

The Science Engagement Framework is launched. It aims to encourage science promotion, communication and engagement activities in the country, and to improve the co-ordination of these activities.

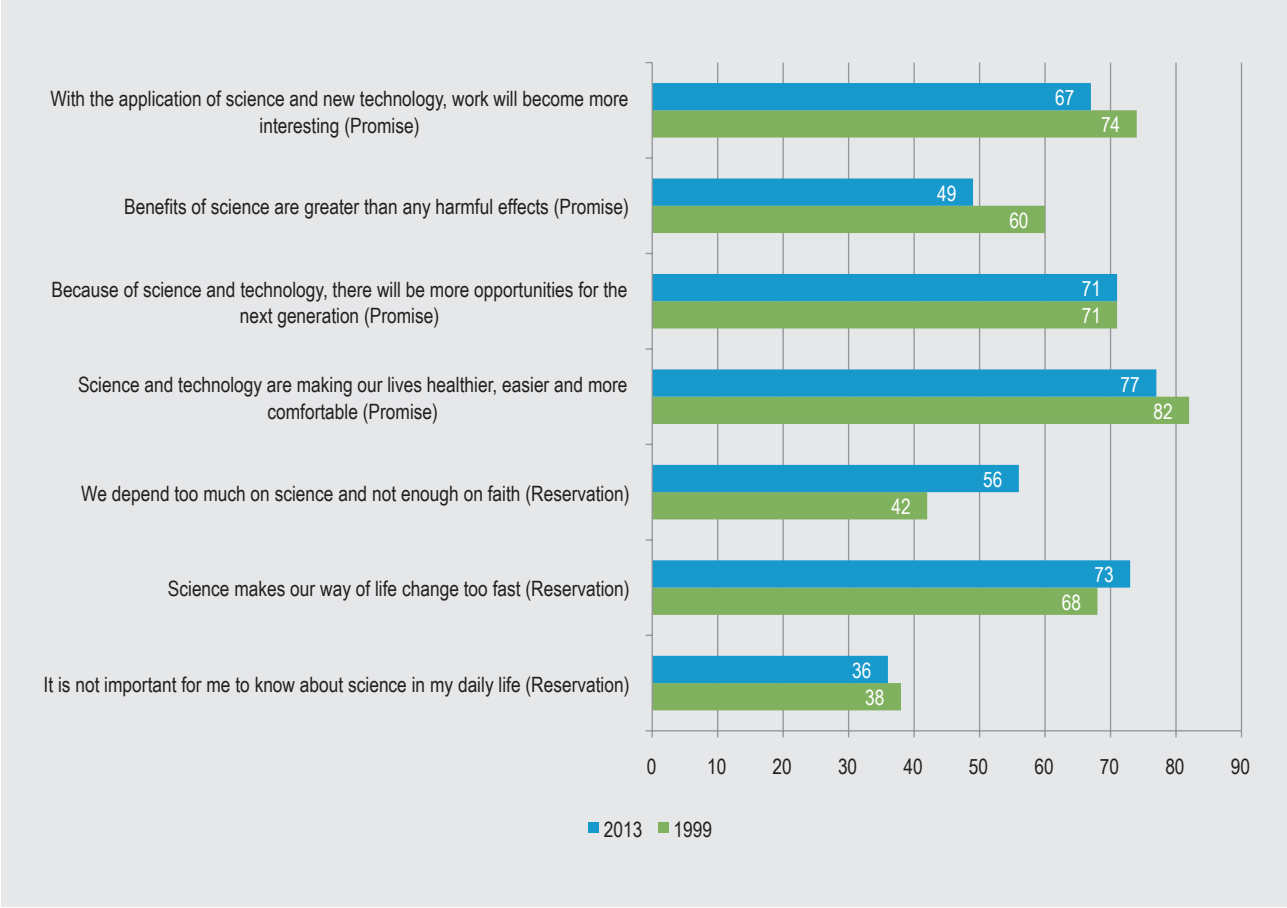
Attitudes to science in South African society

As science and technology have become deeply embedded in our everyday lives, the way in which ordinary people perceive science has been researched not only by the scientific community, but also by social scientists. The assumption is that a positive relationship between the public on the one hand and science and technology on the other can support economic, personal and social development as well as assist in consolidating democracy and citizenship.

