

Learning environments matter: Identifying influences on the motivation to learn science

Salomé Schulze

Department of Psychology of Education, University of South Africa, Pretoria Campus, South Africa
Schuls@unisa.ac.za

Mark van Heerden

Department of Science and Technology Education, University of South Africa, Pretoria Campus, South Africa

In the light of the poor academic achievement in science by secondary school students in South Africa, students' motivation for science learning should be enhanced. It is argued that this can only be achieved with insight into which motivational factors to target, with due consideration of the diversity in schools. The study therefore explored the impact of six motivational factors for science learning in a sample of 380 Grade Nine boys and girls from three racial groups, in both public and independent schools. The students completed the Student Motivation for Science Learning questionnaire. Significant differences were identified between different groups and school types. The study is important for identifying the key role of achievement goals, science learning values and science self-efficacies. The main finding emphasises the significant role played by science teachers in motivating students for science in terms of the learning environments that they create. This has important implications for future research, aimed at a better understanding of these environments. Such insights are needed to promote scientific literacy among the school students, and so contribute to the improvement of science achievement in South Africa.

Keywords: achievement goals; gender and racial group influences on motivation to learn science; influence of school; learning environment; mastery goals; motivation to learn science; science learning values; self-efficacy

Introduction

Achievement in mathematics and science is one of the key indicators to assess the performance of the schooling system of any country (Reddy, 2005). For an emerging economy, such as is the case in South Africa, the science and mathematics literacy of its population is even more crucial (Mji & Makgato, 2006). Effective science and mathematics teaching and learning are essential for economic expansion and global competitiveness. To this end, it is crucial to identify and address factors that impact on students' learning of science in schools in South Africa.

Concern about South African school students' science literacy has been frequently raised (Reddy, 2005). The alarming finding that students continue to underperform was highlighted when South Africa was ranked last out of the 38 countries participating in the Trends in International Mathematics and Science Study (TIMSS) (1999), which gave the South African education system the opportunity to benchmark mathematics and science performance against that of other countries (Reddy, 2005). These poor results led to an increased allocation of resources to science and mathematics at school level. In 2002 Grade Eight and Nine students again participated in TIMSS; the results confirmed poor academic performance. In 2011, forty-two countries participated once more on the Grade Eight level, while three countries (Botswana, Honduras and South Africa), participated on the Grade Nine level. Of these countries, South Africa scored below Botswana in mathematics, and scored the lowest of all countries in science achievement (Reddy, Winnaar, Visser, Arends, Mthethwa, Juan, Rogers, Feza-Piyose & Prinsloo, 2013). However, a closer look at the scores indicated that South African students improved with 60 points in their average score for Grade Nine science from 2002 to 2011, which was found to be especially the case among black students (Reddy, Prinsloo, Arends, Visser, Winnaar, Feza, Rogers, Janse van Rensburg, Juan, Mthethwa, Ngema & Maja, 2011). Age-appropriate students performed better than the others, and girls performed somewhat better than boys. However, at a grade-appropriate level, boys outperformed girls. Students from former white schools also performed better than students from black schools. Although students from independent schools scored better than the others, they were also not globally competitive in this regard.

Of the several factors identified that could influence mathematics and science achievement, student motivation surfaced consistently (Bester & Brand, 2013; Von Rhöneck, Grob, Schnaitmann & Völker, 1998). Motivation to learn is of particular importance for science learning, which requires a deep level of engagement with new material for conceptual change to occur (De Backer & Nelson, 2000). Thus, Koballa and Glynn (2007), Theobald (2006) as well as Zimmerman (2008) maintain that students' apparent lack of motivation to learn science requires some investigation. In spite of this, a dearth of recent South African studies investigating motivational factors for science learning was to be found. Only one study with a similar focus, using Grade Eight to Ten students as participants, could be identified (De Backer & Nelson, 2000), potentially indicating a lack of insight into this current issue.

In the light of this, the aim of this study was to explore motivational factors for science learning among high school students of different gender, racial group and school type, in line with the TIMSS report. A better

understanding of these motivational factors could influence teaching, and ultimately enhance the scientific literacy and academic achievement of South African school students. In this regard, perspectives such as achievement goal theory, and factors related to the motivation to learn science, are relevant to the discussion forwarded here.

