I believe I can do science: Self-efficacy and science achievement of Grade 9 students in South Africa

AUTHORS:
Andrea Juan[1]
Sylvia Hannan[1]
Catherine Namome[2]

AFFILIATIONS:
[1]Human Sciences Research Council, Durban, South Africa
[2]Human Sciences Research Council, Pretoria, South Africa

CORRESPONDENCE TO:
Andrea Juan

EMAIL:
ajuan@hsrc.ac.za

DATES:
Received: 08 Aug. 2017
Revised: 07 Nov. 2017
Accepted: 16 Feb. 2018
Published: 30 July 2018

KEYWORDS:
TIMSS; science attitudes; self-confidence

HOW TO CITE:
Juan A, Hannan S, Namome C. I believe I can do science: Self-efficacy and science achievement of Grade 9 students in South Africa. S Afr J Sci. 2018;114(7/8), Art. #2017-0269, 7 pages. http://dx.doi.org/10.17159/sajs.2018/20170269

ARTICLE INCLUDES:
× Supplementary material
✓ Data set

FUNDING:
None

An important component of an individual's scientific literacy is a positive attitude towards science. However, emphasis is too often placed on achievement scores rather than attitude. While individuals' relative levels of problem-solving skills, inherent aptitudes for the subject matter and teaching practices are conveyed through achievement scores, attitudes to science convey individuals' emotional evaluation of the subject. Attitudes have a strong impact on behaviour: through either facilitating the learning process or hindering it. Furthermore, attitudes towards science reflect the culture which exists within a school, as well as the wider social context within which learning takes place. As a result, understanding attitudes is a key component of the interpretation of achievement results. We used data from 12 514 Grade 9 students in South Africa who participated in the 2015 Trends in International Mathematics and Science Study to investigate students' self-efficacy in science. Multiple linear regression analyses were used to address the following key research questions: (1) What is the relationship between self-efficacy and science achievement for Grade 9 students in South Africa? and (2) What are the contextual factors associated with the self-efficacy of Grade 9 students in South Africa? The findings reveal a positive relationship between self-efficacy and science achievement and suggest a need to also focus on non-cognitive aspects in order to improve science achievement.

Significance:

- The study contributes to understanding the determinants of science performance at school.
- The findings highlight the importance of non-cognitive dimensions in science achievement at school.
- The findings have policy implications for education programmes and teachers in relation to interventions which incorporate non-cognitive dimensions.

Introduction

Science is considered an important area of education in any country, as it contributes to increased science and technology knowledge and increased scientific development in higher education and other related fields, while scientific knowledge has an economic utility and cultural significance. It is therefore concerning that there has been a global decrease in the number of students choosing to pursue science. This shift is particularly apparent in the final years of secondary education.[1-3] South Africa is no exception to this trend. Many students perform poorly in science, and do not choose to continue with it, or may not qualify to study science at university.[4,5] A significant amount of science education research has therefore been dedicated to identifying ways to improve the quality of science education, and subsequently increase enrolments in science-related studies at the post-school level.[6] In the pursuit of remedying this situation, studies have examined the determinants of science achievement. One of the areas of study has been student attitudes. There has been an increased focus on the need to develop positive attitudes towards science, learning science and scientists.[1,3,7]

At a national level, the 2010 and 2013 South African Social Attitudes Survey results showed that generally South Africans expressed positive attitudes about science. However, the statements that measured attitudes about the benefits of science showed a general decline from 1999 when these questions were introduced to the study. An analysis of the items which measured scepticism towards science showed that the South African population seems to have become more cautious about the level of trust they place in science, and more concerned about the impacts of science.[8,9]

The survey also asked questions related to the attitudes of respondents towards science as a subject at school. The results showed that 41% of South Africans felt that the science learned at school was not useful in their daily lives, while almost a third (30%) did not see its value in their jobs. These findings may indicate that people are unaware of the applications of school science in their daily lives, or that school science is taught in a way that is disconnected from individuals' daily life experiences.[9]

Experiences of school science play a critical role in shaping peoples' attitudes towards the science they are taught at school, as well as science-related topics which they encounter outside of school.[6,10] Attitudes towards science that are formed early in life may have an impact on the relationships that individuals have as adults with science in general.[6] It is therefore important to understand the way in which attitudes are shaped and the associated behaviours in order to enhance science education in South Africa.

Positive attitudes towards science are considered to be a central component of an individual's scientific literacy, but are often overshadowed by the emphasis placed on science achievement scores.[6,11] Although achievement scores provide an understanding of an individual's aptitude and problem-solving skills, attitudes offer an emotional evaluation of science and are significant determinants of behaviour in relation to the learning process.[1,6,7] In addition, attitudes towards science are a reflection of the school climate and culture, and highlight the social context in which learning takes place.[6] As such, understanding attitudes is important in the interpretation of achievement results.

