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Integrating language literacy in physical sciences in Riba Cross District, South Africa

Israel Kibirige [a*], University of Limpopo, Private Bag X1106, Sovega, 0727 Polokwane, South Africa. https://orcid.org/0000-0002-6908-2361

Asaph Romolus Mogofe [b]**,** University of Limpopo, Private Bag X1106, Sovega, Polokwane, South Africa. https://orcid.org/0000-0001-6446-8559

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Abstract

The language of teaching and learning challenges Physical Sciences teachers and impacts learners' achievements. The study aimed to investigate how language literacy is integrated into the teaching of Physical Sciences. A descriptive survey design was adopted. The participants were five Grade 10 Physical Sciences teachers and 211 learners (108 boys; 103 girls) from nine schools exhibiting low academic achievements. Data were gleaned through the Literacy Skills Usage Survey Questionnaire (LSUSQ). The results show that 77.78% of the teachers did not engage learners in report writing and arguments which are fundamental to language literacy, suggesting that integrating literacy in science teaching was inadequate. Learners had difficulties in contributing to word walls, writing reports, and arguing from evidence. The lack of integration suggests that teachers lacked training in integrating language literacy into science teaching. These findings underscore the need for workshops to enable teachers to incorporate language literacy in teaching Physical Sciences.

Keywords: arguing from evidence, integrate, language literacy, reading and report writing.

* ADDRESS OF CORRESPONDENCE: **Israel Kibirige**, University of Limpopo, Private Bag X1106, Sovega, 0727 Polokwane, South Africa.

Email Address: kibirigei@gmail.com / Israel.Kibirige@ul.ac.za

1. Introduction

Over half a century, Science education scholars advocated for incorporating language literacy in Physical Sciences lessons (Lyon et al., 2016). Although to be knowledgeable one must be able to read and write, experiences of trial and error, oral communication, and apprenticeship play a significant role. However, science does not differentiate between knowledge and the ability to read and write (Broggy & McClelland, 2012). To gain access to science, one needs to comprehend written texts (Hu & Gao, 2020) because a lack of it restricts reading and writing about scientific knowledge (Hu & Gao, 2020). Reading and writing are essential skills to broaden the teaching and learning of Physical Sciences content (Graham, 2020). Thus, learners need to read and write to hone their inquiry learning process (Maeve & Niamh, 2018; Meskill & Oliveira, 2019; Graham, 2020).

A few studies show positive results in science concept understanding when language literacy, reading and writing, is integrated into science learning (Zarobe & Zenotz, 2017; Buxton et al., 2019; Huang, 2020). The acquisition of many skills requires language literacy in Physical Sciences lessons (Lyon, 2016). Science subjects are more text- or language-dependent (Prinsloo, Rogers & Harvey, 2018) and integrating language in science may enhance learners' motivation (Lasagabaster, 2019), literacy reading (Prieto-Arranz et al., 2015), and science conceptual knowledge (Huang, 2020). Maeve and Niamh (2018) contend that the language used to develop literacy in inquiry Physical Sciences lessons is vital for science understanding. Thus, teaching through inquiry where learners read, write and talk about Physical Sciences enhances learners' literacy and content knowledge (Nelson, 2020). Integrating language into science teaching was beneficial to immigrants' children in Germany (Meisterfeld, 2016; Schmiedebach & Wegner, 2019). Also, language integration into science is essential in other countries where the Language of Teaching and Learning (LoTL) is not the learners' mother tongue. In China (Macaro & Childs, 2019), Sri Lanka (Vithanapathirana & Nettikumara, 2020), Argentina and Spain (Banegas & del Pozo Beamud, 2020), Singapore, Malaysia and Hong Kong (Lin et al., 2019), and indeed in other parts of the world where LoTL is not the mother tongue of the learners.

In South Africa, English and Afrikaans are the two LoTL from grades four to twelve. 80% of the schools learn Physical Sciences in the English language, which is not the learners' mother tongue. Thus, learners' English Literacy levels (ELs) are low in many schools (Turkan & Schramm-Possinger, 2014; Ratini et al., 2018). If the learners' language literacy is not developed, they will perform poorly in examinations (Baker, Lesaux, Jayanthi, Dimino, Proctor, Morris, 2014; Faisal & Martin, 2019). Physical Sciences examinations not only assess learners' content but the English language as well (Baker et al., 2014) because learners use words to describe observations and pieces of evidence. Vygotsky (1978) asserts that learning first occurs in the inter-mental plane before it can happen in the intra-mental plane. This denotes that a learner cannot understand Physical Sciences content because of LoTL, and that the learner will not take part in science lesson discourses. This implies that reading fluency is a forecaster of comprehension (Durukan, 2020).

