PERFORMANCE IN MATHEMATICS AND SCIENCE IN BASIC SCHOOLS IN GHANA

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Abstract

Science and technology are seen globally as the panacea for underdevelopment and are recognized by all governments including those in Africa to be drivers of development. As a result, they can help in poverty reduction by promoting economic development. Yet, despite the importance that is attached to mathematics and science in the school curriculum, Ghanaian students continue to perform poorly in both subjects in national and international examinations. This paper examines Ghanaian students' performance in mathematics and science at the primary and secondary school levels of education and takes a look at factors that militate against students' achievement in mathematics and science at these levels. These have been identified to include, students' low self-confidence in their ability to do mathematics and/or science, weak computational skills that lower student performance in mathematics at all levels, excessive use of didactic approaches to the teaching of mathematics and science, limited use of learning resources in mathematics and science classrooms, limited number of qualified mathematics and science teachers, and teaching to the test. The intervention strategies that have been suggested in the paper tpo deal with issues identified above include using technology appropriately in the teaching and learning of mathematics, encouraging students to spend more time on mathematics and science tasks, guiding students to build self-confidence in mathematics and science, providing opportunities for pupils to study mathematics and science in rich learning environments can boost their confidence. The paper concluded that teachers hold the key to the success of the implementation of the suggested remedies for improving the teaching and learning pf mathematics in Ghana basic schools

The importance of mathematics and science everyday life and particularly in the contemporary Science Technology Engineering Mathematics (STEM) agenda is seen in many ways. Mathematics, for example, is regarded as the essential background component for the basic sciences, for the advancement of technology (e.g. in the aircraft design) and for the manufacture and use of computers and calculators. The concepts, skills, relation and other application of mathematics are highly evident in its application in school subjects like science, commerce, economics and visual arts.The language of modern science and technology is mathematics and so is the language used in coding signals that are communicated to various destinations around the world. The world of work depends heavily on calculation and precision, therefore success in mathematics provides the possibility of success in life (CRDD, 2007).

Indeed, an average understanding of mathematics is considered basic to daily life. Besides, mathematics is one of the basic requirements for progression from the basic school level to senior high school level and from the latter to the tertiary level. Governments all over the world have emphasised mathematics education as the basis for modern scientific and technological developments and an important means of communication (UNESCO, 2015).Furthermore, a report by the Organisation for Economic Cooperation and Development (OECD) indicates that economic growth and social development are closely related to the skills of a population, particularly skills in numeracy, literacy and problem solving. The report points out that policies that put accent on basic skills can have great impact on gross domestic product (GDP). The implication is that the main post-2015 development goal for education should be that all young people achieve basic skills as a foundation for work and learning. According to OECD, “[achieving] such a goal would lead to remarkable overall economic gains while providing for broad participation in the benefits of development” (p.15). Ghana is one of the 76 countries on the radar of OECD, which have data on school enrolment and achievement. With regard to the relationship between basic skills (in numeracy, literacy and problem solving), OECD has estimated that if Ghana achieves *universal* basic skills, this will increase the country’s GDP by 2000 per cent!

Like mathematics, the relevance of science to mankind and society cannot be overemphasised. Science helps us to test claims through the use of experiments and can prevent and/or cure diseases and save lives as a result. Indeed, science enables us to look across the universe, see atoms, fly across the earth and harness the energy of the sun. A number of countries which are pursuing the STEM agenda have exalted science and mathematics in different ways and on different occasions. For example, President Obama in 2005 named 108 mathematics and science teachers as recipients of the prestigious Presidential Award for Excellence in Mathematics and Science Teaching. On the occasion of honouring these teachers, he remarked:

> These teachers are shaping America’s success through their passion for math and science….their leadership and commitment empower our children to think critically and creatively about science, technology, engineering, and math. The work these teachers are doing in our classrooms today will help ensure that America stays on the cutting edge tomorrow.