Creating positive attitudes towards science is a desirable outcome in and of itself; however, positive attitudes are also associated with science-related behaviours both at school and outside of school.[6,7]

In the 2015 Trends in International Mathematics and Science Study (TIMSS), Grade 9 students in South African schools scored an average of 358 points on a scale with a mean of 500 and a standard deviation of 100, and ranked last of the 39 participating countries, three of which participated in TIMSS at the Grade 9 level. Only 21% of the 12 514 South African students reported high levels of self-efficacy, with 45% reporting moderate levels and 35% reporting low levels of self-efficacy. Those students who reported high levels of self-efficacy scored 64 points higher in the science achievement test than those who reported low levels.[12] This finding has negative implications for the continuity of scientific endeavour, as well as for the scientific literacy of future generations, and the country's innovation economy.

The commitment and motivation to learn science can be influenced by whether students enjoy the subject, attach value to it in terms of its usefulness to both themselves and society, and by their science self-efficacy which relates to their self-confidence in their ability to accomplish science-related tasks and activities. In order to investigate students' self-efficacy in relation to science, we address two key research questions:

(1) What is the relationship between self-efficacy and science achievement for Grade 9 students in South Africa?

(2) What are the contextual factors associated with the self-efficacy of Grade 9 students in South Africa?

Literature review

Self-efficacy is a core feature of social cognitive theory, which posits that people do not merely respond to influences within their environment, but actively seek out and interpret information in order to make decisions. This human agency relies, in part, on a person's beliefs in their efficacy to exercise control over their own functioning, as well as events that have an impact on their lives.[13] The founder of the theoretical underpinnings of self-efficacy, Albert Bandura, stated that self-efficacy relates to a personal expectation of one's ability to perform in order to reach specific goals.[13] When applying this to education, the expectation, in turn, affects students' motivation, interest and performance in a subject. This relates to all subjects, including science. Efficacy beliefs therefore affect how much effort people apply to an activity, how long they will continue when encountering obstacles (persistence), and how resilient they are when confronted with difficult situations.[7,13-15] Resilience contributes to the alleviation of stress and promotes adaptation and the development of skills to cope with adversity and change.[14,16,17]

The sources of self-efficacy can be grouped into four categories:

- *Mastery experience* which results from students engaging in science tasks, interpreting the outcomes of those tasks and using this interpretation to formulate beliefs about capability and capacity to perform the task. Successful outcomes result in confidence.
- *Vicarious experience* which stems from students observing peers performing tasks, and then evaluating their own prospect of success in similar tasks.
- *Social persuasion* which refers to judgements that other people make regarding the capabilities of the student. Positive persuasions build stronger beliefs in capabilities and in the successful attainment of goals.
- *Physiological states* experienced when engaging in science tasks: anxiety, stress or excitement. The degree of confidence is gauged by the physical state that is experienced while engaging in the task.[18]

Self-efficacy emerges from what students infer from these sources, and teachers can enhance students' self-efficacy through understanding and utilising these sources.[15,19] Schunk[20], for example, highlights the impact of modelling (reproducing the strategies and behaviours of one or more models, which may be teachers or peers, and patterning one's thoughts and beliefs after theirs), goal setting and self-evaluation on self-efficacy. Pajares highlights that teachers should assess and attempt to develop students' self-efficacy as they progress through school, as these beliefs 'can have beneficial or destructive influences'[15(p.120)].

Factors associated with self-efficacy

The strength of self-efficacy also has an impact on changes in behaviour, as those who have a higher self-efficacy are more likely to exhibit greater persistence in achieving success, no matter what the level of difficulty, and they approach these tasks as challenges to be overcome.[21,22] Conversely, those who have low self-efficacy believe that tasks are more difficult than they realistically are, and consequently experience stress and anxiety when facing these challenges.[23] Low self-efficacy beliefs have a negative impact on academic achievement, and can, over time, 'create self-fulfilling prophecies of failure and learned helplessness that can devastate psychological well-being'[19(p.219)].

Although the findings regarding the link between self-efficacy and science achievement vary, most of the research has shown that there is a significant correlation between the two constructs.[15,18,24-26] This positive relationship remains across levels of education, and is strongly associated with taking science-related majors and the pursuit of science-related careers.[10,18]

Studies have found gender differences related to self-efficacy.[15] However, this association differs internationally, and has been attributed to differences in the opportunities which are afforded to female individuals.[7,27] Britner and Pajares[18] found that gender differences found in the sources of self-efficacy were minimal. In their study, girls reported greater anxiety about their performance in school science, but were more confident in their ability to manage their studies successfully.