Mastering LoTL is important to the learners' academic achievements, especially when it differs from learners' mother tongue (Prinsloo et al., 2019; Zhumabayeva et al., 2019). The Trends in International Mathematics and Science Study (TIMSS) in South Africa for 2016 shows low performance for fourth and eighth-grade students. According to Umalusi, the Quality Assurance body in South Africa, the low performance was associated with the LoTL used in schools (Parliamentary Monitoring Report, 2017; Reddy et al., 2016, Charamba, 2019). Nelson and Allen (2020) assert that language teaching can be integrated into Physical Sciences teaching. After all, science is related to our everyday life (Parmin et al., 2016). It is no wonder Heliawati, Rubini and Firmayanto (2020, p. 1061) stated that "So, content and language are an inseparable unity." Thus, when science and literacy are integrated into science lessons, learners will be motivated to explore a scientific phenomenon (Lasagabaster, 2019). During language integration, we can use 'word walls' where teachers display words for learners to observe (Elliott, 2010). No word should stay on the word wall for a very long time to allow other words to be placed. Also, words should be removed as learners get used to them and are replaced with new problematic words (Carrier, 2011). Learners should be given the freedom to put on the wall words they feel are difficult. The teacher should limit the number of words that should be on the wall at any one time. It is assumed that this would encourage learners to use the word wall in the science discourses.

Learners' discourses are central to the development of literacy (National Research Council (NRC) (2014). During learners' discourses, arguing from evidence is the basis for Physical Sciences learning (Broggy & McClelland, 2012). Therefore, scientific knowledge emerges from constructive arguments from sources and experimentations (Broggy & McClelland, 2012). In the Physical Sciences classrooms, learners should be given occasions to talk about Physical Sciences (NRC, 2014). It means that the teacher needs to provide context and reasons for investigation so that the discussions are authentic and motivating to learners. Ideally, Physical Sciences lessons should be introduced by providing learners opportunities to read (NRC, 2014). Teachers should bring to class Physical Sciences related texts that use correct scientific terms related to the topic (Fidalgo, Torrance, Rijlaarsdam, van den Bergh & Álvarez, 2015). When learners are reading, the teacher should make sure that words are correctly pronounced to help learners become proficient readers (Coltheart, 2005). Furthermore, Lyon et al. (2016) found a positive correlation between reading fluency and comprehension. So, if learners can read fluently, their level of understanding is likely to be high, leading to better Physical Sciences performance.

One way to help English learners to improve their language literacy level is to let them write about Physical Sciences (NRC, 2014). Writing in the Physical Sciences classroom can be in various forms like keeping journals, diaries, graphic organisers, poems, laboratory reports and other creative writings (Fidalgo et al., 2015). Therefore, teachers should involve learners in writing because it cements the learners' Physical Sciences process skills (Fidalgo et al., 2015). Matthews (2000, p. 161) contends that "constructivism is an influential learning theory in the teaching of Physical Sciences and Mathematics". Constructivists claim that: "knowledge is not passively received but is actively built up by the cognising subject"; and "that the function of cognition is adaptive and serves the organisation of the experimental world" (Matthews, 2000, p. 175). Thus, the constructivism theory of learning (Vygotsky (1978) guided the study. Vygotsky believes that there must be language development before active learning can take place. It means that social interaction may be curtailed where some language literacy elements are not fully developed, which limit the learning process (Villanueva, 2010). Some language literacy elements include speaking, reading, writing and comprehension (Meskill & Oliveira, 2019). During constructivism, learners write, speak and read texts, draw graphs and pictures to comprehend and communicate scientific information (Nelson, 2020). Furthermore, Gottlieb (2016) contends that learners should be exposed to integrating content, literacy, cognition, and language to develop explaining skills. The Department of Basic Education (2012) found that low language proficiency was one reason for learners' poor performance in Grade 12 Physical Sciences examinations in South Africa. Learners lack meaning making, which establishes relations between entities of experiences (Somerville & Faltis, 2019).