A similar statement on mathematics and science had been made earlier by the British Prime Minister, David Cameron:

> Maths and science must be the top priority in our schools - there’s no

> secret to success in the modern world. If countries are going to win in the global race and children compete and get the best jobs, you need mathematicians and scientists – pure and simple. So today, we commit to deliver more maths and science teachers. This is all part of our long-term economic plan for Britain – making sure our children have the skills they need to thrive and get on. And by sticking to it, we will lift our children's horizons and pull our country up in the world.

The Chinese President Xi Jinping was not left out of the exaltation of STEM. He observed:

> One of the key elements in the 'new normal' is to increase productivity in the Chinese economy through technological advances. These advances can only come through technical innovations, the result of human creativity….Our scientists and engineers should bravely shoulder their responsibilities, overtake others, and find the right direction, to which they should stick…They should have the courage and confidence to blaze new trails, overcome difficulties and seek excellence, and audaciously make world-leading scientific and technological achievements.

On the African front similar sentiments have been expressed about the importance of mathematics and science. For example, the mission of the African Institute of Mathematical Sciences (AIMS) is to enable Africa's brightest students flourish as independent thinkers, problem solvers and innovators capable of propelling Africa's future scientific, industrial, educational and economic self-sufficiency.AIMS is designed to promote STEM in Africa in order to improve economies in Africa (Allotey, 2014). Founded 12 years ago, AIMS is a pan-African network of centres of excellence for postgraduate training in research and public engagement in mathematical sciences. It has centres of excellence in South Africa, Senegal, Ghana, Cameroon and Tanzania.

At a historic conference in Dakar-Senegal dubbed the Next Einstein Forum (NEF) global gathering attended by Africa's top scientists, policymakers and start-ups, Rwandan President Paul Kagame said Africa would not develop unless it invested more in science and technology. He said the pressure is on Africa to catch up and keep pace with the rest of the world so that the continent is not left behind once again in the wake of technological progress.He argued that investment in science, technology, engineering and mathematics is the undeniable engine for economic growth and social inclusion (Kegame, 2016).Kagame announced that the Rwanda chapter of AIMS will be opened in August, 2006.At the conference, African and world leaders from over 100 countries issued a joint call to action for increased investment and support for STEM. President Kegame said:

> Our aim is shared and sustainable prosperity. And the key to that is science and innovation, bound by research….Africa does not invest enough in research and

development and the share of higher education students enrolled in science and engineering is too low.

The forum spotlighted the work of the inaugural class of NEF Fellows selected from nine African countries for their ground breaking contribution to science. The Senegalese President MackySall pointed out that the NEF global gathering provided a platform to nurture African talent so the continent could return to its roots as the cradle of innovation. Echoing the sentiments of the two heads of state, South Africa's Minister for Science and Technology NalediPandor said not much innovation would come from Africa if the continent continued investing less than 0.6 per cent of its GDP in research and development.

In Ghana, despite the importance that is attached to mathematics and science in the school curriculum, students continue to perform poorly in both subjects in national and international examinations. In this paper, I will examine Ghanaian students' performance in mathematics and science at the primary and secondary school levels of education, take a look at factors that militate against students' achievement in mathematics and science at these levels and explore ways of addressing the issues of low achievement in core mathematics and integrated science.

Pupils' Performance in Mathematics at the Primary Level

As access to basic education in Ghana continues to improve, education actors are increasingly focusing attention on the quality of education. One important tool that has been used to track pupils' literacy and numeracy competences and proficiency at the primary level is the National Education Assessment (NEA). This is used to measure specifically minimum competence and proficiency in mathematics and English. The NEA, which is conducted every two years, is based on a random, stratified sample of pupils in Primary 3 and Primary 6. Pupils are considered to have achieved *minimum competency* if they answer at least 35% of the test items correctly and *proficiency* if they answer at least 55% correctly.