The influence of other attitudes to science, in terms of enjoyment and value, has also been examined. Students' enjoyment of science and the value they place on it in terms of its usefulness, can affect their commitment and motivation to learn the subject.[7]

The role of the teacher in terms of encouragement, teaching approach and the learning environment they create is also important.[15,27] Positive teacher-directed instruction involves the explicit teaching of scientific rules, principles, concepts and strategies for problem-solving. This instruction often includes modelling a variety of examples and guiding students through 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. Feedback from teachers clarifies areas in which a student is doing well, but may also show how far a student must improve. This feedback is a form of social persuasion.[18] It refers to judgements that teachers make regarding the capabilities of the student. Positive persuasions build stronger beliefs in capabilities and in the successful attainment of goals. Self-efficacy and achievement may be enhanced through teaching practices that incorporate progress feedback, modelled strategies, self-evaluation and goal setting. Through the use of such methods, teachers can promote improved academic performance and motivation for continued learning.[15,20] Resilience is affected by the mindset of students, and students who have the belief, or are taught, that they can develop their intellectual abilities, tend to perform better. Students with a growth mindset therefore persevere when faced with challenges.[28,29]

When examining academic achievement in South Africa, the role of socio-economic status (SES) cannot be overlooked. The educational outcomes of students in South African schools are influenced by the socio-economic imbalances which exist in the country. Students attending schools in the richest quintile (quintile 5) significantly outperform students from schools in the other four quintiles.[30] Further important factors are parental involvement and attitudes, with students from family environments in which parents highly value science being more likely to achieve well in science.[31,32] Various forms of parental involvement have been found to be associated with self-efficacy, including involvement in school functions and extra-curricular activities, modelling persistence and teaching children how to cope with difficulties, encouraging children to try various activities and supporting their efforts, and providing an environment that allows for mastery experiences and stimulates curiosity.[33,34] Students from high SES families are more likely to achieve better results in science[35,36], and students who attend schools where their peers come from higher SES families also outperform their peers at schools with lower concentrations of wealth.[37] Students from families with higher SES have more home resources, such as computers and books, as well as 'social capital' in terms of supportive relationships among schools and individuals which highlight societal norms and values, which lead to school success.[34,36,38]

Methodology

The data used for this article were from the TIMSS 2015 study conducted by the International Association for the Evaluation of Educational Achievement (IEA). The sampling procedure followed a two-stage stratified cluster sample design.[40] In the first stage the population of South African schools that offered Grade 9 classes in 2013 was stratified according to province, type of school (public or independent) and language of instruction.[39] Schools were then sampled using a systematic random sampling approach. In the second stage of sampling, intact classes were selected with equal probability from each participating school.[40] The 2015 sample consisted of 12 514 students in 292 schools.

Measures and variables

This section details the variables that were used and prepared for inclusion in regression analyses for the purpose of addressing the research questions. In the TIMSS contextual questionnaire for students, questions fall within three broad measures of attitudes and self-belief. These measures include students enjoying science, valuing science and self-efficacy in science. The scaled index for self-efficacy was created by the IEA from the following statements: 'I usually do well in science'; 'Science is not one of my strengths'; I learn things quickly in science'; 'Science is harder for me than any other subject'; 'I am good at working out difficult science problems' (all indicating mastery experience); 'Science is more difficult for me than for many of my classmates' (vicarious experiences); 'My teacher tells me I am good at science' (social persuasion); 'Science makes me confused' (physiological states).[12] Indices for enjoyment of and valuing science were also created in a similar fashion by the IEA. The enjoyment index was created from the following statements: 'I enjoy learning science'; 'Science is boring'; 'I like science'; 'I wish I did not have to study science'; 'I learn many interesting things in science'; 'I look forward to learning science in school'; 'Science teaches me how things in the world work'; 'I like to conduct science experiments'; and 'Science is one of my favourite subjects'.[12]

The valuing index was created from the following statements: 'I think learning science will help me in my daily life', 'I need science to learn other school subjects'; 'I need to do well in science to get into the university of my choice'; 'I would like a job that involves science'; 'I need to do well in science to get the job I want'; 'Learning science will give me more job opportunities when I am an adult'; 'It is important to learn about science to get ahead in the world'; 'My parents think that it is important that I do well in science'; and 'It is important to do well in science'.[12]

Other variables in the regression model included students' classroom and home experiences. The index for classroom experiences was created by the IEA from the following statements: 'I know what my teacher expects me to do'; 'My teacher is easy to understand'; 'I am interested in what my teacher says'; 'My teacher gives me interesting things to do'; 'My teacher has clear answers to my questions'; 'My teacher is good at explaining science'; 'My teacher does a variety of things to help us learn'; 'My teacher lets me show what I have learned'; 'My teacher tells me how to do better when I make a mistake'; and 'My teacher listens to what I have to say'. Home experiences were assessed by the following items: 'My parents ask me what I am learning in school'; 'My parents make sure that I set aside time for my homework'; and 'My parents check if I do my homework'. Responses to these statements were converted to dummy variables, where one (1) indicates that the activity was done and zero (0) indicates the absence thereof.