Scientific issues such as medical advances, environmental sustainability, ozone depletion, deforestation and climate change require a society that is engaged with science. There is thus a pressing need to improve scientific literacy across all groups within society. School science experiences play an important role in shaping peoples' attitudes towards both school science and science-related topics outside of school. Attitudes formed early in life may influence the relationships that adults have with science in general. The importance of the relationship between the South African public and science has increasingly been recognised by policy makers[1]. Thus, policies have been implemented that stimulate interest and participation in science subjects and careers; encourage investment in research and development; and increase public participation in science policy formulation and adoption.

In 2013, the South African Social Attitudes Survey found that generally, South Africans expressed positive attitudes about science (Figure 1). However, the statements that measured attitudes about the benefits of science showed a general decrease from the previous study conducted in 1999. This may indicate that the public is becoming increasingly cautious about the relevance of science and technology. This finding was echoed in responses to statements that reflected concerns about the role of science. The South African public seems to have become more critical about the impact of science. These attitudinal changes have important implications for the public's relationship with science.

FIGURE 1: SOUTH AFRICAN ATTITUDES TO SCIENCE (1999 AND 2013)

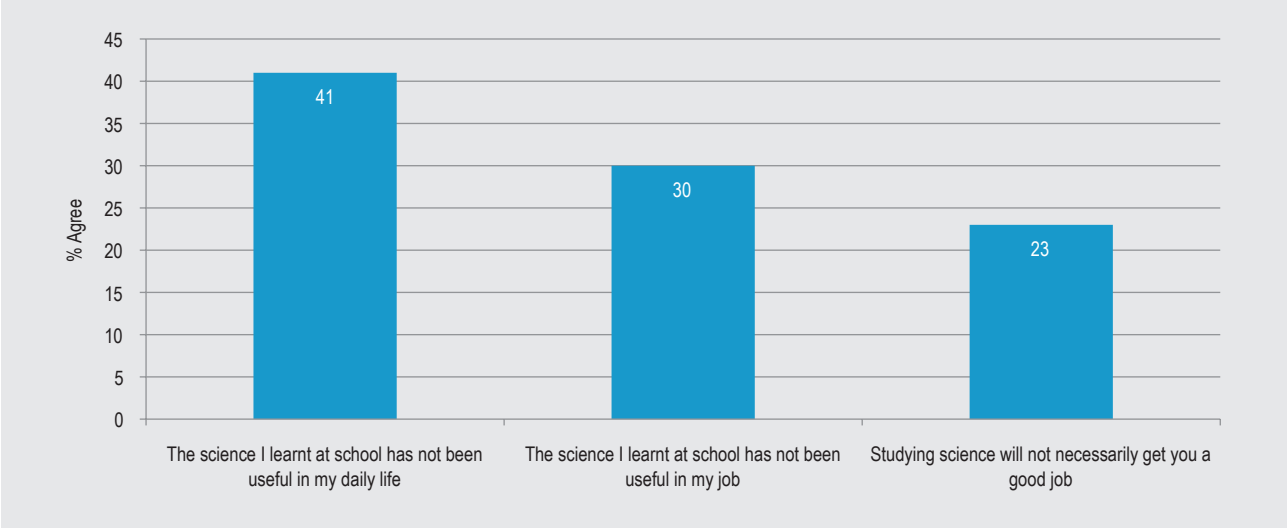


Source: Reddy, V; Juan, A; Hannan, S; Arends, F; Gastrow, M and Roberts, B. (2015) Science awareness, attitudes and astronomy: Continuity and changes.

[1] Reddy, V., Gastrow, M., Juan, A. & Roberts, B. (2013) "Public attitudes to science in South Africa." South African Journal of Science. 109(1/2): 1-8.