The NEA report of 2009 shows that less than 30% of primary school pupils in predominantly rural districts reached competency in English in these assessments. Performance in mathematics was even worse, with only 48% of P6 pupils reaching the minimum competency level and 11.4% attaining proficiency (Ministry of Education, 2009). The corresponding national figures for mathematics in P6 in 2009 were 61.9% minimum competency and 13.8% proficiency. Four years later, in 2013, whereas the pupils' performance in English had improved slightly, their performance in mathematics had deteriorated significantly. In English, 80% of P6 pupils reached minimum competency level with 39% reaching proficiency level. In mathematics, only 50% of P6 pupils reached minimum competency level with a mere 10.9% reaching competency level! It is worth noting that, for bothP3 and P6, approximately 40% of the pupils failed to achieve even minimum competency in mathematics. In sum, The NEA—

administered in 2005, 2007, 2009, 2011and 2013— has shown not only that children in Ghana have struggled to read, but also that performance in mathematics has lagged behind grade expectations, with the percentages of P3 and P6 pupils achieving proficiency in mathematics falling below 20% (MOENEAU, 2014)

Students' Performance in Mathematics and Science at the Junior High School Level

The grading of students' performance in the Basic Education Certificate Examination (BECE) at the junior secondary is done on the standard nine intervals (Stanine) scale and this makes it difficult to compare performance across years. On that scale, the centre interval is within a quarter of a standard deviation of the mean, and each of the other intervals are a half standard deviation wide (exclusive of the tails). Using this scale, students' grades are pre-determined in the sense a fixed percentage is allocated to each of the nine grades, 1-9. For example, in each year and on the positive side of the distribution, 4% of the candidates obtain Grade 1, 7% obtain Grade 2, 12% obtain Grade 3, 17% obtain Grade 4 and 20% obtain Grade 5. This pattern is repeated on the negative side of the distribution. Here too, 4% obtain Grade 9, 7% obtain Grade 8, 12% obtain Grade 7, and 17% obtain Grade 6. The number of candidates who obtain a particular grade may vary from year to year but the proportions obtaining the various grades are similar. It is therefore extremely difficult to compare the candidates' performance year by year.

One way around this is to compare the students' performance in international examinations on different occasions and determine whether or not there is improved performance. One such international examination is the Trends in International Mathematics and Science Study (TIMSS) examination.Ghana participated in the TIMSS in mathematics and science in 2003, 2007 and 2011. Table 1 provides a summary of the performance on Ghanaian junior high school students who took part in TIMSS, 2003, 2007 and 2011.

Table 1: Ghanaian Junior High School Students' Performance in TIMSS 2003-2011

Year	International Average	Subject	Ghana's Score	No. of Participating Countries	Position of Ghana
2003	466	**Mathematics**	**276**	45	**44th**
2007	500		**309**	48	**47th**
2011	500		**331**	42	**42nd**
2003	473	**Science**	**255**	45	**44th**
2007	500		**303**	48	**48th**
2011	500		**306**	42	**42nd**

Source: TIMSS, 2003, 2007, 2011

In 2003, out of the 45 countries that participated, Ghana's eighth graders were 44^{th} in both mathematics and science, beating only South Africa in both subjects (TIMSS, 2003). In 2007, Ghanaian eighth graders were 47^{th} out of 48 countries (TIMSS, 2007) in both mathematics and science beating only Qatar. In 2011, Ghana came last in both subjects (TIMSS, 2011).It can be seen from the Table 1 that Ghanaian students' performance improved slightly in both subjects. However, inspire of the upward trend in performance in both subjects, the scores were all far below the international average.

The reasons for the students' poor performance were given as poorly-resourced schools, large classes, curricula hardly relevant to the daily lives of students, lack of qualified teachers, weak grip of content knowledge and inability to apply basic mathematical principles by students (to Anamuah-Mensah, Mereku and Ampiah , 2008; TIMSS, 2003,2007). Other reasons were non-adherence to rubrics, misinterpretation of questions, unfavourable conditions of service of the teacher which affect teacher preparation, teacher quality and its accompanied impact on students as well as ineffective supervision of instruction (TIMSS, 2011).