In the science classroom, the meaning-making process takes place through various discourses, and the learners make meaning by relating their earlier experiences and the purpose of the activity (Ollerhead, 2019). Learners bring different levels of language literacy experiences to the science classroom. It is difficult for teachers to control students' experiences (Charamba & Zano, 2019; Ramirez & Ross, 2019). The science teachers' role is to make students' prior experiences continuous with the lessons (Dewey, 1998). Learning is based not only on the learners' endowed capacity to learn (Zavala, 2019), but the prior knowledge related to the lessons (McKinney & Tyler, 2019). Thus, science teachers need to address how students use language to communicate with their peers (Vygotsky, 1978). It suggests that some teachers do not integrate literacy in the teaching of Physical Sciences (Bacon, 2020). As a result, learners fail to develop LoTL in Physical Sciences. To date, it is not clear how much language literacy integration takes place in Physical Science lessons in South Africa. Therefore, the study investigated how language literacy was integrated into the teaching of Physical Sciences in Riba Cross District, South Africa.

1.1 Purpose of the Research

The study aimed to investigate how language literacy was integrated into the teaching of Physical Sciences in Riba Cross District of Limpopo Province of South Africa. To meet the aim of the study, two objectives were used: 1) to establish how language literacy is integrated into the teaching of Physical Sciences in schools; and 2) to identify elements of language literacy, which was integrated into the teaching of Physical Sciences.

1.2. The importance of research

Language literacy is one of the means through which science learning takes place and the language literacy of learners is expected to increase from one level to another. Unfortunately, science teachers pay little attention to language literacy teaching (Zein, 2016), and as a result, learners do not get assistance in speaking, reading and writing in science lessons (Gunes, 2019). Due to inadequacies in LoTL, many learners could not grasp the science content and express the content they knew. One challenge learners face when studying science is the nature of the science language, which is concise, precise, and authoritative. Language teaching in science lessons is not limited to English but also to other home languages (Prinsloo et al., 2019; Zhumabayeva et al., 2019). The learners' lack of proficiency in LoTL jeopardises their reading comprehension. Learners need scaffolding from their teachers to learn science vocabulary (Guo, Wang, Hall, Breit-Smith & Busch, 2016; Pritchard & O'Hara, 2016; Mahan, 2020). They need to learn how to process science content to become independent science learners. Language integration is beneficial in other fields, like engineering (Montgomery & Madden, 2019). It is also envisaged that language and science literacy assist learners to make better choices for their livelihood (El Islami et al. (2018). There are conflicting results on the effect of integrating language in teaching content in science and other subjects. For instance, Surmont et al. (2016) show that learners taught using language integration improved their understanding of content, while Fernández-Sanjurjo et al. (2017) found no change in Performance. Given these conflicting results, it was deemed necessary to determine how science teachers integrate language literacy in the Physical Sciences lessons in Riba Cross District in South Africa. This study contributes to the body of knowledge regarding language integration in science teaching and learning.

2. Method

2.1 Model of the research

A quantitative research approach was used because it is useful in quantifying opinions, knowledge, attitudes, behaviour, and practices (Cohen, Manion & Morrison, 2007). The study aimed to investigate the integration of language literacy in the teaching of Physical Sciences in schools. A descriptive survey design was used to allow the researchers to identify how language literacy was integrated into teaching Physical Sciences in schools. The design provides an opportunity to generalise the findings (Lodico, Spaulding & Voegtle, 2006).

2.1.1. Participants

The study participants comprised of 5 Physical Sciences teachers (males) and 211 learners (108 boys: 103 girls). The participants were from nine secondary schools purposively selected, based on their poor performances in Physical Sciences Grade 12 final examinations, from Riba Cross District.

2.1.2. Demographic features of participants

Table 1: Demographic of the participants

Learners	Grade	Gender	Department	Ages (Range)
108	Grade 9	Male	Science	15-17
103	Grade 9	Female	Science	15-17
Teachers	Qualification	Gender	Department	Years of teaching
1	Bachelor of Education (B.Ed.)	Male	Science	7
2	Bachelor of Science (B.Sc.) + Postgraduate Certificate in Education (PGCE)	Male	Science	5
3	Bachelor of Education (B.Ed.) Honours	Male	Science	6
4	Higher Diploma in Education	Male	Science	10
5	Secondary Teachers Diploma (STD) + Advanced Certificate in Education (ACE)	Male	Science	14