The 2013 public relationship with science module also asked respondents about their attitudes towards science as a school subject (Figure 2). Forty-one percent of South Africans did not feel that the science that was learnt at school was useful in their daily lives, while 30% felt that it had no value in their jobs[2]. This may indicate that people do not understand, or are not made aware of, the association between the science they learnt at school and their everyday experiences, or that the science that is taught at school seems disconnected from daily life.

FIGURE 2: SOUTH AFRICAN ATTITUDES TOWARDS THE SCIENCE LEARNT AT SCHOOL (2013)



Source: Reddy, V; Juan, A; Hannan, S; Arends, F; Gastrow, M and Roberts, B. (2015) Science awareness, attitudes and astronomy: Continuity and changes.

It is therefore crucial to ensure that positive school science experiences are provided to promote a public that is more engaged with science and technology.

Why student attitudes matter in South Africa

Many governments and societies are concerned that not enough young people are choosing to study Science, Technology, Engineering and Mathematics (STEM) in secondary school. In South Africa, there is the added concern that women and black South Africans remain under-represented in STEM fields in the labour market. Projections of skills gaps in STEM fields may negatively impact economic development in the future. Thus, a significant amount of research in science education is devoted to understanding ways to improve the quality of science education, with a view to increasing enrolments in science-related post-school studies. Understanding how attitudes are shaped and the behaviours to which they are linked may prove useful in science education in South Africa.

Positive attitudes about science are seen as key to an individual's scientific literacy, but are often overlooked in favour of achievement scores. While achievement scores convey levels of problem-solving skills and intelligence, attitudes convey the emotional evaluation of science and have a powerful influence on behaviour: either facilitating or hindering the learning process. Attitudes towards science also reflect the school culture and climate, and the wider social context in which learning occurs. As such, understanding attitudes is a key element of interpreting achievement results.

Having a positive attitude towards science is a desirable outcome in and of itself, but positive attitudes are also associated with science-related behaviours at school and once schooling has been completed. Students' commitment and motivation to learn science can be affected by whether they find the subject enjoyable; attach value to the subject in terms of its usefulness to themselves and society; and by their self-confidence in their ability to perform specific activities or accomplish science-related tasks (self-efficacy). The decision to pursue science beyond the compulsory stage[3] of education is influenced by the usefulness and relevance of science to students, and by the value attached to the subject. Therefore, those students who highly value science are more likely to continue to study science further. Highly valued subjects also lead to high educational aspirations and to improved achievement[4].