The values for all indices were converted to scale scores (all indices were put on a common scale to account for differences across the indices) and then converted to z scores (mean=0, standard deviation=1). Using z-scores enables the comparison of two or more scores that are from different normal distributions.

The following variables were included in this regression analysis as controlling variables: gender, age, squared age and home SES. The home SES is a composite variable with 14-item variables if a learner indicated having a fridge, television, own room, own/shared computer, Internet connection, landline telephone, motor car, water flush toilets, running tap water, electricity, dictionary, a gaming system, own cell phone and a study desk. Using factor scores from a principal component analysis as weights, a home SES variable was then constructed for each learner. The eigenvalue (variance) for each principal component indicated that the principal component accounted for 79% of the variation. In using the square of the age variable, we were testing a quadratic relationship between age, self-efficacy and science achievement. The assumption was that the age variable was non-linearly related to science achievement and self-efficacy.

The TIMSS 2015 study included a science test. Science scores were reported on a common scale with a centre point of 500 and standard deviation of 100 by using item response theory.

Data analysis

Using multiple regression analyses, we developed two models to investigate whether self-efficacy explains science performance, and whether it is associated with student contextual factors. Student measures that were statistically significant at the 95% ($p<0.05$) and 99% ($p<0.01$) confidence levels were identified. The first model explains the association between science performance and self-efficacy while controlling for attitudinal factors including enjoying science and valuing science as well as gender, age, square of age and home SES. In the second model, we investigated the association between self-efficacy and students' home and school experiences controlling for home SES, science performance, gender, age and the square of age. The data analysis was done with SPSS version 24 and the IEA International Database (IDB) Analyzer (version 3.1.17), which is a plug-in for SPSS developed by the IEA specifically to analyse data from IEA surveys. The software takes into account the complex sample design and makes use of plausible value technology. The IDB Analyzer generates SPSS syntax that takes into account the sampling design in the computation of sampling variance, and the plausible values used to compute achievement scores. The IDB Analyzer enables the calculation of descriptive statistics and conducts statistical hypothesis testing among groups in the population without the need for programming code.[41] All models estimated in our analysis rely on this procedure.

Results

Table 1 sets out the means and standard deviations of the variables and constructed indices. Table 2 represents the results of the multiple regression analysis conducted to test if self-efficacy significantly predicts overall science performance. This model accounted for 27% of the variance in science achievement (adjusted $R^2=0.27$, $p<0.00$). The gender, home SES and age variables behave as expected. On average, girls tended to score almost 6 points lower than boys ($\beta=$ -5.86, $p<0.01$) and each additional home asset was associated with a 31-point increase in science scores ($\beta=$ 30.86, $p<0.01$). The findings regarding age show that science achievement is positively associated with age ($\beta=$ 90.82, $p<0.01$) up to a point but as students get older (above the grade appropriate age), the effect of age is negative ($\beta=$ -3.72, $p<0.01$).

After taking into account other key background characteristics such as gender, age and home SES, as well as other measures of attitude, self-efficacy still had a significant positive association with science achievement. Every standard deviation increase in the self-efficacy index was associated with a 7 scale score point increase in science achievement ($\beta=7.29$, $p<0.01$). Interestingly, valuing science was associated with a decrease in science achievement. This finding suggests that valuing science alone is not a strong enough attitude to ensure that students perform well in science. This result highlights the need to focus on encouraging the enjoyment of science, as well as building students' self-efficacy in science.

Table 3 presents results of the second model – a multiple regression analysis conducted to determine the contextual factors associated with self-efficacy. This model accounted for 31% of the variance in self-efficacy (adjusted $R^2=0.31$, $p<0.00$). The model shows that after controlling for gender, age and home SES, interaction between teachers and students (classroom experiences) had the highest effect on self-efficacy ($\beta= 0.51$, $p<0.01$), science achievement had the second highest effect ($\beta= 0.17$, $p<0.01$) and parents checking homework had a very low ($\beta= 0.04$, $p<0.05$) but significant effect on self-efficacy.

