Vol. 9(2), pp. 9-17, December 2018
DOI: 10.5897/IJSTER2017.0442
Article Number: C1A461A59687
ISSN 2141-6559

http://www.academicjournals.org/IJSTER

ACADEMIC JOURNALS

International Journal of Science and Technology Educational Research

Full Length Research Paper

Exploring the Mathematics and Science subject matter content in the Primary School Level in Lesotho teachers

Mosotho J. George[1*], Mamontsi Kolobe[1] and Eunice K. Moru[2]

[1]Department of Chemistry and Chemical Technology, National University of Lesotho, P. O. Roma 180, Lesotho, South Africa.
[2]Department of Mathematics and Computer Science, National University of Lesotho, P. O. Roma 180, Lesotho, South Africa.

Received 2 September, 2018; Accepted 27 September, 2018

Mathematics and Science education is very important for any nation to realise meaningful economic development. Most studies looking at this important aspect of education focus on post primary to tertiary education leaving the primary level which is a foundation for those levels making the story incomplete. This study explored the dynamics of primary school teaching of Mathematics and Science with respect to **the subject matter content knowledge for Mathematics and Science by the pre-service and in-service primary school teachers in Lesotho. The study assessed the Mathematics and Science subject content of 85 first-year pre-service teachers at the College of Education and 22 in-service as reflected in their scores in the national examinations at three levels: Primary School Leaving Education, Junior Certificate and Cambridge School Certificate. This was followed by a questionnaire to assess their views on subject specialisation as a remedy for poor performance. The results revealed that there are some teachers who have never passed Mathematics and Science at any level of education examined nationally, thus making it difficult and uncomfortable for these teachers to teach these subjects effectively as demonstrated by 14% of the in-service teachers. A large majority (77%) recommended the introduction of subject specialisation to commence at primary school level in order to improve Mathematics and Science performance.**

Key words: Mathematics and Science Education, primary school level, learner attainment, subject specialisation, Lesotho.

INTRODUCTION

Basic education is an important component to socio-economic development of any country as it provides a foundation upon which many diverse careers can be built. This realisation has prompted many governments to adopt a shift of funding policy by World Bank and the International Monetary Fund towards this sector leading to many countries adopting “free” primary education (Parker, 2010). Lesotho, a focus of this study, is a tiny mountainous country, classified as a Least Developed Country, fully landlocked within South Africa, and is

*Corresponding author. E-mail: jm.george@nul.ls or maluti2005@gmail.com.

indeed not an exception to this global trend. The Lesotho's Ministry of Education and Training adopted and introduced Free Primary Education in 2000 resulting in the increase in primary school enrolment, as such, the associated challenges such as overcrowding and shortage of qualified teachers especially in the Mathematics and Science education have been experienced (Ogunniyi and Rollnick, 2015).

Mathematics and Science are not only important in explaining some complex natural phenomena such as gravity, life, etc. (Centre for Education in Science and Technology, n.d.), they are critical components in knowledge-based economy development that is defined as fusion of Science and Technology with the economy; as such they are said to be enabling subjects that form a basis upon which many professions can be established (Cozzens et al., 2007). Delpy and Pike (2010) state that the future of mankind is dependent on the fruits of research in Engineering and the Physical Sciences which play a critical role in developing economic growth and improving our quality of life. This is in cognizance of the fact that most scientific discoveries are not merely providing more insights into the universe, but continue to have far reaching implications. The Government of Lesotho has identified Science and Technology as key drivers for economic development as an inclusion of Science and Technology research in the National Strategic Development Plan of 2012/2013 - 2016/2017, as well as adopting a National Science and Technology Policy of 2005. However, all these cannot be realised without heeding the role of Basic Science and Mathematics education as a cornerstone towards any Science-based profession (Kola, 2013).

Teachers form an indispensable input into the realisation of the afore-mentioned national milestones. Consequently, many efforts have been put in place towards addressing some challenges that may (continue to) impede their realisation. There seems to be a global trend that fewer Mathematics and Science experts are drawn into teaching (National Science Learning Centre, n.d.). The Government of Lesotho has engaged the United States of America's Peace Corps to assist in strengthening the English, Mathematics and Science teaching from secondary schools through to primary and Early Childhood Care centres (Lesotho Peace Corps, n.d.). Other efforts include establishment of the Thaka-Khoali concept funded through UNESCO Lesotho which employs the Living Labs concept in the enhancement of teaching and learning of Mathematics and Sciences at secondary level (Kompi and Molisana, 2013). In 2011, UNESCO and GEMS Foundation contributed about US$ 1 million for a project aimed at enhancing Mathematics, Science and Technology education in Lesotho and Kenya over a four-year period (United Nations Education, Scientific and Cultural Organisation, n.d.).