2.1.3. Data collection tool

The researchers designed language Literacy Skills Usage Survey Questionnaire (LSUSQ), comprising teachers' and learners' parts. Each part had two sections: Section A was the study participants' biography, and section B had 18 items for teachers and 16 items for learners, respectively. The items were close-ended Likert questions comprising 5 responses (Maree & Pieterson, 2007): (1) strongly disagree, (2) disagree, (3) unsure, (4) agree, and (5) strongly agree. Three experts checked the open-ended questions in the questionnaires: a Physical Sciences Head of Department; and two Physical Sciences practising teachers. Content Validity Index (CVI) was calculated using the formula below (Brennan & Hays, 1992):

$$CVI = \frac{Number\ of\ items\ judged\ by\ both\ judges\ as\ right}{Total\ number\ of\ items\ in\ the\ questionnaire}$$

CVI for teachers' questionnaire was 0.83, and that for learners was 0.88, and therefore the questionnaires were considered valid. The questionnaires were piloted to 2 teachers, and ten learners from educational backgrounds similar to that of the study sample. A Cronbach alpha coefficient (∝) was computed from the results using the formula below (Cronbach, 1951, p. 299):

$$\propto = \left(\frac{K}{K-1}\right)\left(1 - \frac{\sum S_i^2}{S^2{}_{sum}}\right)$$

Where:

- K= number of components (K- Items);
- S_i^2 = variance of K individual items;
- $S^2{}_{sum}$ = variance for the sum of all items.

Cronbach alpha coefficients were got for each item. The overall Cronbach Alpha values of 0.85 and 0.73 were got for teachers' and learners' questionnaires, respectively. These values show the instruments were reliable because any item with a coefficient of ≤ 0.70 was acceptable for research (Tuan et al., 2005). Thus, the final version of the teachers' questionnaire comprised 17 items.

2.1.4. Data collection method

The researcher collected data in two weeks. The LSUSQ were administered to teachers and learners to gather data (Wray & Bloomer, 2006).

2.1.5. Analysis of data

The data were analysed using descriptive statistics (Gall, Gall & Borg, 2007) using SPSS version 22. Percentages, means and modes were used to show the frequencies of various responses expressed by the participants. Data were presented in tables and graphs to show the key features.

3. Findings and Discussion

3.1. Biographic information

In Table 2, out of the nine schools, school E had the highest number of learners (45) while school B had the lowest number (8) and other schools, for instance, School F had 12 learners in Grade 10, while School E had 45 learners (Table 2). In all the schools, three language literacy elements that scored less than three encouraged learners to contribute to the word walls; writing reports, and engage in arguments from evidence. The lowest scores suggest teachers did not assist learners to use language to understand science. The reason could be that teachers of content subjects like Physical Sciences are not trained to teach language. Consequently, learners' low achievement in contextual questions in the final examinations may be attributed to their poor English language proficiency (Department of Basic Education, DBE, 2011).

The learners' profile per school and class was included in determining the sample's composition (Table 2).

Table 2: Learner distribution per class per school

School	Number of participants	Percentage	Cumulative Percentage
A	20	9.48	9.48
B	8	3.79	13.27
C	26	12.32	25.59
D	25	11.85	37.44
E	45	21.33	58.77
F	12	5.69	64.46
G	26	12.32	76.78
H	17	8.06	84.84
I	32	15.16	100.00
Total	211	100.00	

3.2 *Learners' home language*

Learners' mother tongue, Sepedi constituted 83.41% compared to 16.59% for other languages like Siswati, Ndebele, IsiZulu, and Venda. The overall mean of learners' responses to literacy inclusion in the Physical Sciences classroom was 3.48 ± 0.62 SD, which is between Unsure (3) and Agree (4).

The line graph below (Figure 1) represents the learners' average responses per questionnaire item.