Students' Performance in Mathematics and Science at the Senior High School Level

Unlike the grading system used in the final BECE, the grading system used in the senior high school final examination – i.e. the West African Secondary School Certificate Examination (WASSCE) is criterion referenced in the sense that the examining body is interested in whether or not senior high school students can meet appropriate standards of competence. Here, there is no concern for percentages, only whether or not the criteria have been met. Apart from helping educators and planners to know how well students have acquired the knowledge and skills which they are expected to possess, the criterion referenced system provides room for comparison of students' performance on a yearly basis. Table 2 shows Ghanaian students' performance in the WASSCE in the four core subjects from 2009 to 2017.

Table 2: WASSCE (MAY – JUNE) RESULTS IN CORE SUBJECTS FROM 2009 TO 2017

(A1 –C6)

SUBJECT	2009	2010	2011	2012	2013	2014	2015	2016	2017
English	68,854	-	122,699	108,633	267,504	108,633	133,972	125,065	155,077
Language	43.9%	-	75.9%	45.2%	65.7%	45.2%	50.1%	53.19%,	54.06%
Integrated	54,113	-	62,308	98,603	202,636	68.965	62,374	113,933	125,204
Science	34.5%	-	42.0%	56.8%	49.7%	28.7%	23.3%	48.48%	43.66%
Core	44,934	-	65,005	77,882	149,612	77,884	64,268	77,108	122,450

Mathematics	28.6%	-	43.8%	49.4%	36.6%	36.6%	24.0%	32.83%	42.73%
Social	121,558	-	121,993	137,714	331,255	331,255	137,839	129,058	149, 806
Studies	77.5%	-	82.2%	137,714	57.4%	57.4%	51.6%	47%	52.2%

Source: WAEC, 2009, 2013, 2017

Over the nine-year period, both mathematics and science recorded very poor performance. Whereas candidates obtained up to 87 percent credit pass rate in Social Studies (in 2012) and up to 76 percent in English language (in 2011), they only managed 49 percent in mathematics (in 2012) and 57 percent in science (in 2012). It is interesting to note that all the core subjects recorded their best results in either 2011 or 2012 and recorded their worst performance in 2015.
Even for English language, where the results have always been reasonably good, the credit pass rate dropped from 75.9% in 2011 to 50.1% in 2015. The credit pass rate for social studies dropped from 87.1% in 2012 to 51.6% in 2015. Similarly, the credit pass rate for mathematics dropped from 49.4% in 2012 to 24.0% in 2015 and that for integrated science dropped from 56.8% in 2012 to 23.3% in 2015.

It is worth pointing out that the students who sat the 2011 and 2012 versions of the WASSCE had had four years of senior secondary education and those who sat the examination in 2013 were a mixture of students with four years senior secondary education and those with three years of senior secondary education. Students who sat the examination in 2009 and also in 2014 - 2017 had three years of senior secondary education. It would appear on the face of it that students who studied the various senior high school subjects for four years did better than their counterparts who studied the same subjects for three years. An investigation into the apparent correlation between period of study and performance is worth pursuing in a thorough study with robust analysis.

Figures 1 gives a representation of how candidates fared in core mathematics (vertical blocks) and integrated sciencein the school WASSCE from 2009 to 2017 inclusive.