Students were asked how often certain activities took place at home. These activities included parents wanting to know what was learned at school and parents checking homework, and ensuring that time was set aside for homework. The responses to these questions reflected the different levels of engagement between parents and students. The act of parents checking whether homework was done was found to be positively associated with the expression of self-efficacy by students. Students whose parents checked their homework had a 0.04 of a standard deviation score higher for self-efficacy than students whose parents did not check their homework, with all other factors in the model taken into account ($p<0.05$). This relationship remained, even when factors such as science achievement, home SES and gender were taken into account. This finding points to a need to raise awareness among parents and caregivers of the importance of engaging with students about their homework and reading about science. Higher levels of home SES were related to more positive attitudes about science.

Classroom experiences, as measured by classroom interactions between students and teachers, were assessed by examining instructional practices. The focus of the items that constituted the index was the degree of engagement between student and teacher. It was found that positive classroom interactions were significantly associated with increases in self-efficacy ($\beta= 0.51$, $p<0.01$).

The influence of gender is striking. When factors such as science achievement, home SES and classroom experiences were controlled for, girls were less likely to have confidence in their ability to learn science ($\beta= -0.05$, $p<0.05$).

Table 1: Descriptive statistics of predictor variables

Variable	**Continuous variable**		**Dummy variable**	
***N*=12 514**	**Mean**	**Standard deviation**	**Percentage of students with dummy=1**	**Percentage of students with dummy=0**
Science achievement	372	100		
Self-efficacy	10.20	1.95		
Enjoy learning science	10.64	1.93		
Value science	10.85	1.90		
Age	15	1.22		
Age^2	249	39.56		
Home socio-economic status	2.91	0.95		
Gender (girl)			51	49
Parents ask me what I am learning in school			63	37
Parents make sure that I set aside time for my homework			66	34
Parents check if I do my homework			57	43

Author's own calculations from the TIMSS 2015 database[42]

Table 2: Multiple regression results investigating the association between science performance and self-efficacy

Explanatory variable	**Regression coefficient**	**Regression coefficient (s.e)**	**Regression coefficient *(t*-value*)***	**Standardised coefficient**	**Standardised coefficient (s.e.)**	**Standardised coefficient (*t*-value)**	***p*-value**
Gender (girl)	-5.86	1.90	-3.08	-0.05	0.02	-3.03	<0.01
Age	90.82	25.49	3.56	1.03	0.29	3.61	<0.01
Age^2	-3.72	0.78	-4.74	-1.37	0.28	-4.88	<0.01
Home socio-economic status	30.81	2.92	10.57	0.27	0.02	12.96	<0.01
Enjoy science	16.58	2.58	6.42	0.16	0.03	6.16	<0.01
Value science	-14.23	2.10	-6.78	-0.14	-0.02	-6.32	<0.01
Self-efficacy	7.29	2.63	2.77	0.07	0.02	2.83	<0.05
Constant	-232.98	208.98	-1.11	–	–	–	

Authors' own calculations from the TIMSS 2015 database[42]

Table 3: Multiple regression results investigating the association between self-efficacy and contextual factors

Explanatory variables	Regression coefficient	Regression coefficient (s.e)	Regression coefficient (*t*-value)	Standardised coefficient	Standardised coefficient (s.e.)	Standardised coefficient (*t*-value)	*p*-value
Gender (girl)	-0.05	0.02	-2.81	-0.04	0.02	-2.84	<0.05
Age	-0.35	0.20	-1.70	-0.41	0.23	-1.75	
Age^2	0.01	0.01	1.52	0.36	0.23	1.56	
Home socio-economic status	0.05	0.01	4.40	0.05	0.01	4.32	<0.01
Science achievement	0.00	0.00	8.59	0.17	0.02	8.29	<0.01
Parents ask what has been learnt in school	0.00	0.01	0.19	0.00	0.01	0.19	
Parents make sure that time is set aside for homework	0.01	0.01	0.91	0.01	0.01	0.91	
Parents check if homework is done	0.04	0.02	2.33	0.04	0.02	2.37	<0.05
Classroom experiences	0.51	0.02	31.01	0.51	0.01	48.79	<0.01
Constant	2.33	1.68	1.39	.	.	.	

Author's own calculations from the TIMSS 2015 database[42]

Discussion and conclusion

The aim of our study was to determine the degree to which self-efficacy beliefs are associated with science achievement of a sample of Grade 9 students in South Africa. In addition, we examined contextual factors that may shape science self-efficacy in these students. Self-efficacy was found to be positively associated with achievement. This finding is consistent with a number of studies such as Britner and Pajares[18], Singh et al.[24], Juan et al.[25] and Sabah and Hammouri[26]. Higher levels of enjoyment, which had the highest association with science achievement compared with the other two attitudinal indices (value and self-efficacy in science), and improved self-efficacy, may therefore translate into more effort being put into learning and understanding school science.