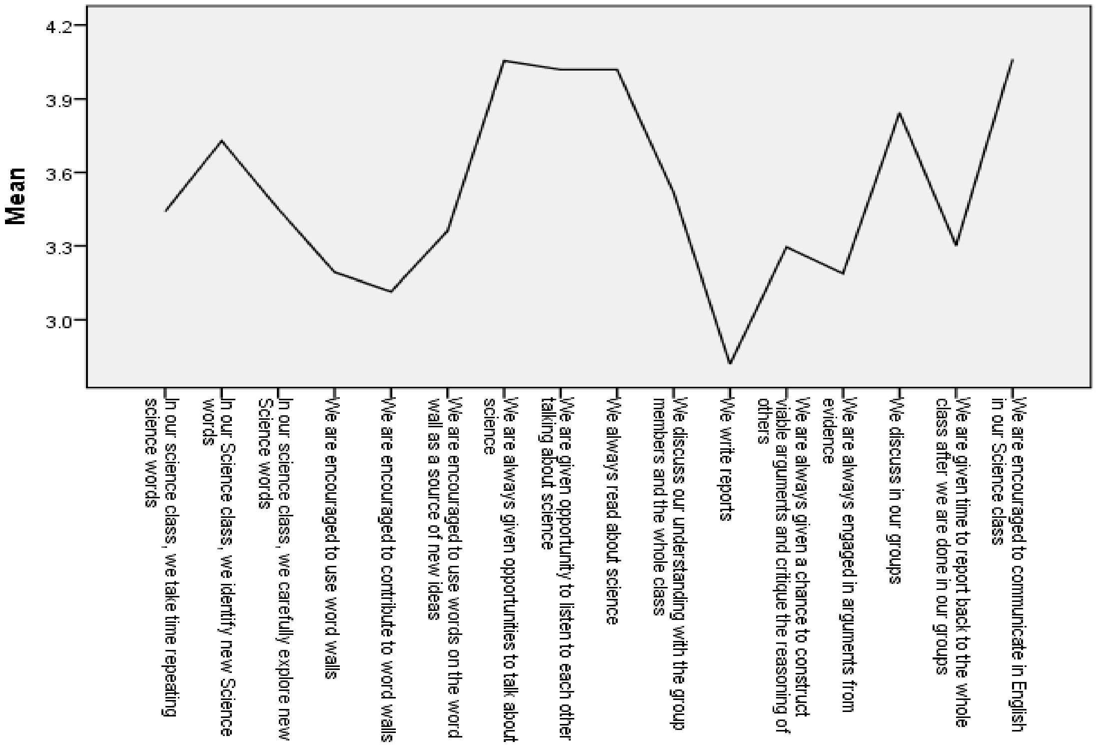

Figure 1. Learners' average responses per questionnaire item

Figure 1 shows that language literacy elements integrated into the Physical Science classroom: learners' use of the word walls; talking about science; learners listening to each other; reading about science; discussing in groups and entire class in English. Three language literacy elements that scored less than three were encouraging learners to contribute to the word walls, writing reports and engaging in arguments from evidence. These results suggest learners were not used to active learning because of their low language proficiency.

3.3 *Writing reports*

The following compound boxplot (Figure 2) shows learners' scores when writing reports is compared among the schools.