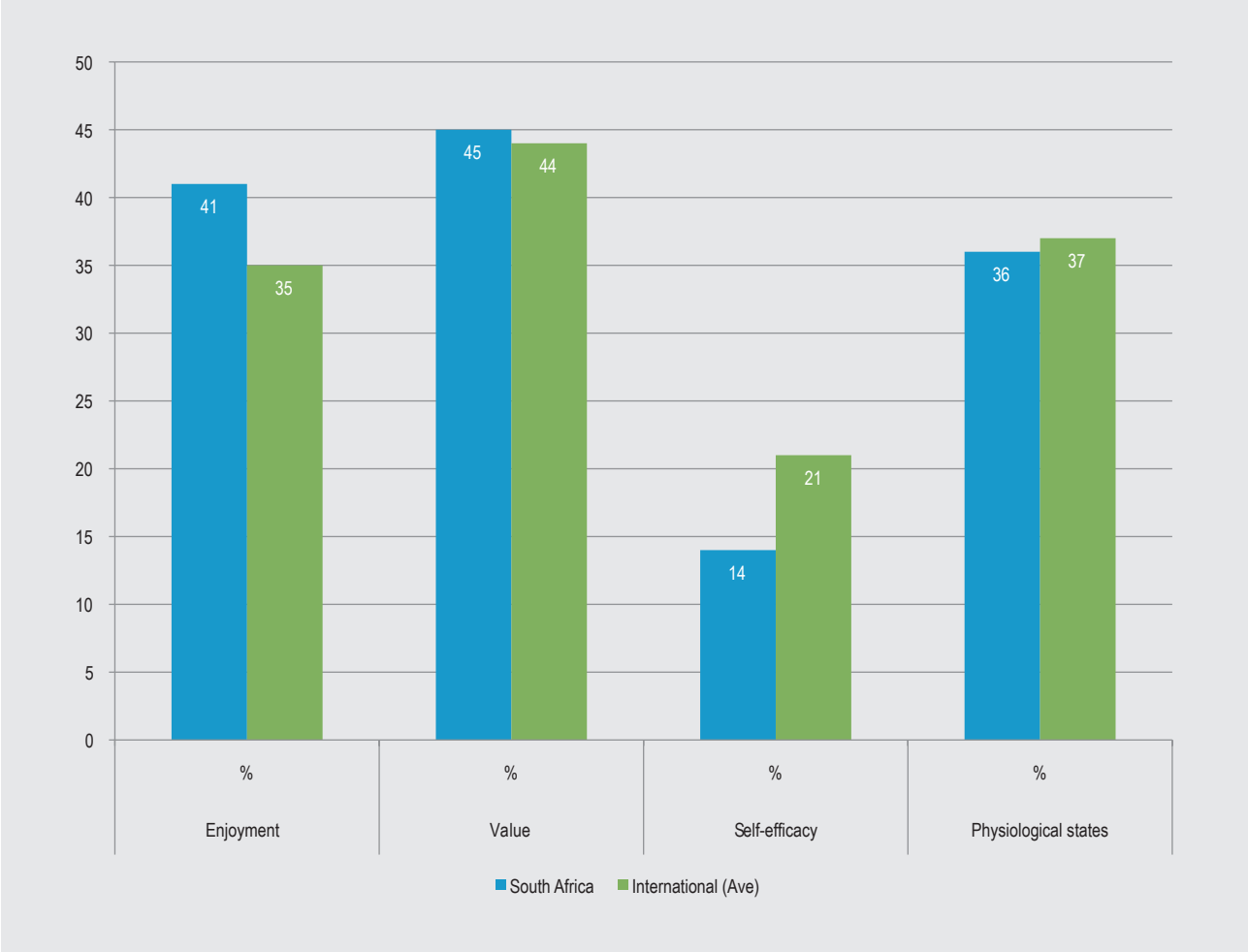
[2] The findings did show generational and educational level effects, with younger and more educated respondents possessing more positive attitudes towards the science learnt at school.
[3] All South African students study general science until the ninth grade. In the tenth grade students can choose to continue with science subjects, including physical science and biology.
[4] Osborne, J., Simon, S., & Collins, S. (2003). "Attitudes towards science: A review of the literature and its implications." International Journal of Science Education, 25(9): 1049-1079.

Assessing the attitudes of South African students

The 2011 Trends in International Mathematics and Science Study (TIMSS) measured attitudes to science through numerous items in a student questionnaire. Students were asked to rate their level of agreement with statements related to the value that they attached to mathematics and science; their level of self-efficacy in their ability to learn science; their motivation to participate in activities purely out of interest and enjoyment; and whether they were motivated to study mathematics and science in order to achieve external goals such as better career choices in the future.

These indicators were grouped into four broad categories: valuing science, enjoyment of science, confidence in ability to learn science (self-efficacy), and physiological states experienced when engaging in science tasks (anxiety, stress or excitement).

FIGURE 3: PERCENTAGE OF STUDENTS EXHIBITING POSITIVE ATTITUDES TO SCIENCE (2011)



Derived from the TIMSS 2011 database

Figure 3 offers up several interesting points. South African students' enjoyment of science was higher than the international average. In contrast, self-efficacy in science was lower than the global average. The percentage of South African students who reportedly experienced positive physiological reactions to science such as excitement and a lack of anxiety were similar to the international average.

The outcome of having a positive or negative attitude towards science is exhibited in behaviours such as spending more time learning or taking science subjects in later years at school. The factors that shape attitudes present opportunities for developing interventions to change negative attitudes which may, in turn, change the manner in which science is learnt[5].