The second model examined the contextual shapers of self-efficacy. The importance of positive classroom experiences in relation to the engagement between teachers and students was highlighted. The implication is that, at the school level, it is crucial to invest in approaches that inculcate positive attitudes and learning behaviours, and to view this as a key goal of quality education. Students spend the majority of their time at school, and schools are therefore the primary settings for developing students' self-efficacy. 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 in general and self-efficacy in particular.

In order to promote self-efficacy in science, classroom teaching should incorporate practices which motivate students and enhance their confidence in their abilities. Children rely on the judgement of others to make their own judgements of confidence and self-value (social persuasion). As such, teachers have a responsibility, beyond classroom instruction, to nurture the self-beliefs of their students.[15] Teachers should also aim to increase their students' confidence as they progress through school, starting as early as possible so that self-efficacy is developed as a habit.[15]

Providing students with complex, meaningful tasks that can be mastered while offering support and encouragement may help to develop students' self-efficacy (through mastery experience). Individualised classroom structures and instructions which are tailored to the academic capabilities of students may minimise social comparisons. Students may therefore be inclined to judge their progress in relation to their own standards rather than in comparison with their classmates' progress (vicarious experience).[15]

Encouraging a growth mindset, in which students are taught that they can develop their intellectual abilities over time, thereby encouraging resilience when encountering challenges, may provide a piece of the puzzle.[28,29] This requires fostering a school culture in which students are encouraged and teachers are provided with the knowledge and skills to enable them to cultivate their students' self-efficacy.

Outside of the classroom environment, parental involvement in checking homework was found to be related to students' self-efficacy. This finding is consistent with other studies which have found that various forms of parental involvement are associated with students' self-efficacy.[33,34] This finding also highlights a need to further involve parents and caregivers in their children's science learning and emphasises their role in engaging with students about their homework and reading about science. School policies should focus on encouraging the active involvement of parents in the educational process. In line with other studies[35,36], we found that higher levels of home SES were related to more positive attitudes about science. This result is a concern, as a large percentage of South African students come from households with low home SES. Encouraging positive classroom interactions and parental involvement for all students, and particularly those of lower socioeconomic status, is therefore critical for increasing students' self-efficacy.

The stereotypical view is that doing science is more consistent with a male self-image than with a female one. We examined whether a gender-related image of science impacted the self-efficacy that students expressed towards science. Unlike the findings of Britner and Pajares[18], we found that when factors such as science achievement, home SES and classroom experiences were controlled for, girls still reported lower levels of self-efficacy than did boys. This may be a result of the 'traditional' gender roles which are ingrained in society, where science has historically been seen as a career for men rather than women. This low level of self-efficacy may have future implications for subject choice and the representation of women in science, technology, engineering and mathematics (STEM) careers and the continued gender bias in STEM endeavours. Particular attention must be paid to inequalities between the genders in relation to the effectiveness with which schools, and societies as a whole, promote motivation and interest in science. In the classroom, teachers should be gender sensitive in terms of actively engaging both genders in the lesson. Parents and teachers should encourage girls to tackle academic and social obstacles with confidence, and challenge the gender stereotypes associated with specific academic fields.[15] Furthermore, emphasis should be placed on academic success in science as being a result of sustained effort rather than an outcome of individual characteristics such as gender.[15] Programmes that use female role models may encourage girls to recognise that they are capable of high science achievement and pursuing science careers. At a broader societal level, initiatives that challenge the pervasive discourse surrounding gender appropriate subjects and careers should be embarked upon by the national government. This complex phenomenon requires further research.

Our findings point to a need to acknowledge the role of attitudes in academic science achievement by policymakers, parents and teachers. This acknowledgement must be accompanied by initiatives that actively develop a positive sense of self-efficacy in students. Additionally, the findings point to the importance of socialising children early on about the benefits of science, in order to promote interest and science self-efficacy.

Acknowledgements

We acknowledge Dr Linda Zuze, visiting Associate Professor at the University of the Witwatersrand Centre for Researching Education and Labour, for her critical review of the article.

Author's contributions

A.J.: conceptualisation, methodology, project leadership, overall writing. S.H.: literature review, overall writing. C.N.: data analysis, sample analysis.