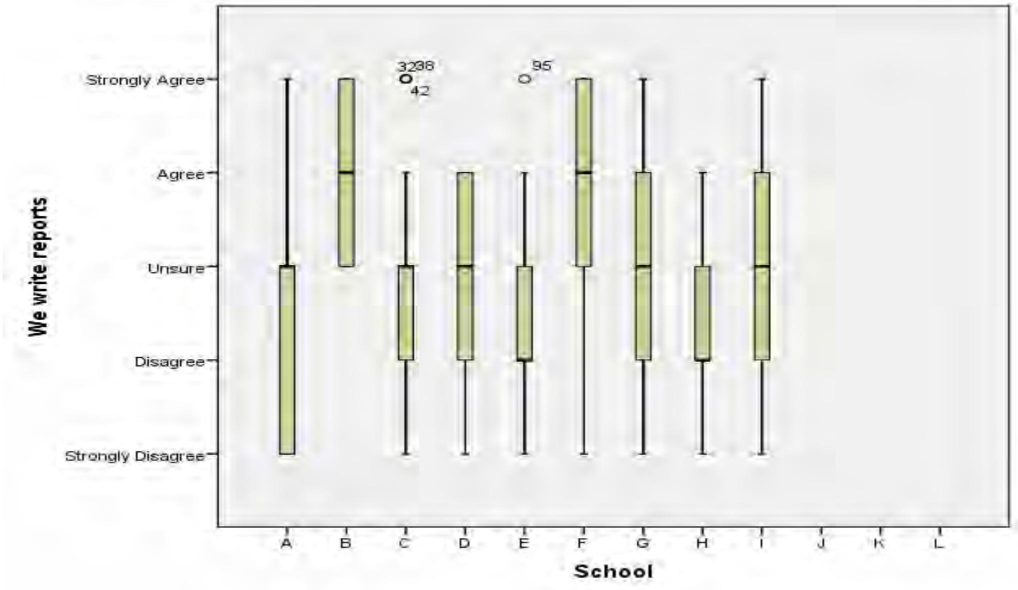

Figure 2. A comparison of schools regarding the writing of reports

Figure 2 shows that only two schools, B and F, out of the nine (22.22%) engaged learners in report writing. Learners were encouraged to use word walls; talk about science; listen to each other talking about science; reading about science, and communicating in English during Physical sciences classes. The results show that most of the schools did not engage learners in report writing. Also, learners did not contribute to the word walls and did not argue from evidence (Figures 1 and 2). These results suggest teachers did not use report writing in teaching Physical Sciences. It could be true that report writing was left to English language teachers. Science teachers may lack the competencies to use report writing in teaching science, suggesting that teachers may have challenges to relate science teaching to inquiry teaching. These results are in sharp contrast to Chabalengula and Mumba (2012) who contend that inquiry into Physical Sciences teaching and learning involves report writing. Also, the social constructivist learning approaches that lead to language literacy elements were not developed among learners (Villanueva, 2010). Vygotsky (1978) asserts that there must be language development before effective learning occurs. It is so because, during constructivism, learners must write, speak and read texts to comprehend and communicate scientific concepts (Villanueva, 2010).

Schmiedebach and Wegner (2019) argue that practical work or hands-on learning could promote conceptual understanding if small qualitative practical tasks like report writing skills are used. However, experimental work is often teacher-directed, and learners often cannot relate it to language literacy and other subjects (Chabalengula & Mumba, 2012). During practical work assessment in Physical Sciences, teachers use a rubric and assume that following the rubric learners will understand science content. Typically, learners are provided with an aim; hypothesis; procedure; and are expected to record observations (Hapgood & Palincsar, 2007). Learners may reduce practical work to a game of "correct answers" and "what should happen" (Hapgood & Palincsar, 2007). While the communication of experimental findings is part of scientific activity, it is not always done in many Physical Sciences classrooms. Incorporating writing in Physical Sciences improves learners' reading skills and vice versa (Graham, 2020). Thus, Physical Sciences and literacy form an intersection using reading, writing, and oral language to answer Physical Sciences content (Maeve & Niamh, 2018).

3.4. *Arguing from evidence*

The results of learners arguing from evidence is compared among the schools and the scores are presented in Figure 3.