Achievement Goal Theory

Motivation refers to a sustained, process driven, goal-directed activity (Schunk, Pintrich & Meece, 2008). Motivation in the classroom context is defined as “the degree to which students invest attention and effort in various pursuits, which may or may not be the ones desired by their teachers” (Brophy, 2010:3). To conceptualise student motivation patterns in science classrooms, and how these were shaped, this article draws on achievement goal theory.

Achievement goal theory divides achievement goals into two broad categories, namely *mastery* and *performance* goals. Mastery goals are linked to the intrinsic value of learning. Such intrinsic motivation “is the motivation to engage in an activity for its own sake – for the pleasure and satisfaction derived from its performance” (Vedder-Weiss & Fortus, 2012:1065). Students who exhibit a mastery goal focus for science learning are therefore interested in learning science for the sake of acquiring new knowledge and skills involving a broad range of emotional, cognitive, adaptive and behavioural outcomes (Freeman, 2004; Vedder-Weiss & Fortus, 2011). These students generally have positive self-efficacies and are unconcerned with how other people regard them. They tend to enjoy challenging tasks and only request assistance when necessary (Koballa & Glynn, 2007). In contrast, students who are oriented towards academic performance goals focus on displaying their competence to others (Vedder-Weiss & Fortus, 2012; Velayutham, Aldridge & Fraser, 2011). These students compare their performance with those of other students because they need to show that they are quicker or better in science than the others. Performance goals thus emphasise comparison and public competition.

The prominence that schools attach to certain goals is related to the students’ adoption of the goals (Kaplan & Maehr, 2007). Students who had strong mastery of goal orientations reported that their teachers used student-centered approaches, encouraged higher-order thinking, respected the students and tailored instructions to individual needs in supportive classroom environments. However, students at many public high schools tended to be motivated by external goals associated with competition and rewards (Ramnarain, 2013; Vedder-Weiss & Fortus, 2012). For example, Ramnarain (2013) investigated the motivation for science learning of Grade 12 students from township

schools in South Africa. He found that their educational environments facilitated a strong performance goal orientation, instead of the desired mastery goal orientations. However, it should be kept in mind that his sample included only black students, to the exclusion of other racial groups. The results may therefore not be applicable to all students.

Although mastery goals seem to be associated with more positive outcomes than performance goals, results are inconclusive (Freeman, 2004). This confirms the need for additional research on this issue.

Factors related to the Motivation to Learn Science

Several factors may be related to the motivation to learn science including the personal attributes of students (*exempli gratia* (e.g.) their self-efficacies, learning strategies, and their perceptions of the value of science); the educational settings in which they study (e.g. teachers’ teaching methods and the school culture) and moderator variables (e.g. racial group, gender and age).

Regarding the personal attributes of students, self-efficacy seems to play an important role. According to self-efficacy theory, which is based on Bandura’s (1986) social cognitive theory, students will be more likely to demonstrate an incentive to learn science if they believe they can produce the desired outcomes. The crux of the theory is that “the initiation of and persistence at behaviors [sic] and courses of action are determined primarily by judgments and expectations concerning behavioral skills and capabilities and the likelihood of being able to successfully cope with environmental demands and challenges” (Maddux, 1995:4). This indicates that students’ motivational beliefs and self-regulatory practices are crucial for the active engagement required to learn successfully. It is therefore essential to instill in students the belief that they can succeed in learning science, and to develop the required learning strategies to do so (Velayutham et al., 2011). Students with a high self-efficacy are more likely to put effort into a task, evaluate their progress, and apply self-regulatory strategies (Schunk & Pajares, 2005). The main sources of self-efficacy in science learning are students’ experiences of success, vicarious experiences by observing other students succeed, encouragement and the emotional states of wellbeing (Britner, 2008; Usher & Pajares, 2008).

Active learning strategies can influence student motivation for science learning. These strategies require students’ attention and involvement in class activities and are linked to a commitment to the construction of knowledge and insight. Students who are mastery-orientated tend to exhibit such manner of engagement (Vedder-Weiss & Fortus, 2012).

Students’ perceptions of the value of science learning are directly linked to the effort and tenacity

exhibited by the students (Wolters & Rosenthal, 2000). Students are motivated by activities that are interesting, useful, and applicable to their daily lives. Students who lack self-efficacy still attempt to complete tasks if they value the activities (Schunk & Zimmerman, 2007). Task value is significantly related to self-regulatory and cognitive strategies (Wolters, Yu & Pintrich, 1996). This motivates a given student to sustain the effort required to master tasks.