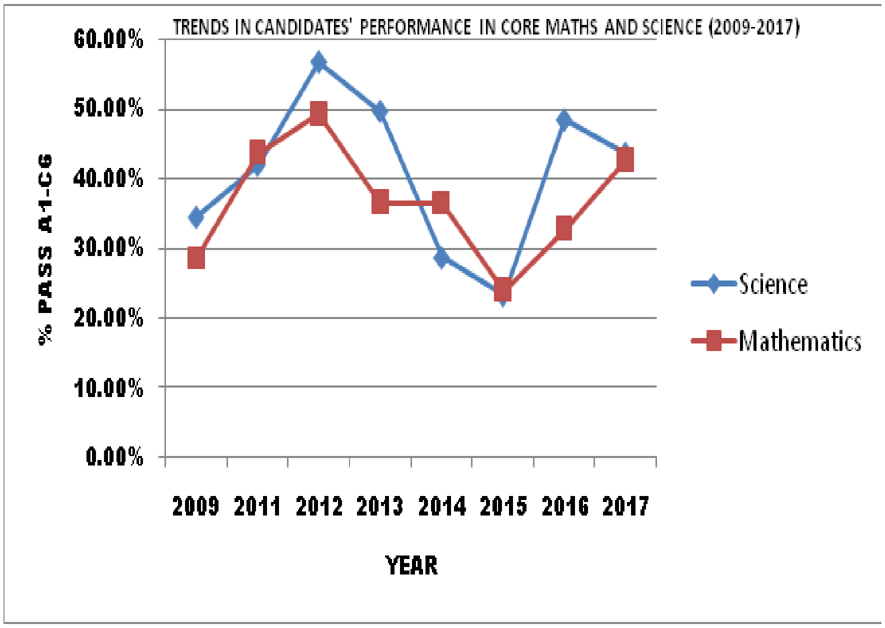

Figure 1: Trends in Candidates' Performance in the School WASSCE from 2009 to 2017 Inclusive

As mentioned above, the students' results were worst in both subjects in 2015. Following this, a number of intervention programmes in mathematics and science under the secondary education improvement project (SEIP, 2014) had already been put in place in 2014/2015 academic year and these appeared to have yielded some results in the 2016/2017 academic year, as the students' performance was better in both subject than it was in 2015.

Even so, the trend shows that in the period under discussion, neither of the subjects hit the 60% mark in the A1-C6 grade categories. The low credit pass rates in the two core subjects is worrisome because these subjects are gate keepers in the sense that without credit passes in at least one of them, access to tertiary education is almost impossible. The relatively low achievement of students in mathematics and science at the senior high school level has been of concern to many parents and educators for some time now. Educators have attributed this largely to inadequate knowledge of subject matter, poor infrastructure, teacher quality and ineffective supervision of instruction and the abstract manner in which a section of teachers teach the subject to the students(Anthony-Krueger, 2007)

Fletcher, Mishiwo and Sedaga (2016) have also identified a number of factors that militate against students' learning of mathematics and science. These factors include weak computational skills that lower student performance in mathematics at all levels, unqualified teachers' weak content and/or pedagogical content knowledge in mathematics and science, limited use of learning resources in mathematics and science classrooms, excessive use of didactic approaches to the teaching of mathematics and limited number of qualified mathematics and science teachers.

Furthermore, a major reason attributed to the failure is students' perceptions of their ability or inability to do mathematics and science, which can influence their achievement in both subjects positively or negatively. Students' low self-concept in the study of mathematics and science is one of the main causes of their phobia for these subjects. As a result of students' low perception of their ability to study mathematics and science, they tend to attribute failure in these subjects to their 'lack of ability' in the latter. Thus, students' anxiety in mathematics and science in a way 'jinxes' their success in the study of these subject.

Academic Self-concept and Achievement Motivation

According to Weiner's attribution theory, the causes individuals attribute to events have an impact on the way they cognitively, affectively, and behaviourally respond on future occasions (Weiner, 1986, 2005). Four attributions are typically identified in the literature – attributions to luck, task difficulty, ability and effort. These causal attributions can also be mapped according to their locus, stability, and how they can be controlled (Weiner, 1992). The control dimension tends to be a significant determinant of students' responses to setback, pressure, and fear of failure (Borkowski, Carr, Rellinger, & Pressley, 1990).