Despite some loud calls for increase in enrolment in Science and Mathematics, as well as these commendable efforts to improve the teaching and hence understanding of Mathematics and Science, there continues to be a insert the word 'low' between a and return on investment as the enrolment rate at Higher Education level does not seem to improve as reported by Lesotho's Council on Higher Education (2012). Figure 1 depicts the total enrolment at Higher Education institutions in Lesotho in 2011/2012 period. Natural and Applied Sciences such as Agriculture, Engineering and Health and Allied fields account for a lowly 24% combined (Council on Higher Education, 2012).

A closer look at these statistics reveals that most of the Science and Mathematics programs are still dominated by males except the health and allied area that is dominated by females (Figure 2). This can only but point to the fact that these calls are not heeded as the number or rather the ratio of students taking these programs is not improving. The above observations as well as some common public assertions (through the media and gatherings) that the Higher Education is responsible for poor attainment of Science, technology and engineering in general, prompted the researchers in this study to explore what role if any the primary school education plays in this given that most of the blame is focussed on the higher levels. "Mathematics and Science interventions should begin in primary schools," read one headline on the University of Johannesburg newsletter following the seminar hosted jointly by professors from the University of Johannesburg - South Africa and Helsinki University – Finland (University of Johannesburg News, 2015). This seminar demonstrated that most of the children's Science learning was mostly through memorising definitions and recalling some loosely connected facts, mostly because the teachers themselves could not understand those concepts hence make the learners recite them like a poem. This report somehow gave some impetus and some value to the feeling that perhaps the challenges require a little deeper digging and more embedded than what has been thought of previously.

There are many factors that are believed to affect learners understanding and overall attainment in Mathematics and Science. These can either be curricular or extra-curricular and are widely documented in literature (Wallace, 2015; Wiseman, 2012). These may include poor investment in teaching infrastructure in the form of laboratories, availability of books, level of education and economic for parents as well as general appreciation of Science by the public that is deemed responsible for poor Science performance in Africa (Irwin, and Wynne 1996; Pouris and Pouris, 2009). Another aspect that has been reported in Lesotho was the fact that experimental component of the Science subjects was not provided for in the time table hence its performance is highly dependent on the teachers' sacrifices, which in turn overloads both the teachers and learners as it de

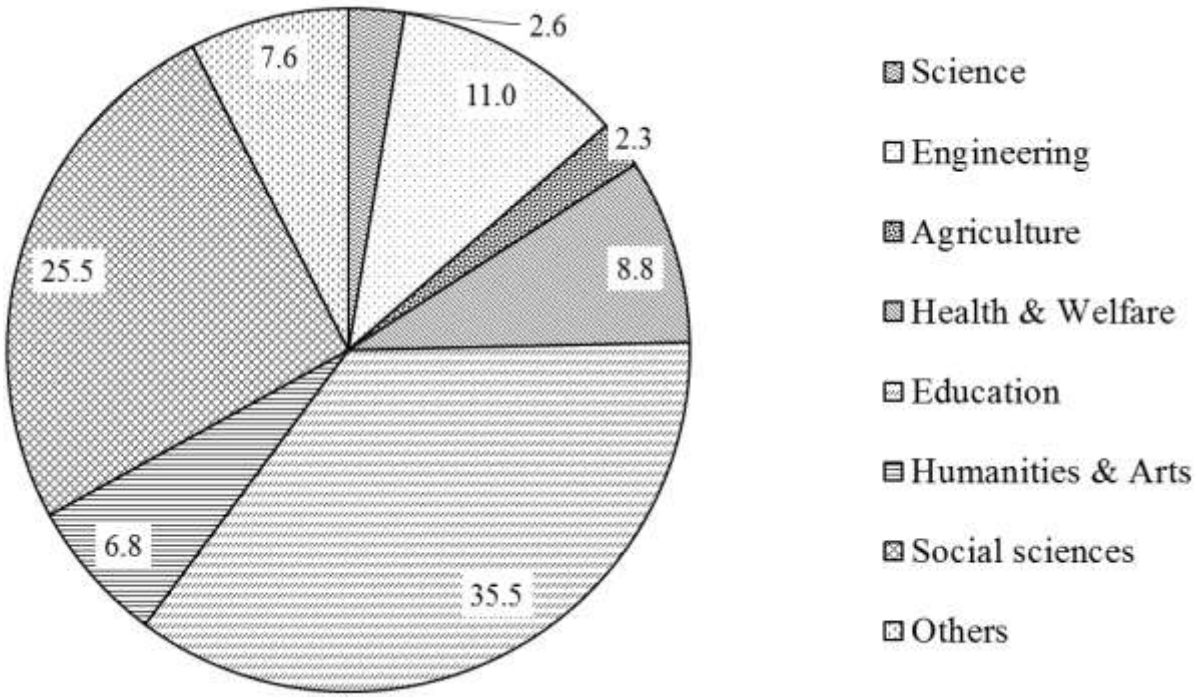

Figure 1. The enrolment in higher education institutions in Lesotho by area of study.