With regard to educational setting, teaching methods are significant to affect motivation and achievement in science (Lawrenz, Wood, Kirchoff, Kim & Eisenkraft, 2009; Roth & Tobin, 2002, 2004; Tobin, Roth & Zimmerman, 2001). Teachers affect students' attitudes to science through the curriculum, and the learning experiences that it provides (Kalu & Ali, 2004). The challenge is to develop classroom practices that facilitate students' conceptual understanding of science. The goal of activities should be clear so that students are motivated to participate (Andrée, 2012). Students bring their own cultural values into the science classroom. Border crossing between epistemologies of science and indigenous knowledge systems are therefore important, particularly in the South African context. Accordingly, Morrison and Lederman (2003) highlight the value of determining the students' existing knowledge and starting from there. Student-centered, cooperative learning approaches (Hänze & Berger, 2007; Stamovlasis, Dimos & Tsaparlis, 2006) and inquiry-based teaching (Schneider, Krajcik, Marx & Soloway, 2002) are important. Inquiry-based teaching by means of projects and experiments, for example, helps to foster connections between the student and real-world experiences and motivates student engagement (Walshaw, 2012).

Teachers' assessment methods can also affect student motivation. If teachers provide clear evaluation criteria and individualised corrective feedback on tasks, the students' academic performance improves (Morais, 2002). Ramnarain (2013) found that summative examination systems facilitated extrinsic motivation in students, and facilitated surface learning, as opposed to the deep learning required for studying science.

The learning environment or 'school culture' plays a role in the mastery goals that students set (Kaplan & Maehr, 2007). For example, the degree to which students are motivated appears to be related to teachers' interest in and respect for their students, along with how the teachers enforce discipline. The more democratic the school culture, the more students are motivated by internal goals and the process of learning (Vedder-Weiss & Fortus, 2011, 2012).

The above-mentioned factors that motivate science learning could be moderated by racial

group, gender and age. For example, researchers found that if students' racial and cultural background was at odds with the science content they were taught, their involvement and learning were hampered (Aikenhead, 2006; Aikenhead & Ogawa, 2007; Brown, 2004; Rodriguez, 2001; Tobin, 2006). This confirms the importance for science teachers of relating their teaching to indigenous knowledge systems. One study with African-American boys revealed the importance of educational utility beliefs for the academic motivation of this group (Butler-Barnes, Williams & Chavous, 2012).

Regarding gender differences in the motivation to learn science, a South African study found that the boys in the sample viewed their own abilities in science to be significantly higher than the girls and they also held more stereotyped views of science (De Backer & Nelson, 2000). Females often lacked the social support and self-efficacy to persist in science-related majors. They frequently needed a strong identification with particular career paths, leadership and maturity, mentoring and guidance to continue with mathematics and science (Kerr & Robinson Kurpius, 2004). Girls' motivation for science was positively related to their mothers and their peers' support of science, their gender egalitarian beliefs, and their exposure to feminism (Leaper, Farkas & Brown, 2012). Changing curricula to be more in accordance with students' interests improved achievement for girls in particular (Häussler & Hoffmann, 2002). In an early study, a moderate correlation was also found between attitude toward science and achievement in science, especially for girls (Weinburgh, 1995).

With regard to age, the critical period for encouraging students to remain in the scientific pipeline is the high school years (Muller, Stage & Kinzie, 2001). However, studies found a decline in students' interest and motivation towards learning science in high school (Galton, 2009; Osborne, Simon & Collins, 2003). This decrease in motivation can be linked to changes in the classroom environment from primary school to high school (Galton, 2009; Kaplan & Maehr, 2007; Pintrich, 2003). However, some authors believed that this decline in motivation was not an inevitable trend. The freedom students enjoy, such as subject choices and engagement with others, could possibly enhance motivation to learn science, as their maturity increased with age (Vedder-Weiss & Fortus, 2011).

In consideration of the above, the specific aim of this study was to examine students' views of motivation variables that might affect their academic achievement in science, as well as determine the influence of moderator variables, namely gender, racial group and school. This might help to

identify factors that could be targeted by teachers to enhance students' motivation to learn science. The next section explains the research method.