The control dimension can affect the observer's emotions directly and can also affect observers' inferences about the cause of an event, which in turn shapes the actor's emotions and behaviour. For example, a teacher attributing a student's success to effort can experience positive feelings of admiration for that student. On the other hand, attributing poor performance to a lack of ability may evoke negative feelings of shame in that student. Furthermore, a student whose performance has been criticised by a teacher because of the teacher's perceived lack of ability of the student is likely to put in less effort on subsequent occasions. This situation can set in motion a vicious circle in which failure breeds failure. The criticism would lower the students' self –concept, which in turn would diminish his/her motivation to invest time and effort on similar subsequent tasks, which would then lead to failure, thereby completing the circle.

The opposite is true because if a student's success is acknowledged by his/her teacher, he/she is more likely to put in more effort on subsequent occasions. Here the initial success can breed success because of its ability to heighten the students' self-concept and increase his/her motivation to engage in similar activities (Weiner, 2005).A study by Abu-Hilal (2000) found that students' perceptions regarding the importance of mathematics exerted a significant effect on achievement and that mathematics achievement increased self-concept. Similarly, results from a longitudinal study of elementary and middle school students indicated that initial mathematics achievement was significantly related to subsequent mathematics self-concept (Skaalvik&Valas, 1999). Green, Nelson, Martin and Marsh (2006) simplified this assertion by stating that improved academic self-concept leads to better academic achievement, and improved achievement leadsto better academic self-concept.

According to Bong and Skaalvik (2003), self-concept is what people think of themselves based on their experiences and abilities. It is one's self-image. Self-concept is a complex view of oneself. Klobal and Musek (as cited in Baadjies, 2008) described self-concept as ''an individual's perceptions of herself or himself; it is a psychological entity and includes one's feelings, evaluations and attitudes, as well as descriptive categories'' (p. 2). Thus, self-concept is a cognitive generalization about the 'self', which mostly includes self-descriptions of neutral values. Self-concept, according to Cokley (2000), also encompasses a comparative component in which students assess their academic attitudes and skills in comparison with other students.

A study by Guay, Marsh, and Boivin (2003) found that as children become older, the rating of academic self-concept becomes more reliable and more stable. This claim is based on developmental and psychological theory suggesting that, as children become older, they have an increased awareness of themselves and the world around them. If this finding is anything to go by then studying adolescents' self-concepts with the view to understanding their achievement in specific fields is worthwhile (Chui-Seng, 2004).

Academic self-concept refers to individuals' knowledge and perceptions about themselves in achievement situations.Academic self-concept is considered an important component of academic motivation research (Cokley, 2007). Academic self-concept has been linked strongly to academic achievement (Marsh, 1990). Cokley (2007) considers academic self-concept as an important psychological construct because it is able to bring about changes in academic achievement. This notion is of particular relevance to this paper, which is on ways of breaking the 'jinx'associated with the learning of mathematics and science.

Marsh (1993) found that the relationship between academic self-concept and academic achievement is very specific. Thus, specific achievement in subject-related self-concepts, are highly related to academic success in that content area. Research has also supported the view that academic self-concept and academic achievement mutually reinforce each other to the extent that a positive (or negative) change in one facilitates a commensurate change in the other (Bracken, 1996). Several facets of academic self-concept (self-ratings of overall academic ability drive to achieve, mathematical ability) and achievement expectancies (expectations of graduating with honours) positively related to chemistry achievement (House, 1999).Abu-Hilal's (2000) study found that students' perceptions regarding the importance of mathematics exerted a significant effect on achievement and that mathematics achievement then increased self-concept. Similarly, results from a longitudinal study of elementary and middle school students indicated that initial mathematics achievement was significantly related to subsequent mathematics self-concept (Skaalvik&Valas, 1999).