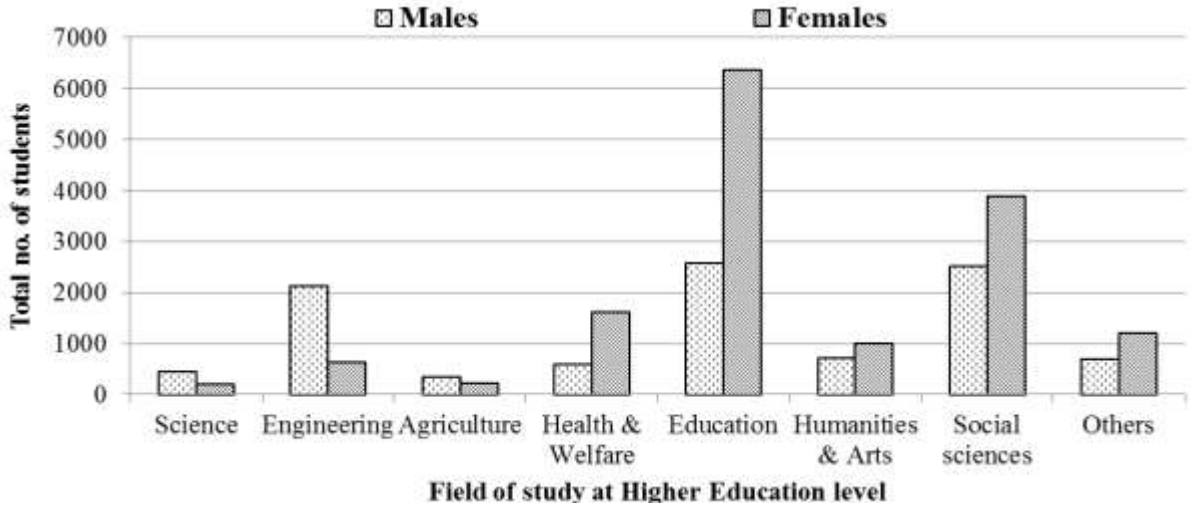

Figure 2. The classification of enrolment area by gender and field of study in higher education.

prives them some time for extracurricular activities (George and Kolobe, 2014; George, 2017).

This study aims to investigate the dynamics of primary school Mathematics and Science education with respect to: 1) the teachers' primary and secondary school subject matter content knowledge in Mathematics and Science, 2) the structure of the teacher training program as well as 3) the teacher deployment in the primary schools. It is believed that these play a very important role in catalysing interest in Mathematics and Science career.

When students are admitted into teacher training institutions they bring with them some subject matter content knowledge from their previous education. It is mainly their attainment in these subjects that is used as an entry requirement. This is important because strong subject matter knowledge is needed to be translated into

Table 1. The grading system for Standard Certificate and General Certificate of Education.

Grade	S.C. Grade	G.C.E Grade
Credit	One	A (1)
Credit	Two	A (2)
Credit	Three	B (3)
Credit	Four	B (4)
Credit	Five	C (5)
Credit	Six	C (6)
Pass	Seven	D (7)
Pass	Eight	E (8)
Ungraded	Nine	U (9)

the knowledge of teaching that subject (Ball et al., 2000). The nature of the teacher training programmes is also important as it is responsible for providing opportunities for enhancement of subject matter knowledge and its translation to the knowledge of teaching. Having acquired a teacher training certificate or diploma, how is one allocated a teaching load? Is it in line with teachers' competencies or in line with the requirements of the school or the entire schooling system? These are some of the issues that require consideration in order to judge success or failure of an educational system.

RESEARCH METHODOLOGY

Framing the research questions for the study

The main research questions were: *What is the level of Mathematics and Science content in the primary school teachers and what are the views these teachers have on the factors influencing their teaching and attitude toward Mathematics and Science education in the primary education?*
These questions were broken down into the following aspects:

(i) General subject matter content knowledge of Mathematics and Science as reflected by the attainment at three tiers of school: PSLE, JC and COSC levels by the pre- and in-service teachers.
(ii) The entry requirements for teacher training in relation to Mathematics and Science.
(iii) The views of the teachers in relation to their Mathematics and Science subject matter content knowledge for teaching.