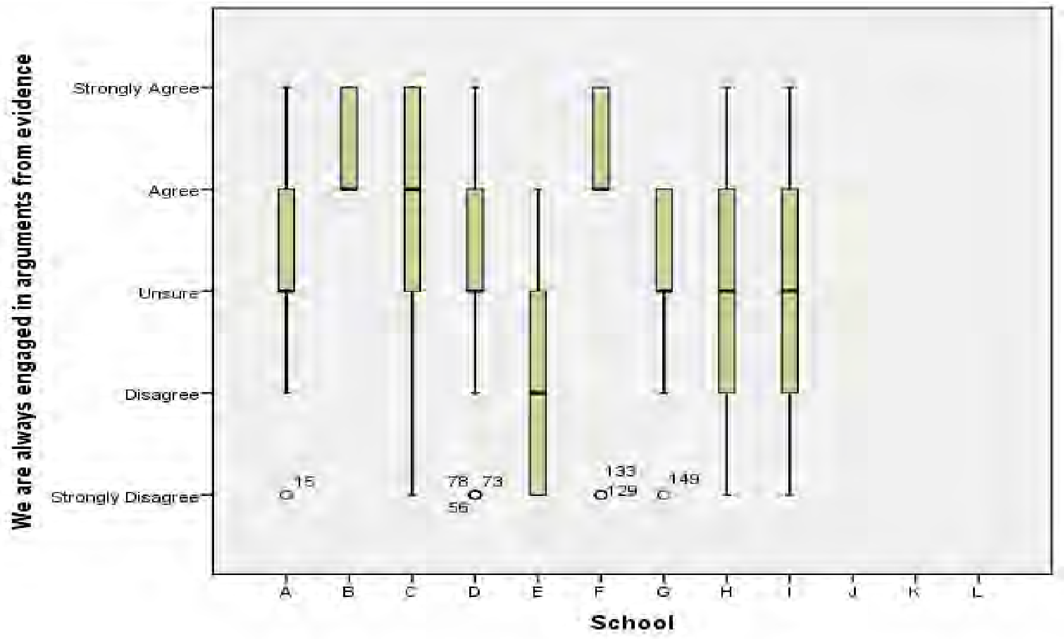

Figure 3. A comparison of schools regarding arguing from evidence

Figure 3 shows that the vast majority of the schools did not engage learners in arguing from evidence because only Schools B and F had their lowest and highest quartile above level 4 regarding arguing from the evidence. The study findings show that arguing from the evidence was in some classes fairly integrated into the teaching of Physical Sciences. The number of learners who agreed that arguing from the evidence was incorporated into the science lessons was almost the same as the number of learners who disagreed (Figure 3). Yet the information from teachers shows that only two schools engaged learners in arguing from evidence. Therefore, it may suggest that learners were not sure what arguing from the evidence entailed, possibly because it was not common in the schools. If learners do not argue from evidence, the conceptualisation of science becomes low. Argumentation plays a central role in building explanations, models, and theories (Carrier, 2011). This is so because scientists use arguments to relate evidence to support their claims (Graham, 2020). Furthermore, Clark, Judd, Smith and Ahlstrom (2020) view argumentation as a process of bringing together theoretical ideas. They emphasise the importance of argumentation in the construction of scientific knowledge. The implication is that argumentation is a discourse that needs to be appropriate to learners using suitable instruction and task structuring (Clark et al., 2020). Vygotsky (1978) points out that the role of social interaction in the meaning-making processes is through the mediation of language, arguing from evidence and discussions to enhance science content. For example, teachers conducting interactive read-aloud in the class asked learners to recall information or repeat the text's language (Coltheart, 2005). In that way, meaning-making activities became literal exercises (Coltheart, 2005). Again, teachers conducting interactive read-aloud in the class often bridge between language and content (Morton, 2020) and hence learners easily recall information. To determine this, the overall mean and median of how language literacy was integrated per class in a school is presented in Figure 4.

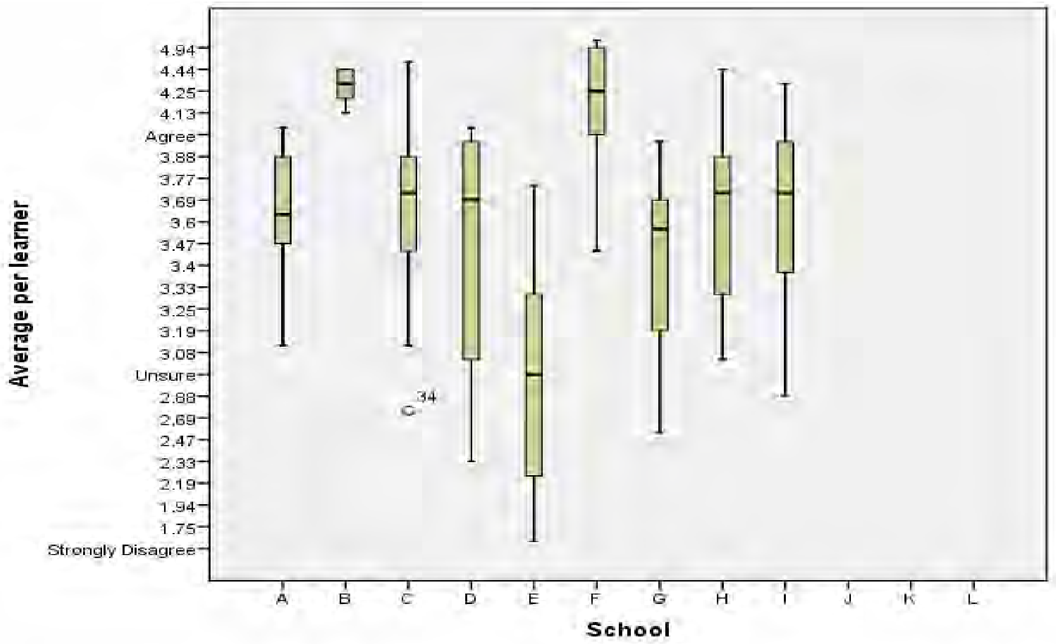

Figure 4. Overall performance per school

Figure 4 shows that it is only in 2 schools (B and F) out of the nine sampled schools, where learners agreed that language literacy was included in the Physical Sciences classroom. In the scores, learners in seven schools (77.78%) did not agree that language literacy was included in the Physical Sciences.

The results show that school B and school F (Figures 2, 3, 4) scored the highest in most of the aspects of integrating literacy in the teaching of Physical Sciences. This may be because of the low number of learners in the classes; eight in School B and twelve in School F (Table 2). This may give the impression that a teacher managing a class with fewer learners may find it easier to integrate literacy in teaching Physical Sciences than in a big class. While class size may play a role, Yore and Treagus (2006) highlight that language teaching in Physical Sciences is challenging for many teachers. Even though it is assumed that teacher-training institutions train pre-service teachers on how to integrate the English language into content subjects (Schleppegrell, Aghugar & Oteiza, 2004).