Breaking the Jinx

Jen and Chien (2008) have shown a causal relationship between academic self-concept and mathematics achievement. This relationship is supported by both the skill development and reciprocal effects models of causality. The skills development model states that academic achievement exerts a positive effect on academic self-concept of students. This model maintains that past achievement, whether significant or otherwise, affects the formation of self-concept (Barker, Dowson &McInerney, 2005). This model implies that academic self-concept emerges principally as a consequence of academic achievement. In a study done by Helmke and Van Aken (as cited in Vialle, Heaven &Ciarrochi, 2005), they found that academic achievement has more of an impact on self-concept than the other way around. This finding is relevant to *breaking the jinx* regarding the learning of mathematics and science because if the mathematics and science curricula are delivered in such a way that students always succeed, then a virtuous circle is set in motion. Once this is achieved, the jinx under discussion would have been broken!

The reciprocal effects model has already been discussed above (Green et al, 2006) but it is worth mentioning that a finding made earlier by Barker, Dowson and McInerney (2005) that self-beliefs predicted increases in academic achievement and that higher levels of academic achievement also predicted improvements in self-beliefs is equally relevant to the subject under discussion. According to Green, et al, the reciprocal effects model has had the most support and that the model has major implications for the importance placed on academic self-concept as a means of facilitating other desirable educational outcomes, as well as being an important outcome variable.This finding is also relevant to breaking the jinx regarding the learning of mathematics and science because if the mathematics and science curricula are delivered in such a way that students develop positive self-concepts, then again a virtuous circle would have been set in motion and the jinx under discussion would have been broken!

Teaching and Learning of Mathematics and Science

One of the fundamental responsibilities of mathematics and science teachers is to ensure that learners build structures that are more complex and abstract than those they possess before instruction. In line with this, there are calls for teaching approaches that engender learner participation and creativity in mathematics and science lessons. Such approaches are out of sync with the transmission view of teaching whereby teachers simply solve learners' problems in mathematics and science for them under the guise of providing examples. Research (e.g. Coben, Brown, Rhodes, Swain &Ananiadou, 2003) has shown that this didactic approach to mathematics and science teaching is inferior to approaches which engage learners in meaningful activities and encourage learner participation. As Fletcher (2005) points out, at best, the transmission style of teaching achieves what the teacher usually sets out to do – preparing learners for examinations. At worst, it becomes simply a way of directly telling learners how to do things. This approach may not necessarily lead to learners understanding what they have been told to do. What is lacking in this approach is any sense of genuine enquiry by the learner. Even when didactic methods of teaching appear to be attractive because they are time-efficient as a means of delivering information to a large number of learners, problems generally appear with retention and internalisation of that information by the learner.

Whichever approaches are going to be selected for a particular lesson, the teacher needs to ensure that a positive learning environment exists for all the learners in order to make the approaches as effective as possible. There must be an atmosphere that motivates learners to learn and achieve. As Reece and Walker (2003) rightly observes, the teacher must be a motivator:

> …there is no doubt that the choice of [a] teaching strategy can have an effect upon the motivation and interest of the student. The manner in which the teacher approaches the teaching will have an effect upon motivation: an enthusiastic approach is more likely to motivate [students] than a dull approach. (p. 110)

Indeed, motivation is a key aspect of learning. With all other factors being equal, a highly motivated learner can achieve more than one who is not. A teacher's role is "therefore to maintain the motivation of those who are intrinsically highly motivated and to motivate those lacking in it" (p. 111). Also, that effective learning is supported when learners are actively engaged in the learning process has been highlighted by a number of authors and researchers (Swan, 2005; Swan & Green, 2002;Watson, De Geest&Prestage, 2003; James & Pollard, 2006). Swan for example, has demonstrated that the use of interactive approaches in the teaching of mathematics and science not only motivates learners but improves their retention and achievement generally in both subjects.