Method

The research design was exploratory and descriptive. The sample was selected from Pretoria high schools that were accessible. In that sense, it was a convenience sample (McMillan & Schumacher, 2010). The sample was also purposefully selected for variety. Inclusion criteria considered gender, racial group and type of school (public and independent schools). More than one independent school was used, because of the small enrolment numbers. Thus, four schools were selected. School A was an inner city independent Catholic school for girls (black students only); School B was an independent Protestant school in the north-eastern suburbs of the city (black students and co-educational); School C was an independent Protestant school in the eastern suburbs of Pretoria (co-educational, predominantly white students), and School D was a multi-cultural public school near the city centre. The schools were comparable in socio-economic terms. Grade Nine students were selected because this was the last year in which students are compelled to take science as part of the curriculum. Thus, the sample comprised 183 Grade Nine students from three independent schools (47, 82 and 54 students, respectively) and one public school (197 students). Of the sample, 133 students were male and 186 were female. There were 38 white students; 284 black students; and 20 coloured students. (Some missing values occurred in all instances. Data of two Indian students were also excluded, due to their limited numbers).

Data collection procedures included obtaining permission from the Department of Education, ethical clearance from the College of Education Ethics Committee at the University of South Africa, as well as consent from parents and assent from the

students themselves. Participants were given assurances of anonymity and confidentiality.

All the students completed the Student Motivation to Learn Science (SMLS) questionnaire with written permission from the authors of the questionnaire (Tuan, Chin & Shieh, 2005). (The authors referred to 'achievement' goals, which are synonymous with 'mastery' goals.) The SMLS is made up of 35 items, with six motivation subscales as follows: self-efficacy, use of active learning strategies, perceptions of the value of science, performance goals, mastery goals, and learning environment. Nine of the items were negatively formulated. Responses to the items were by means of a five-point, Likert-type scale that ranged from (1) 'strongly disagree' to (5) 'strongly agree'.

Data analysis was done by means of the comparison of means and standard deviations. T-tests and analyses of variance (ANOVAs) were also executed to test the following three hypotheses: (i) there are significant differences in SMLS between the two genders of the whole sample and between each racial group separately on the six subscales; (ii) there are significant differences in SMLS between the three racial groups on the six subscales; and (iii) there are significant differences in SMLS between the two school types (public and independent) on the six subscales. The hypotheses were tested on the 5% level of significance. The hypotheses distinguished between gender, racial group and school type in line with the TIMSS report. Muller et al. (2001) have also pointed out the need for research to disaggregate data by gender and racial group.

The Cronbach's alphas on the six subscales were .7 and above and thus acceptable (McMillan & Schumacher, 2010). Because an existing questionnaire was used, construct validity was not considered, but face validity was judged favourably by the authors of this article. The results are presented in the next section.

Table 1 Means, standard deviations and significance of differences between the boys and girls on six motivation factors

Factor	Male (N = 132)		Female (N = 186)		<i>T</i>	<i>Sig. (p)</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Self-efficacy	3.8034	0.6548	3.8633	0.6977	.203	p > 0.05
Active learning	3.7570	0.6800	3.8363	0.6628	.253	p > 0.05
Science value	3.9902	0.8140	4.1094	0.7059	.510	p > 0.05
Performance goals	3.1679	0.9360	3.2649	0.7992	3.186	p > 0.05
Mastery goals	4.1345	0.6557	4.1222	0.7077	.026	p > 0.05
Learning environment	3.4750	0.7796	3.3472	0.7393	.586	p > 0.05

Note: *df* = 316

Results

Hypothesis 1

Table 1 illustrates the means, standard deviations and significance of differences for the motivation factors of the two genders.

Table 1 indicates that the highest means for the boys were for mastery goals (4.1345). For the girls, two means were above four, namely mastery goals (4.1222) and science value (4.1094). For both genders, the lowest means were with regard to

performance goals (3.1679 and 3.2649). It should also be noted that the standard deviation for the boys regarding performance goals was high (.9360). This shows that the boys differed markedly in their views on the extent to which they were motivated by performance goals.

When Hypothesis One was tested by means of a t-test, the null-hypothesis was accepted. Thus, there were no significant differences between the boys and girls on any of the motivation subscales. However, when the hypothesis was tested for the racial groups separately, white as well as black boys and girls differed significantly with regard to the

motivational value of science. The 16 white boys in the sample were significantly more motivated by this factor than the 21 white girls ($M = 4.23333$ and 3.74286 ; $F = 1.646$; $p < 0.05$). Interestingly, and in contrast to the aforementioned, the 144 black girls were significantly more motivated by their perceived value of science than the 98 black boys ($M = 4.01224$ and 4.19132 ; $F = 2.934$; $p < 0.05$).