Data acquisition and analysis

To address the posed question, the study was divided into two parts: desk research and questionnaire. The desk research was carried out to explore the entry requirements at the primary teachers training college, Lesotho College of Education (LCE) by looking into the college's entry requirement from the LCE's calendar for 2011/2012 academic year as well as the basic requirements for passing any particular level of study and overall completion of the programme. Regarding the basic education, some documents from the Examinations Council of Lesotho (ECOL) that are circulated to the schools advising them about the minimum learners' attainments at a particular level were used and were confirmed by going through the official ECOL's pass lists for PSLE, JC and COSC, respectively. For PSLE, 1st Class pass is when 60% is obtained in Sesotho, English, Mathematics and the Aggregate; 2nd Class pass when 50% is obtained in Sesotho, English, Mathematics and the Aggregate; and a 3rd Class for obtaining 40% in any three subjects and the Aggregate and 30% obtained in the remaining two subjects. At JC subjects are graded from A to F (A is 80% and above, B is the 70 -79%, C is 60-69%, D is 50-59%, E is 40-49% while F is the attainment below 40%). At COSC, candidates are graded in two ways, namely, Standard Certificate (S.C.) grade and General Certificate of Education (G.C.E.) grade as shown in Table 1.

On the other hand, the questionnaire was developed and distributed to mainly the first year pre-service teachers at the college and few were distributed to the in-service teachers. The essence of the questionnaire was to respond to the following broad ideas: attainment scores at the three school levels in Mathematics, Science and English in an effort to establish the teachers' background subject matter knowledge in these three subjects from primary and secondary level; and to establish the teachers views on teaching of Mathematics and Science compared to the other subjects as well as their views on teaching subject specialisation at primary school education. To achieve the latter, a 5-point Likert scale scoring (1 - poor/bad to 5 - excellent) was used to establish their views on the following:

(i) Their impression about the performance of their primary school teacher in Mathematics/Sciences compared to the other subjects;
(ii) How comfortable they are about teaching Mathematics and Science post qualification (more relevant to the in-service teachers); and
(iii) Their views about teaching subject specialisation at primary school level.

RESULTS AND DISCUSSION

Profiling the research population

This study was based on the two distinct groups: first year Diploma in Education – Primary (Dip. Ed. Pri.) 85 students picked randomly at the Lesotho College of Education as well as the already 22 practising teachers from various schools in the outskirts of Maseru City (about 50 km radius) due to limited resources for a wider population; these teachers were also picked at random. The authors felt it was important to also assess the

gender distribution of the respondents. Unfortunately, the pre-service teachers at the college did not respond to this question. However, of the already practising teachers, 64% (14/22) were females indicating a gender imbalance. An attempt to explore the geographical regions that respondents studied their primary education did not present reliable results since most of the respondents only presented their districts with no mention of whether their places were in rural or urban areas. This aspect is important given that most experienced teachers migrate to urban or peri-urban places and leave the most recently graduated ones and even unqualified teachers to teach in the rural areas. It was established that most of the teachers (86%) had diploma qualifications while the remaining 14% had Bachelor's degree. All the practising teachers were aged higher than 30 years.

Assessment of the entry requirements into the primary teachers diploma/degree programmes

Before exploring the entry requirements, it is perhaps prudent to present a general overview of the school system in Lesotho as far as Mathematics and Science are concerned. Before the introduction of Lesotho General Certificate of School Education, LGCSE in 2013, the school system in Lesotho did not enforce Mathematics and Science as compulsory subjects at school leaving qualification, Cambridge Overseas School Certificate (COSC), hence some of the potential candidates to the teachers training college ended up evading these subjects in their last years of secondary education. This was very unfortunate since some of these school leavers ended up qualifying into the teaching profession where they have had to also teach these two subjects and as will be demonstrated later with difficulty and possibly also contributing to the weak attainment of these subjects by the learners and eventually by the communities themselves as a consequence of poor appreciation of the subjects and the principles thereof. Fortunately, the Ministry of Education has recently wisely made these subjects mandatory at the LGCSE which means whether or not the school leavers pass or fail them, they will have at least done these subjects.

The assessment of the entry requirements for the teachers' qualifications by both institutions that offer the teaching programs at diploma level, the LCE and at degree level, National University of Lesotho (NUL), revealed that neither Mathematics nor Science are requirements for entering the program. The minimum entry requirements at LCE in the two programs offered therein, Diploma in Education Primary (Dip. Ed. Pri.) - a three-year fulltime program and a Distance Teacher Education Program (DTEP) - a 4-year distance program for the candidates who are already teaching were a pass with credit in 3 subjects including English and a pass in the remaining two at the COSC level with no specific mention of the subjects of this study (Lesotho College of Education, 2011a). The Science courses for the programmes cover biology, chemistry and physics together with the methods of teaching. As explained in the course outlines, one of the course aims is to "help students acquire adequate knowledge and understanding of Science concepts that are needed to teach Science effectively at Lesotho Primary Schools" (Lesotho College of Education, 2011b). In Mathematics also, content and methods of teaching are treated with the same purpose. By default, the entry requirements at the NUL do not require any achievement in the target subjects since entry requirements are based on the successful completion of the college diplomas. Consequently, no efforts were made to retrieve some information about the Mathematics and Science content at the B.Ed. level since it was regarded as irrelevant at that stage.