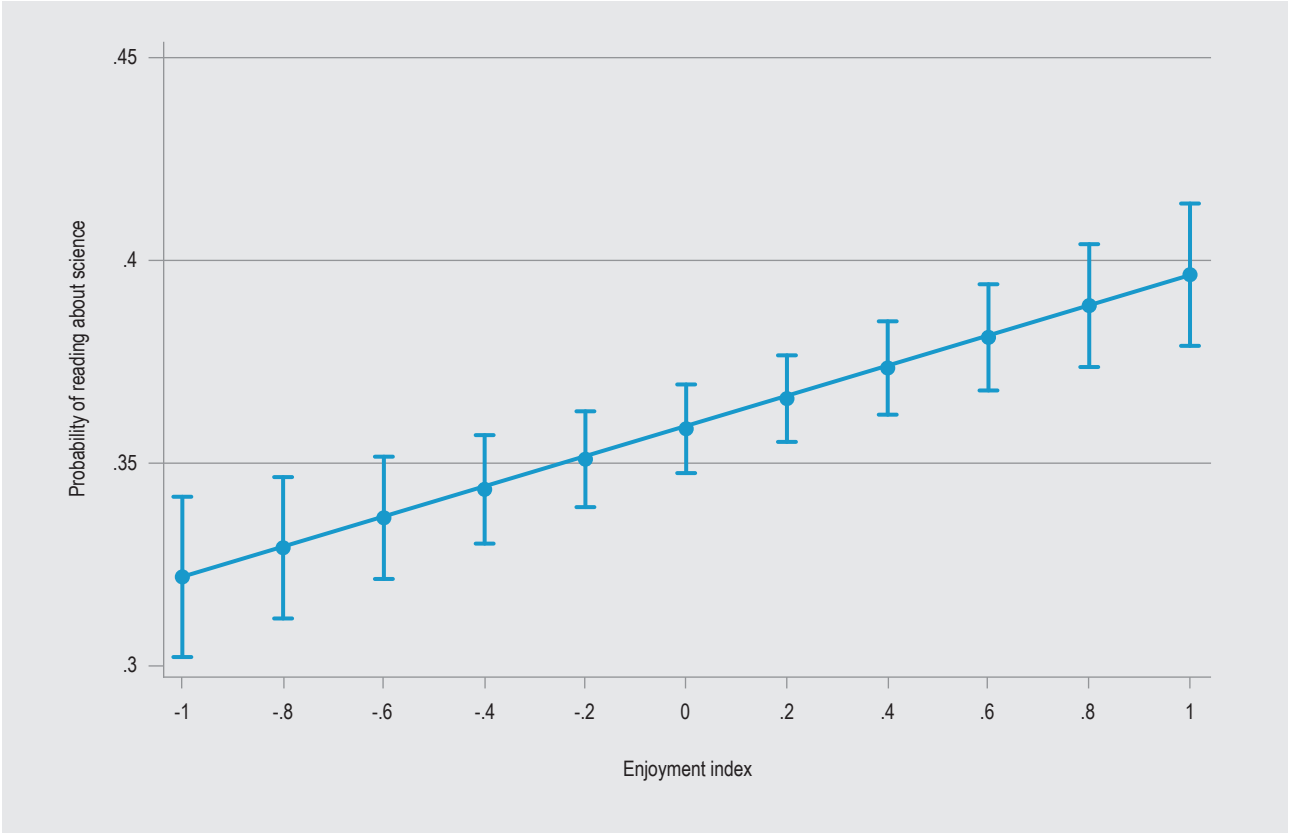
[5] TIMSS does not collect information on teacher attitudes. It is thus not possible to judge if teachers' attitudes (positive or negative) affect students.

Attitudes are shaped by both personal and observed experiences. Factors such as gender, the home environment and curriculum delivery may shape student attitudes. Some of the factors that are associated with the formation and shaping of attitudes were explored.