Hypothesis 2

Table 2 reflects the means and standard deviations of the motivation factors of the three racial groups that participated in the study.

Table 2 Means and standard deviations of three racial groups on six motivation factors

Factor	White (N = 38)		Black (N = 283)		Coloured (N = 20)		F	Sig (p)
	Mean	SD	Mean	SD	Mean	SD		
Self-efficacy	3.8798	0.6768	3.8381	0.6676	3.9250	0.6536	.491	p > 0.05
Active learning	3.7434	0.7023	3.8443	0.6083	3.6884	1.0183	1.051	p > 0.05
Science value	3.9703	0.7382	4.0942	0.6973	3.7767	1.2276	1.38	p > 0.05
Perform goals	3.4797	0.6598	3.1185	0.9000	3.4375	0.8065	2.184	p > 0.05
Mastery goals	3.8486*	0.7279	4.1780*	0.6434	3.8000	1.0682	3.346	p < 0.05
Learning environment	3.2387	0.7141	3.4624	0.6994	3.3750	1.0539	.788	p > 0.05
Overall motivation	3.7014	0.5073	3.7775	0.4017	3.6782	0.6749	.623	p > 0.05

Note: $df = 354$; * $p < 0.05$; missing values occurred

Table 2 shows that only two means were above four, and they were both for the black racial group. These high means were with regard to science value (4.0942) and mastery goals (4.1780). For both the white and coloured groups, the learning environment had the lowest motivation; for the black group, performance goals were the least motivational.

The Tukey's post hoc tests were used in conjunction with an ANOVA in order to find means that differed significantly. Analysis of variance and Tukey's post hoc tests indicated that there were no significant differences between the racial groups,

except in one instance. With regard to mastery goals, the black students indicated significantly higher mastery goals (on the 5%-level) than the white students ($M = 4.1780$ and 3.8486 ; $F = 3.346$; $p < 0.05$). Thus, Hypothesis Two is accepted, except in the case of the mastery motivation of black and white students.

Hypothesis 3

Table 3 depicts the means, standard deviations and the significance of the differences between the motivation variables of the two school types.

Table 3 Means, standard deviations and significance of differences between independent and public schools on six motivation factors

Factor	Independent (N = 183)		Public (N = 195)		T(df)	Sig. (p)
	M	SD	M	SD		
Self-efficacy	3.8871	.6657	3.7457	.6986	2.012(376)	p < 0.05
Active learning	3.8834	.6154	3.7007	.7109	2.662(376)	p < 0.01
Science value	4.1167	.7173	3.9344	.8252	2.281(374)	p < 0.05
Performance goals	3.2431	.8119	3.1259	.9203	1.307(374)	p > 0.05
Mastery goals	4.1934	.6449	3.9961	.7772	2.669(374)	p < 0.01
Learning environment	3.3941	.7151	3.4071	.7927	-.166(373)	p > 0.05

According to Table 3, the factors with the highest motivational value were science value and mastery goals for independent school students (4.1167 and 4.1934). In all instances (with the exception of learning environment), the independent school students experienced the factors as more motivational than the public school students, as indicated by their higher mean scores. The students

from the public school in this sample experienced their learning environment as more motivational than the students from the independent school cluster. Table 3 also indicates high standard deviations for performance goals, thus revealing great variety in views of how motivational this factor proves to be.

When the third hypothesis was tested by means of a t-test, significant differences were determined between the students of the two school types for all factors except for performance goals and learning environment. Students from independent schools were significantly more motivated by four factors: their self-efficacies ($M = 3.8871$ and 3.7457 ; $t = 2.012$; $p < 0.05$); active learning ($M = 3.8834$ and 3.7007 ; $t = 2.662$; $p < 0.01$); science value ($M = 4.1167$ and 3.9344 ; $t = 2.281$; $p < 0.05$); and mastery goals ($M = 4.1934$ and 3.9961 ; $t = 2.669$; $p < 0.01$).