Assessment of the teachers' subject matter content knowledge from schooling in Mathematics and Science subjects

Assessment of the Mathematics and Science undertaking at school level revealed that all the pre-service teachers took the COSC Mathematics and Science. There were some in the in-service group that had not taken the COSC Mathematics, and some who had not even passed Mathematics at primary school. Fortunately, from the sample used, none had completely failed both subjects at primary level although this is a possibility since the learners can pass the PSLE without the necessity to pass either of the subjects as long they have passed others as evidenced in the ECOL PSLE Pass Lists (Examination Council of Lesotho, 2014; Examination Council of Lesotho, 2013). Figure 3 shows pictorially the attainment of the pre-service teacher respondents at the JC and COSC levels in the target subjects as well as English Language which is mandatory to pass at all these levels.

The average for the COSC is numerically higher (poorer attainment) than the JC level for all the three subjects with mathematics recording the poorest performance (average of 3.9 and 4.5 for JC and COSC levels). This demonstrated a general drop in performance with averages in COSC being 4.49, 3.84 and 3.15 down from 3.93, 3.35 and 2.67 at JC for Mathematics, Science and English respectively.

The overall summary of attainment in the three subjects at the COSC level is shown in Figure 4 for the pre-service teachers using the classical symbols assigned for different attainment levels. Of all the respondents, 12% (assigned Grade NA) did not do Science (Biology, Chemistry or Physics) at COSC level. Coincidentally, the same learners did not do very well in Mathematics since they obtained Grades 7 and 8 respectively which are in

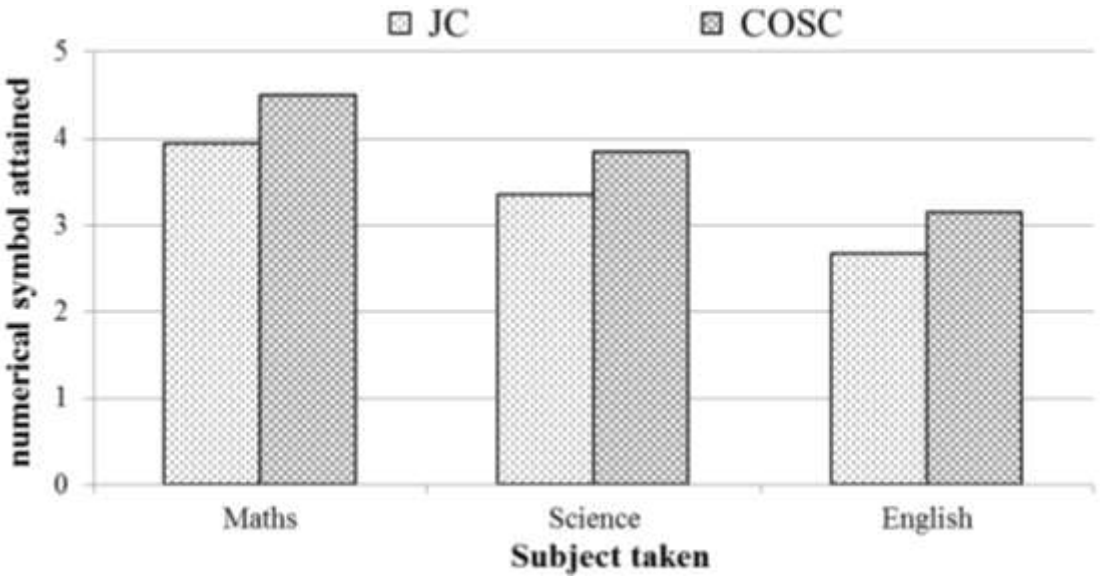

Figure 3. The average attainment in the three subjects at JC and COSC levels of study.

the range of 40 - 49% numerically (Examination Council of Lesotho, n.d.). As can be seen, about 12% of the respondents did not take the Science at COSC. Interestingly, there were some respondents (about 15%) who attained a poorer pass than a credit pass (numerical grade greater than 6) in English yet the entry requirements stated that the entry requirement is at least a credit symbol (a symbol numerically ≤ 6).