References

1. Osborne J, Simon S, Collins S. Attitudes towards science: A review of the literature and its implications. Int J Sci Educ. 2003;25:1049–1079. https://doi.org/10.1080/0950069032000032199

2. Barmby P, Kind PM, Jones K. Examining changing attitudes in secondary school Science. Int J Sci Educ. 2008;30:1075–1093. https://doi.org/10.1080/09500690701344966

3. Sarjou AA, Soltani A, Kalbasi A, Mahmoudi S. A study of Iranian students' attitude towards science and technology, school science and environment, based on the ROSE Project. J Stud Educ. 2012;2(1):90–103. https://doi.org/10.5296/jse.v2i1.1438

4. Mji A, Makgato M. Factors associated with high school learners' poor performance: A spotlight on mathematics and physical science. S Afr J Educ. 2006;26:253–266.

5. Martin MO, Mullis IVS, Foy P, Stanco GM. TIMSS 2011 international results in science. Chestnut Hill, MA/Amsterdam: Boston College/IEA Secretariat; 2012.

6. Juan A, Reddy V, Zuze TL, Namome C, Hannan S. Does it matter whether students enjoy learning science? Exploring student attitudes towards science in South Africa. HSRC Policy Brief [document on the Internet]. c2016 [cited 2017 Jul 04]. Available from: http://www.timss-sa.org.za/download/Attitudes%20Policy%20Brief.pdf

7. Hassan G. Attitudes toward science among Australian tertiary and secondary school students. Res Sci Technol Educ. 2008;26:129–147. http://dx.doi.org/10.1080/02635140802034762

8. Reddy V, Gastrow M, Juan A, Roberts B. Public attitudes to science in South Africa. S Afr J Sci. 2013;109(1/2), Art. #1200, 8 pages. http://dx.doi.org/10.1590/sajs.2013/1200

9. Reddy V, Juan A, Hannan S, Arends F, Gastrow M, Roberts B. Science awareness, attitudes and astronomy: Continuity and changes [document on the Internet]. c2015 [cited 2017 Jul 12]. http://www.timss-sa.org.za/download/SASAS%20final%20report.pdf

10. Lyons T. Different countries, same science classes: Students' experiences of school science in their own words. Int J Sci Educ. 2006;28:591–613. http://dx.doi.org/10.1080/09500690500339621

11. Bybee R, McCrae B. Scientific literacy and student attitudes: Perspectives from PISA 2006 science. Int J Sci Educ. 2011;33:7–26. http://dx.doi.org/10.1080/09500693.2010.518644

12. Martin MO, Mullis IVS, Foy P, Hooper M. TIMSS 2015 international results in science [document on the Internet]. c2016 [cited 2017 Jun 22]. Available from: http://timssandpirls.bc.edu/timss2015/international-results/

13. Bandura A. The explanatory and predictive scope of self-efficacy theory. J Soc Clin Psychol. 1986;4:359–373. https://doi.org/10.1521/jscp.1986.4.3.359

14. Keye D, Pidgeon AM. An investigation of the relationship between resilience, mindfulness, and academic self-efficacy. Open J Soc Sci. 2013;1(6):1–4. http://dx.doi.org/10.4236/jss.2013.16001

15. Pajares F. Gender and perceived self-efficacy in self-regulated learning. Theor Pract. 2002;41:116–125. http://www.jstor.org/stable/1477463

16. Wang MC, Haertel GD, Walberg HJ. Educational resilience in inner cities. In: Wang MC, Gordon EW, editors. Educational resilience in inner-city America: Challenges and prospects. Hillsdale, NJ: Lawrence Erlbaum Associates; 1994.

17. Ahern NR, Kiehl EM, Sole ML, Byers J. A review of instruments measuring resilience. Issues Compr Pediatr Nurs. 2006;29:103–125. http://dx.doi.org/10.1080/01460860600677643

18. Britner SL, Pajares F. Sources of science self-efficacy beliefs of middle school students. J Res Sci Teach. 2006;43:485–499. https://doi.org/10.1002/tea.20131

19. Margolis H, McCabe PP. Improving self-efficacy and motivation: What to do, what to say. Interv Sch Clin. 2006;41:218–227. https://doi.org/10.1177/10534512060410040401

20. Schunk DH. Self-efficacy for reading and writing: Influence of modelling, goal setting and self-evaluation. Read Writ Q. 2003;19:159–172. https://doi.org/10.1080/10573560308219

21. Bandura A. Perceived self-efficacy in cognitive development and functioning. Educ Psychol. 1993;28:117–148. https://doi.org/10.1207/s15326985ep2802_3

22. Tuan H, Chin C, Shieh S. The development of a questionnaire to measure students' motivation towards science learning. Int J Sci Educ. 2005;27:639–654. http://dx.doi.org/10.1080/0950069042000323737