Furthermore, many studies in different contexts have confirmed the superiority of active teaching and learning over passive learning which transmission approaches promote (Askew, Brown & Millett, 2003; Swan, 2005). Indeed, the transmission methods used in mathematics and science classrooms and laboratories do not develop deep learning in students, which would lead to sustained knowledge, skills and understanding. Students taught using the transmission approach are usually much interested in how many past papers they work through and how many questions they solve even if they do not understand the questions or their solutions very well. This observation also confirms Swan's position on transmission teaching: Transmission approaches can appear superficially effective when short-term recall is required, but they are less effective for longer-term learning, because they:

- encourage the rote memorising of disconnected rules, which are often misapplied and quickly forgotten
- take no account of learners' prior knowledge (and misunderstandings)
- encourage a passive attitude among learners, who feel that they have nothing to contribute
- encourage learners to measure their success by "how many questions they have done, rather than by what they have understood" (Swan, 2005, p.4).

Such 'traditional' methods of teaching view the role of the teacher as that of imparting knowledge in one way communication sessions often in the form of lectures. Even if such traditional teaching approaches involve question and answer sessions, they are mainly teacher centred and this puts the students in a passive role. On the other hand, discussions encouraged in mathematics and science lessons create a culture of sharing experiences in which everyone expresses his/her ideas and opinions. Surely, when learners have the opportunity to share problems or issues, this can generate holistic thinking around areas of good or bad practice which can be shared and acted upon (Mujis& Reynolds, 2001). The results are even better when appropriate resources are used in the lesson. Indeed, resource-based learning is generally thought to be learner led, not only because learners can work at their own pace and have total control in time management to complete various tasks, the promotion of independent learning this engenders helps the learner expand opportunities by having contact with others involved in the learning process (Fletcher, 2009).

One major way of breaking the jinx associated with the learning of mathematics and science is to ensure that lessons are challenging, active, learner-centred and motivating (CALM). Challenging lessons are those with a range of activities flexible enough to 'stretch' the thinking and imagination of learners across the ability range; active lessons are those in which learners are actively engaged and do not remain passive recipients of information; learner-centred lessons are those in which learners' independent thinking skills develop as fully as they should because their learning is not restricted to what the teacher has decided they need to learn; and motivating lessons contain interesting and fun activities that engage students and support their growing understanding and knowledge. In addition, mathematics and science teachers should be creative and innovative (e.g. use technology appropriately) and encourage learners to spend more time on mathematics and science tasks. As self-concept influences achievement, mathematics and science teachers should guide students to build positive self-concept in these subjects and prepare students well for examinations.

Conclusion

Providing opportunities for pupils to study mathematics and science in rich learning environments can boost their confidence and interest in these subjects so they become good problem solvers at an early age. Exposing pupils in the primary school to quality literacy and numeracy learning activities will enhance their learning of science because they will understand science tasks better and identify which numeracy techniques are required to deal with these tasks. Teachers and their supervisors hold the key to the implementation of both suggestions. Indeed, teachers constitute the most important resource in education therefore there is no gainsaying that any educational system is as good as the teachers in it. It follows that the main way of improving the quality of learning that takes place in any educational system is to improve the quality of teaching in that system. One way of improving the quality of teaching is by providing mathematics and science teachers with the opportunity to develop their subject knowledge base in their specialism, and their pedagogical skills and behaviour to enable them to provide quality teaching.

Hence, in pre-service as well as in-service training, emphasis should be placed on both content knowledge and pedagogical content knowledge in mathematics and science as the two types of knowledge are needed toequip teachers with skills to analyzestudents' thinking processes so as to help them achieve their potential in the learning of both subjects.Effective mathematics and science lessons that are capable of breaking the jinx are those that include problem-solving-based mathematical and scientific tasks that engage students at their level of readiness and provoke them to develop conceptual understanding. That way they will be empowered to use appropriate procedures and problem-solving strategies. Such lessons can only be delivered by motivated teachers who can stay *calm* in mathematics and science classrooms!

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