The responses from the in-service teachers were not included in these analyses. However, it is worth mentioning that a significant fraction (just about 23%) of these teachers did not do Mathematics at school leaving certificate (COSC) level while 32% did not obtain a credit pass (Grade less or equal to 6 in Mathematics) and almost the same population (36%) had not done Science at COSC, but had rather done Human and Social Biology and/or Agriculture, which are traditionally regarded as softer Science than pure Biology and Physical Sciences.

Assessment of the teacher's attainment in Mathematics and Science in relation to other subjects

This question was coupled with the issue of the inspiration for one to pursue Mathematics and Science careers. This is because these are believed to be linked somehow; as a good teacher always inspires his/her learners to emulate him without even asking. Again, it is believed that learners' attainment and attitude towards certain courses could be linked to the teacher's understanding and command of the subject (Rand Education, n.d.). Since these questions are qualitative in nature, a five-point Likert score ranging from 1 (very poor) and 5 (excellent) was used for the responses. The results shown in Figure 5 show that teachers' attainment in relation to other subjects was generally average. Interestingly, the lowest score was obtained although with a very lowly 6% of these student-teachers.

The views of the in-service teachers about their overall teaching of Mathematics and Science in comparison with the other subjects

This section was more relevant and targeted at the in-service teachers since one of the questions they were asked was how they find teaching Mathematics and Science. Figure 6 shows the responses to the questions relating to the ease with which the teachers find the teaching of Mathematics and Science relative to the other subjects.

Clearly, most of the teachers were modest with majority scoring themselves an average score (3/5) and a few scoring themselves excellent (5/5). Interestingly, some (14%) rated themselves to be poorly performing, and this percentage drops to 3% for overall teaching. For these questions, the issue seemed to be more of Mathematics than Science. Some teachers mentioned that they gauge their attainment relative to their learners' attainment and their peers in other schools at the national PSLE examinations. This self-blame however is a bit subjective and harsh given that the attainment of learners cannot only be attributable to the teachers, but rather to a number of factors such as family background, background knowledge, attitude towards learning,

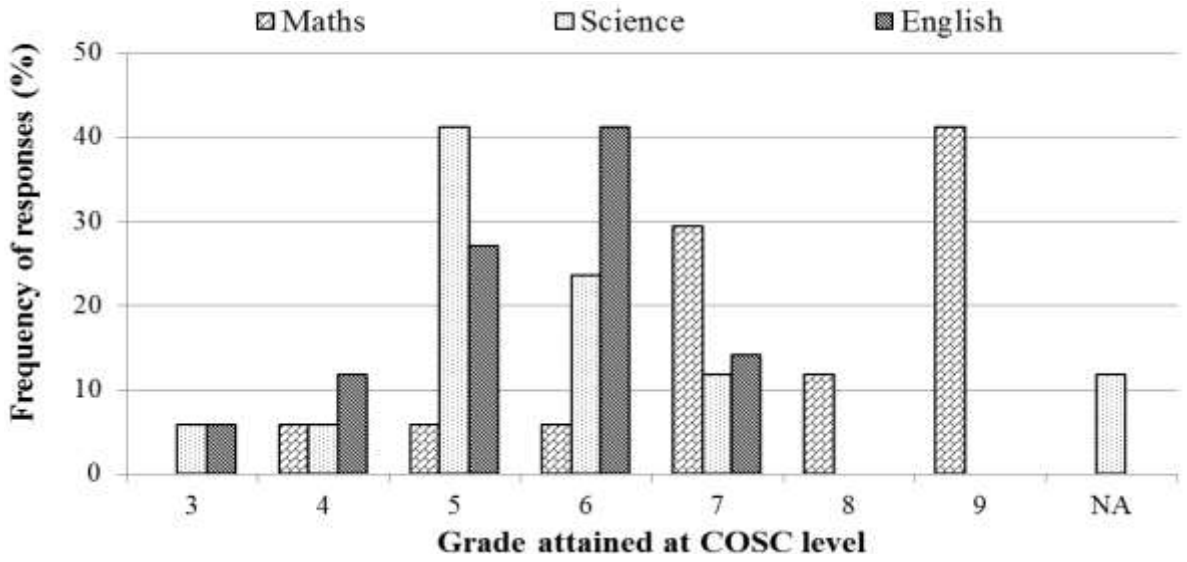

Figure 4. Attainment in Mathematics, Science and English at COSC level by the learner teachers at LCE.