23. Pajares F. Self-efficacy beliefs in academic settings. Rev Educ Res. 1996;66:543–578. http://dx.doi.org/10.3102/00346543066004543

24. Singh K, Granville M, Dika S. Mathematics and science achievement: Effects of motivation, interest, and academic engagement. J Educ Res. 2002;95:323–332. https://doi.org/10.1080/00220670209596607

25. Juan AL, Reddy V, Hannan S. Attitudes to science: Part of the puzzle to improve educational achievement? Africa Growth Agenda. 2014;7(1):13–16. http://hdl.handle.net/10520/EJC163568

26. Sabah S, Hammouri H. Does subject matter matter? Estimating the impact of instructional practices and resources on student achievement in science and mathematics: Findings from TIMSS 2007. Eval Res Educ. 2012;23:287–299. http://dx.doi.org/10.1080/09500790.2010.509782

27. George R. A crossdomain analysis of change in students' attitudes toward science and attitudes about the utility of science. Int J Sci Educ. 2006;28:571–589. http://dx.doi.org/10.1080/09500690500338755

28. Dweck C. Mindset: The new psychology of success. New York: Random House Inc.; 2006.

29. Yeager DS, Dweck C. Mindsets that promote resilience: When students believe that personal characteristics can be developed. Educ Psych. 2012;47:302–314. http://dx.doi.org/10.1080/00461520.2012.722805

30. Van der Berg S. How effective are poor schools? Poverty and educational outcomes in South Africa. Stud Educ Eval. 2008;34:145–154. https://doi.org/10.1016/j.stueduc.2008.07.005

31. George R. Measuring change in students' attitudes toward science over time: An application of latent variable growth modeling. J Sci Educ Technol. 2000;9:213–225. https://doi.org/10.1023/A:1009491500456

32. Perera LDH, Bomhoff EJ, Lee GHY. Parents' attitudes towards science and their children's science achievement. Discussion paper 02/14. Melbourne: Monash University; 2014.

33. Fan W, Williams CM. The effects of parental involvement on students' academic selfefficacy, engagement and intrinsic motivation. Educ Psych. 2010;30:53–74. http://dx.doi.org/10.1080/01443410903353302

34. Schunk DH, Pajares F. The development of academic self-efficacy. In: Wigfield A, Eccles J, editors. A volume in the educational psychology series. Development of achievement motivation. San Diego, CA: Academic Press; 2002.

35. Özdemir E. Modelling of the factors affecting science achievement of eighth grade Turkish students based on the third international mathematics and science study – Repeat (TIMSS - R) data [dissertation]. Ankara: The Middle East Technical University; 2003.

36. Sun L, Bradley KD, Akers K. A multilevel modelling approach to investigating factors impacting science achievement for secondary school students: PISA Hong Kong sample. Int J Sci Educ. 2012;34:2107–2125. http://dx.doi.org/10.1080/09500693.2012.708063

37. Webster BJ, Fisher DL. Accounting for variation in science and mathematics achievement: A multilevel analysis of Australian data third International Mathematics and Science Study (TIMSS). Sch Eff Sch Improv. 2000;11:339–360. http://dx.doi.org/10.1076/0924-3453(200009)11:3;1-G;FT339

38. Dika SL, Singh K. Applications of social capital in educational literature: A critical synthesis. Rev Educ Res. 2002;72:31–60. https://doi.org/10.3102/00346543072001031

39. Reddy V, Visser M, Winnaar L, Arends F, Juan A, Prinsloo CH, et al. TIMSS 2015: Highlights of mathematics and science achievement of Grade 9 South African students. Pretoria: Human Sciences Research Council; 2016.

40. LaRoche S, Joncas M, Foy P. Sample design in TIMSS 2015. In: Martin MO, Mullis IVS, Hooper M, editors. Methods and procedures in TIMSS 2015 [document on the Internet]. c2016 [cited 2017 Jul 24]. Available from: http://timssandpirls.bc.edu/publications/timss/2015-methods.html.

41. Foy P. TIMSS 2015 user guide for the international database [document on the Internet]. c2017 [cited 2017 Jun 15]. Available from: https://timssandpirls.bc.edu/timss2015/international-database/downloads/T15_UserGuide.pdf.

42. Human Sciences Research Council. Trends in International Mathematics and Science Study (TIMSS) 2015 Grade 9: Learner background (BSG) – South Africa as one of 39 countries [data set]. In: TIMSS 2015 learner background. Version 1.0. Pretoria: Human Sciences Research Council [producer]; 2015. Human Sciences Research Council [distributor]; 2017. http://dx.doi.org/10.14749/1499247520