Students with positive attitudes towards science tend to engage in desirable science behaviours

Students were asked whether they read about science in their spare time. This behaviour indicates an engagement with science beyond what is mandatory during school lessons. Those students who enjoyed science were 21% more likely to read about science when outside school. Similar patterns were found for those who valued science and expressed high self-efficacy. These patterns held even after other student background factors, including gender and socioeconomic status, were considered (Figure 4).

FIGURE 4: PROBABILITY OF READING SCIENCE OUTSIDE SCHOOL BY ENJOYMENT OF SCIENCE (2011)



Derived from the TIMSS 2011 database

Students need to be willing to engage with science problems and be open to new challenges in order to be able to master the subject. Proficiency in science requires a mix of content knowledge and willingness to engage with new material. TIMSS measures students' openness to problem solving through their responses to questions about the extent to which they feel they can solve complex scientific problems. It was found that students who had a strong belief that they could succeed in science tasks were more than four times more likely to attempt these activities than students who were not confident in their science ability. It is not clear from this finding whether students with greater self-belief achieve higher scores irrespective of the level of difficulty of the task presented, or whether positive experiences about problem solving lead to higher levels of self-efficacy.

In conjunction with reading about science outside school and being open to problem solving, science achievement was viewed as a behavioural outcome. Table 1 compares average achievement scores by grouping students into three different levels of attitude – high, medium and low. Internationally, there was a striking similarity between attitude levels and average achievement scores. On average, students with more positive attitudes on any of the three attitude indicators tended to achieve better mathematics and science scores. In South Africa, the difference in achievement results was most pronounced between the highest category and the middle and bottom categories.

TABLE 1: ENJOYMENT, VALUING AND SELF-EFFICACY OF SCIENCE BY AVERAGE ACHIEVEMENT SCORE (2011)

		HIGH		MEDIUM		LOW	
		%	Ave score	%	Ave score	%	Ave score
Enjoyment	South Africa	41	376	45	311	14	313
	International (Ave)	35	515	44	472	21	450
Valuing	South Africa	57	344	26	319	16	346
	International (Ave)	41	502	33	477	26	457
Self-efficacy	South Africa	17	399	59	326	24	323
	International (Ave)	20	536	49	482	31	450

Derived from the TIMSS 2011 database

The findings from Table 1 indicate that although students exhibited a more positive attitude in terms of valuing science, this did not translate into better science achievement. This may be because both weak and strong students share similar views about science.

Self-efficacy was found to be positively associated with achievement. Higher levels of enjoyment, which had the highest association with science achievement, and self-efficacy may therefore translate into more effort being put into learning and understanding school science (Table 2).

TABLE 2: RELATIONSHIP BETWEEN ATTITUDES AND SCIENCE ACHIEVEMENT (2011)

	Science achievement
Gender (Girls)	----
Age	----
Home socioeconomic status	++++
Enjoyment	++++
Value	----
Self efficacy	++++

Note: ++++,---- $p \leq 0.01$
Derived from the TIMSS 2011 database

Students who are positive about science tend to have parents who show interest in their science homework

Considerable literature supports the importance of a supportive home environment and parental behaviour in shaping students' achievement at school[6]. The relationship between these factors and attitudes towards science were explored. Students were asked how often certain activities took place at home. These activities included parents wanting to know what was learnt at school, parents checking homework and ensuring that time was set aside for homework. The responses reflected the different levels of engagement between parents and students. In general, participating in these activities was found to be positively associated with the expression of positive attitudes by students. This relationship remained even when factors such as science achievement, socioeconomic status and gender were taken into account (Table 3).