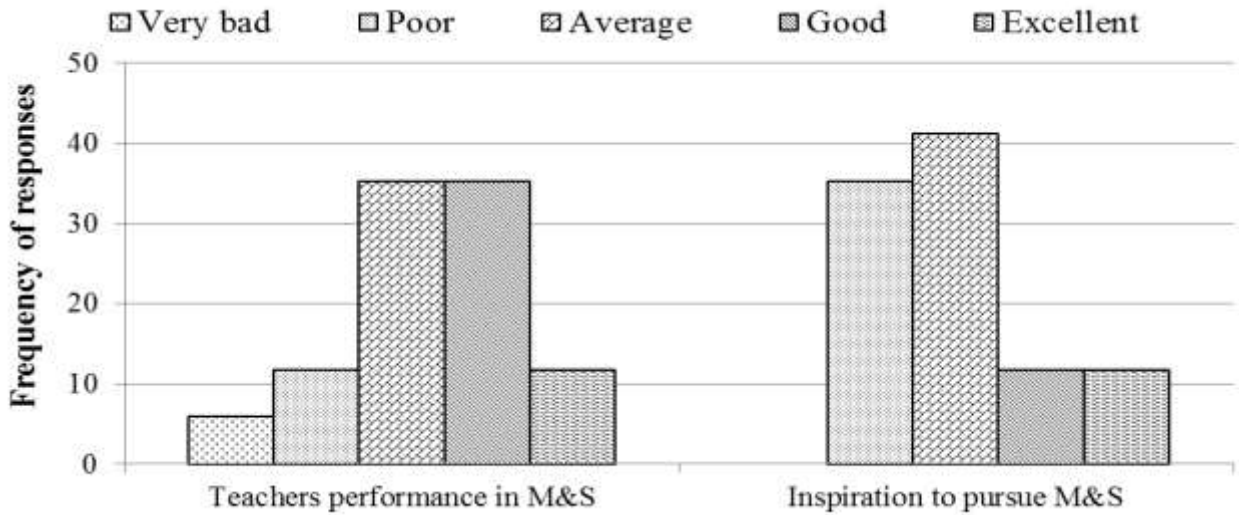

Figure 5. Some perceived teachers' attainment and learners' inspirations by the teachers.

availability of resources, just to name but a few, in addition to the individual pupil's aptitude as discussed earlier.

Views about teaching subject specialisation at primary level

The last question that was presented to all the respondents was their feeling about subject specialisation at primary school. Figure 7 shows a significant majority (77%) felt that subject specialisation was a good idea, of which 32% thought it was excellent. There was a good correlation between those teachers that thought teaching Mathematics and Science equally matched teaching of other subjects. Interesting, the two teachers who scored themselves a 2 out of 5 on both teaching of Mathematics and Science thought that specialisation is not a good idea. Unfortunately, these teachers could not be identified (as data collection was blinded) so that they could be asked why if they thought their Mathematics teaching was not comparable to other subjects why they would still want to teach.

It is almost conclusive to recommend that subject specialisation at primary school could be a unanimous agreement if the neutral responses are ignored since those against the idea only constitute 9%, with no responses on the extreme negative. It would be

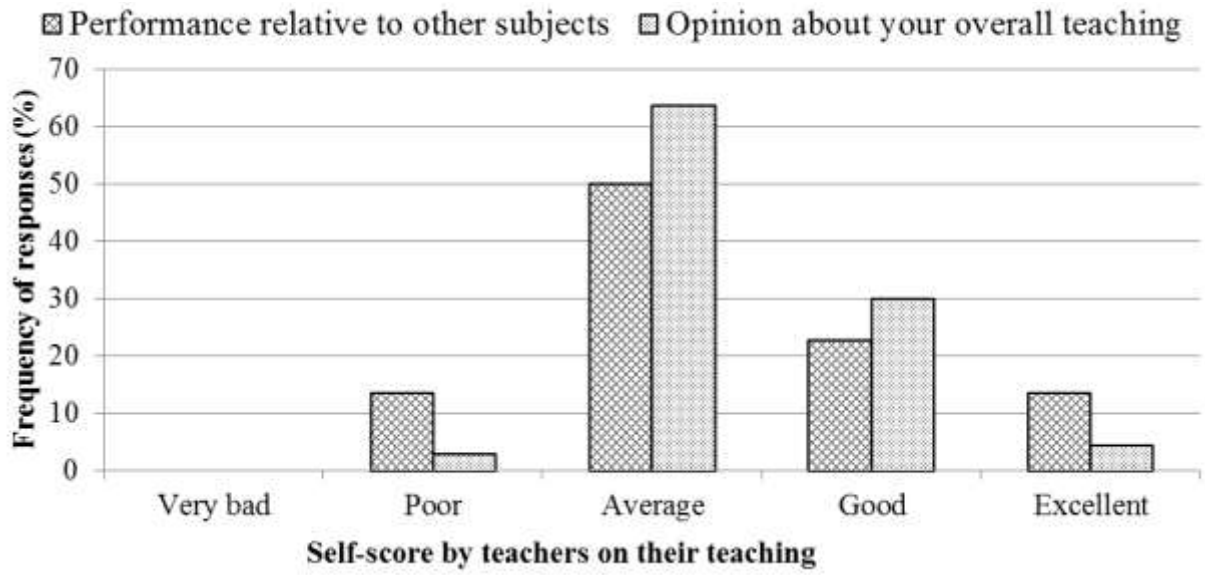

Figure 6. Self-scoring/assessment of the in-service teachers on their teaching of Maths and Science relative to other subjects and the overall teaching.