Discussion

Table 1 and the testing of Hypothesis One showed that the boys and girls in the sample had similar motivation goals. Both genders scored the highest on mastery goals, and lowest on performance goals. Mastery goals are linked to the intrinsic value of learning (Freeman, 2004; Vedder-Weiss & Fortus, 2011). Accordingly, the students of both genders indicated that they felt fulfilled in their ability to solve problems, having ideas accepted, and doing well in tests. In contrast, the students scored relatively low on performance goals items, which were related to extrinsic motivation according to the goal theory (e.g. to be better than others, to get the teacher's attention or to impress others). Since mastery goals are associated with more positive outcomes than performance goals (Freeman, 2004; Ramnarain, 2013), these results are viewed in a positive light. The greater motivational effect of science value for black girls and white boys could be related to their career aspirations (e.g., a career in medicine) that require science. This was revealed by informal interviews that were conducted on-site.

In a further focus on racial group, black students were motivated by mastery goals and the value of science to a greater degree than the other racial groups, as illustrated in Table 2. In particular, hypothesis testing revealed that the difference between the black and the white students with regard to mastery goals was significant on the 5% level. Considering the fact that white students tended to achieve better than black students in Science, as revealed by the TIMSS report, this desire by black students to understand a science subject that had previously been a challenge (perhaps due to the legacy of Bantu Education), was understandable. Moreover, the black racial group was under-represented in study fields related to science. They may therefore have aimed to redress imbalances and enter the labour market in areas that require science competence, for example, engineering and the medical profession. Another significant finding was that the white and coloured students were the least motivated by their learning environments. In consideration of the questionnaire items, this indicates that these students experienced the science content as unexciting, the teaching

method/s as lacking in variety, with no class discussions, an absence of challenging activities, and little personal attention to the students. The black students seemed less critical (demotivated) by the aforementioned classroom practices.

The biggest differences in this study, however, were between the two school types. Table 3 illustrates that the independent school students were significantly more motivated by self-efficacy, active learning, and science value and mastery goals than the public school students in the sample. Informal interviews with some of the students revealed that science teaching in certain classrooms was only 'talk and chalk'. If the independent school students held a stronger belief that they could master science tasks, this could have been developed by teachers in creating classroom environments and using assessment practices that might allow the students to be successful. The teacher/s may also have given the students positive feedback in the science class. Students, who believed they were similar to their peers, and observed the peers' successes in the science class, may feel that they could also attain success. The aforementioned is in accordance with the theory that self-efficacy is built by successful experiences, positive feedback and observing successful peers (Britner, 2008; Schunk & Zimmerman, 2007; Usher & Pajares, 2008). Velayutham et al. (2011) indicate that positive self-efficacies motivate students to put more effort into tasks and to develop strategies to be successful. The results related to Hypothesis Three also imply that the value of science may have been propagated more actively at the independent schools, and that these students were more able to access relevant resources, such as the teachers themselves, so as to help them if they did not understand the work. Such support motivates students to try hard to master difficult work.

Conclusion and Recommendations

There is agreement that the scientific literacy of South African students needs to be enhanced, and that motivation for learning improves academic achievement. However, there is a lack of insight into which motivational factors to target in the diversity of South African schools. Therefore, this study aimed to explore the impact of six motivational factors for science learning of a group of high school students. A sample of 380 Grade nine boys and girls from three racial groups and different schools situated in the Pretoria area completed the SMLS questionnaire. Although the study is limited by its use of a self-report questionnaire, the results are noteworthy for the following reasons.

It is clear that both genders and black students in particular, were more motivated by achievement than by performance goals. This implies that they were motivated by the fulfillment of being able to solve difficult problems, as well as having their

ideas accepted by others rather than by competition. The fact that the black students were also particularly motivated by science learning values reveals the possible influence of pointing out such values to the students.

Another important finding was the apparent lack of motivational value of the science learning environments at schools for white and coloured students. This implies that teachers need to rethink the teaching methods they use, the lesson activities they present, and the personal attention they provide to the students. This issue requires further investigation, perhaps of a qualitative nature, with specific reference to the science-learning environment.

The most important contribution of this study is the identification of the science classroom as the most significant factor in motivating students to achieve academically in Science. It is in the classroom that mastery goals can be emphasised, the value of science learning can be pointed out, the science self-efficacies of students can be facilitated, and stimulating learning environments can be created. Teachers need to cross the border between epistemologies of science and indigenous knowledge systems, encourage higher-order thinking by means of inquiry-based teaching that includes projects and experiments, and provide supportive classroom environments. Good teaching does not take place in every school, but is required for student motivation and academic achievement in science. In the long term, improved classroom learning environments should encourage improved academic scientific achievement, which, in turn, will promote South Africa's global competitiveness and economic development.

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