TABLE 3: THE RELATIONSHIP BETWEEN ATTITUDES AND PARENT BEHAVIOUR (2011)

	Enjoyment	Value	Self-efficacy
Gender (Girls)	--	----	----
Age	--	0	--
Home socioeconomic status	++++	0	++++
Science achievement	++++	++	++++
Parents ask what has been learnt in school	++++	++++	++++
Parents make sure that time is set aside for homework	++++	++++	++++
Parents check if homework is done	++++	++++	++++

Note: ++++,---- $p \leq 0.01$; ++, -- $p \leq 0.05$; 0 $p \geq 0.05$
Derived from the TIMSS 2011 database

[6] See: Jeynes, W. (2005)"A meta-analysis of the relation of parental involvement to urban elementary school student academic achievement." Urban Education 40(3): 237-269; and Sirin, S. (2005) "Socioeconomic status and academic achievement: A meta-analytic review of research." Review of Educational Research 75(3): 417-453.

The measure of socioeconomic status (SES) was based on the number of books within the home, educational study supports (such as a desk and internet connection), as well as parental educational levels. Higher SES was related to more positive attitudes about scientific material. This finding suggests that the additional resources that wealthier students can draw upon encourage more positive views about science.

Students who report positive classroom interactions with their teachers are more optimistic about science

Classroom interactions between students and teachers were assessed by examining instructional practices. Positive teacher-directed instruction involves explicitly teaching scientific rules, concepts, principles and problem-solving strategies. This often includes modelling a variety of examples and guiding students during their review and practice. If students do not have a clear understanding of how a task will look when it is completed, their efforts to complete the task will often be ineffective. Students rated their agreement with the following statements: 'I know what my teacher expects me to do', 'My teacher is easy to understand' and 'I am interested in what my teacher says'.

Feedback from teachers clarifies areas where a student is doing well, but may also show how far a student must improve. This is a form of social persuasion. It refers to judgments that teachers make regarding the capabilities of the student. Positive persuasions build stronger beliefs in capabilities and in the successful attainment of goals. Students rated their agreement with the following statements: 'My teacher tells me I am good at science', and 'My teacher thinks I can do well in science with difficult materials'.

All five items relating to classroom practices were combined into a single indicator of classroom experiences. The findings indicate that positive classroom interactions are associated with positive attitudes across the attitudinal measures (Table 4).

TABLE 4: THE RELATIONSHIP BETWEEN ATTITUDES AND SCIENCE ACHIEVEMENT (2011)

	Enjoyment	Value	Self-efficacy
Gender (Girls)	0	----	----
Age	--	0	----
Home SES	++++	0	++++
Science achievement	++++	0	++++
Classroom experiences	++++	++++	++++

Note: *++++,---- $p \leq 0.01$; ++, -- $p \leq 0.05$; 0 $p \geq 0.05$*
Derived from the TIMSS 2011 database

Boys tend to exhibit more positive attitudes to science

The commonly held view is that doing science is more consistent with a male self-image than with a female one[7]. We examined whether this gender-related image of science impacted the attitudes that students expressed towards science.

When controlling for factors such as science achievement, socioeconomic status and school experiences, girls were still less likely to value science and have confidence in their ability to learn science (Table 3).

These findings echo results from Organization for Economic Cooperation and Development (OECD) countries in the 2012 Programme for International Student Assessment (PISA) study[8], where girls who performed on par with boys were found to exhibit higher levels of anxiety and lower levels of openness to problem solving.

[7] Ceci, S. J., & Williams, W. M. (2011). "Understanding current causes of women's underrepresentation in science". Proceedings of the National Academy of Sciences, 108(8): 3157-3162.
[8] PISA 2012 Results: Ready to Learn (Volume III).

Implications: what can be done to foster positive attitudes?

- Develop communication strategies at both school level and for the general public that highlight the relevance of science to our everyday lives.
- At school level, invest in approaches that address aspects of attitudes and learning behaviours, and consider this as a goal of quality education. Schools should develop policies that highlight the crucial role that teachers play in shaping attitudes towards science, and ensure that techniques are employed to foster positive attitudes.
- Particular attention must be paid to inequalities between the genders in the effectiveness with which schools and societies promote motivation and interest in science. Programmes that use female role models may encourage girls to recognise that they are capable of pursuing science careers.
- Raise awareness among parents and caregivers of the importance of engaging with students about their homework and reading about science.

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