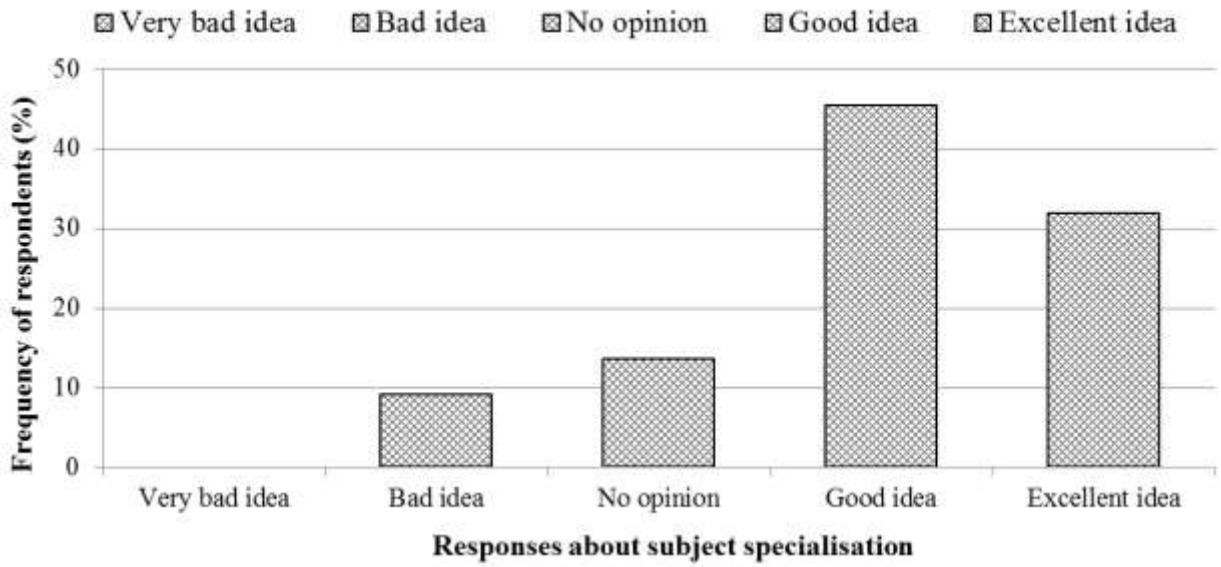

Figure 7. The respondents' opinion about their Maths and Science teaching as well as subject specialisation in primary school education.

interesting to establish the views of those who could not support this idea.

Conclusions

This study presented some interesting aspects of primary education in Lesotho. The main issue is that perhaps the poor attainment of Science and Technology in the country may not only be attributable to tertiary/higher education, since at that stage the learners have probably already missed quite a big chunk to start appreciating most of the highly abstract phenomena without the necessary foundation. This study, limited as it is, has amply identified a need to introduce subject specialisation at primary school level. Although it is believed that this will increase the number of teachers needed to teach at a particular level, this may not necessarily be the case. The same subject combinations practised in secondary schools could be used, where one teacher in a school for

example could be responsible for two subjects across all the grades, rather than the present case where one teacher teaches all the subjects. Alternatively, it can be an intermediate where at least three majors could be proposed: Mathematics/Science, Languages and the Social Studies. This will alleviate some potential problems where the learners could suffer simply because all their teachers are not comfortable with certain subjects and the whole school gets condemned to failing the entire subject. Alternatively, it means if the learners do not understand one teacher, then they are condemned since there is no alternative teacher to relieve them in other subjects.

The authors recommend that primary school teachers be afforded regular in-service training courses in the teaching of Mathematics and Science by teacher training institutions such as NUL and LCE, so that they can be sufficiently empowered for teaching these important subjects. Teachers could also collaborate with peers within the same school as part of their professional development. This could be more effective than if teachers have to wait for teacher trainees at certain times. This is a call also demonstrated by the UK's STEM white paper. Professionalism acquired during training would probably induce in students the liking for the subject. This is because few learners felt that their teachers, directly or indirectly, inspired them to pursue Science-based careers, hence this has to be a cause for concern. It is believed that without much interest and inspiration by teachers, pupils will always find it daunting to choose Science-based careers especially with the ever-demanding nature of Science in the higher levels as observed and reported in the earlier work.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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