3.5. *Teachers' responses*

Highlighted below are the results from five male teachers of schools A, B, C, E and G who agreed to participate in the study.

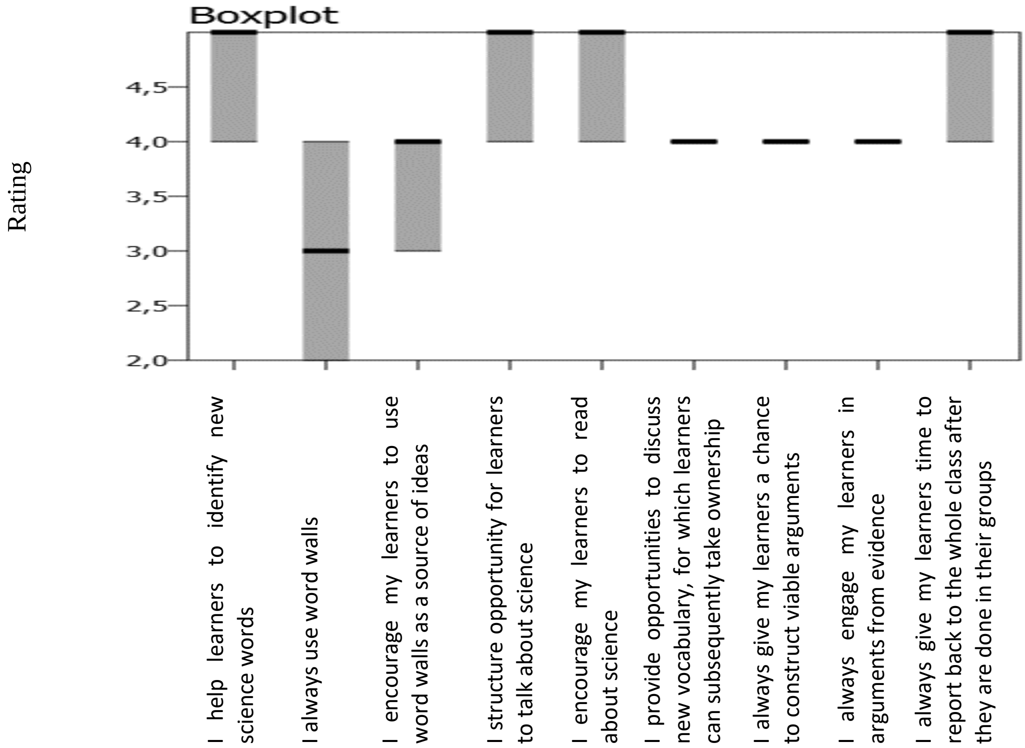

Figure 5. Teachers' rating on the integration of literacy in the Physical Sciences classroom

In Figure 5, the overall teachers' integration of literacy (mean is 4.25 ± SD 0.34), suggesting that teachers integrated language literacy in the teaching of Physical Sciences. Proctor et al. (2020) contend that the linguistic skills of using words and a lexical quality (a deep understanding of words) could improve learners' performance. Understanding words is in line with the Constructivists Theory, where learners interpret the words they read, internalise them and communicate with their peers. In this process, learners improve their understanding of science concepts. Therefore, teaching learners in English, to make sense of written materials and to write reports, where English is not their mother tongue, needs committed and skilled teachers. Carrier (2011) contends that secondary school learners will read with no support from teachers is a myth. Lyon et al. (2016) argue that in assisting learners to comprehend science, understanding the words used to write and talk about science cannot be ignored. Therefore, there is a need for teachers' professional development programmes in integrating language literacy in the teaching of Physical Sciences (Hand et al., 2018).

4. Conclusion and Suggestion

Our results show that a few teachers engaged learners in writing reports and arguing from evidence in Physical Sciences lessons in the classroom. One way to help Physical Sciences learners to improve their language literacy level is to let them read and write about Physical Sciences (National Research Council, 2014). Also, teachers need to consider the multiple roles that language literacy plays in Physical

Sciences: helping learners to learn content, improving literacy, and providing learners with vital elements for everyday living. Several aspects of language literacy were not included in the Physical Sciences such as writing reports, encouraging learners to contribute to the word walls and arguing from evidence. These aspects of language might have affected learners' performance in the Physical Sciences. This quantitative study was limited to a few schools in one province in South Africa. Therefore, there should be further studies that would include other provinces of South Africa and combine quantitative with qualitative approaches to investigate the integration of language literacy in the teaching of Physical Sciences.

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