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The effects of case study teaching on learners' language literacy skills in physical sciences classrooms

Romulus Asaph Mogofe[1], Logamurthie Athiemoolam[2*]
[1]PHD Student, Nelson Mandela University, Gqeberha, South Africa
[2]Secondary School Education, Nelson Mandela University, Gqeberha, South Africa
*Logamurthie Athiemoolam: Logamurthie.Athiemoolam@mandela.ac.za

ABSTRACT
Studies indicate that low language literacy skills in the language of teaching and learning (LoLT) can be a barrier to Physical Sciences learning. In addition, South African learners' language literacy skills in the LOLT are below the level that would allow effective science learning. This study employed a mixed methods design to investigate the effects of case study teaching on learners' language literacy skills in Physical Sciences classrooms in schools in the low performing Sekhukhune District of Limpopo Province in South Africa. The sample comprised 122 Grade 10 learners from four schools (two rural and two urban) selected through a stratified sampling process. Quantitative data were collected through a reading comprehension (pre-/post-) test (with the content validity index (CVI) of 100 % (1) and the reliability index (Cronbach's alpha value) of 0,74 when piloted within the study context) while qualitative data was gleaned using face-to-face interview. The quantitative data was analysed both inferentially (using t-test and Cohen's d-value), and descriptively (means and percentages) which were computed through PSPP statistical package while the qualitative one was analysed thematically using coding methods. The results of this study indicate that the mean performance of 6,44 for the EG and 3,87 for the counterparts in the CG with the p-value of 0,00 measured at the 95% confidence level. From the results, it can be concluded that case study teaching improves the language literacy skills of Physical Sciences learners at secondary school level. The results further indicate that the effect size for rural group is similar to their urban counterparts, which implies CST has a potential to improve rural learners' language literacy skills as much as that of their urban counterparts. The qualitative data revealed that case studies improved language literacy skills because of their real-life relevance and comprehension, engagement through surprise element, group discussion and argumentative skills, constructive arguments and language comprehension. The study recommends the use of CST in science classrooms to improve learners' language literacy. The study also recommend further studies with larger samples, under different context and over a prolonged period of time as it was conducted with a small sample over a relatively short period of time.

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INTRODUCTION

Language literacy skills (LLS) in the language of teaching and learning (LoLT) or the medium of instruction, are essential for effective teaching of Physical Sciences. This is because learners' low level of reading, speaking, and writing skills in the language of learning and teaching (LoLT) Physical Sciences disadvantages them (learners) in grasping the subject content (Francis & Stephens, 2018). This is mainly because a failure to fluently read scientific texts and comprehend it directly impedes effective Physical Sciences learning (Albadi, O'Toole, & Harkins, 2017; Prinsloo, Rogers, & Harvey, 2018). Research indicates that language learners' LLS can develop swiftly in Physical Sciences classrooms if teachers engage them in argumentation and exploratory talks (Kang, Swanson, & Bauler, 2017). In addition, a study by Mammino (2010) has long recommended that language development should form part of Physical Sciences teaching goals as advanced LLS are a pre-requisite for effective science learning. Hence the South African Department of Basic Education was prompted to recommend the intergration of LLS in the teaching of Physical Sciences content.

Problem Statement

The literature indicates that teachers are failing to holistically integrate LLS in the teaching of Physical Sciences and other related content subjects. A plausible explanation for this is that science teachers lack relevant pedagogical strategies needed to fulfil that task in their classrooms (Polat, 2015). Furthermore, in South Africa, poor learner performance in Physical Sciences' National Senior Certificate (NSC) examination is attributed to, among others, learners' inability to read examination questions with comprehension (Department of Basic Education (DoBE), 2017). Even those learners who manage to obtain the minimum requirements for entry into the science related courses at post-secondary school level are found to be inadequately equipped in terms of LLS, academic literacy or reading comprehension in particular. Lack of language literacy skills adequacy for science learning is among the reasons that motivated post-secondary school institutions to design academic literacy programs aimed at university students taking science-related courses to close the LLC gap (which includes reading, writing, reading comprehension and argumentation) created by secondary school science teaching (Van As, Fouché, & Immelman, 2016). Among these efforts, pedagogical strategies like case study teaching (CST) hold significant potential, as they have a potential to engage learners in active learning and critical thinking, collaborative problem-solving, and argumentation, which can foster the development of LLS alongside the scientific literacy. Yet, despite its proven effectiveness in enhancing LLS at the post-secondary level across various disciplines, CST remains poorly explored in secondary school science classrooms, particularly in Physical Sciences. This gap in research reveals a compelling need to investigate the implementation and effect of CST in secondary school context, which this study aimed to address.

Rationale for the Study

There is a need for Physical Science teachers to be retrained to enable them to implement innovative pedagogies that would enable their learners to read, write and talk like scientists in their science classrooms. Innovative science pedagogies can accelerate language learners' literacy skills acquisition, which can enhance their science learning (AlAjlan, 2021). A very good example of innovative methods that can integrate the teaching of LLS in science education is case study teaching (CST) (Aizikovitsh-Udi & Cheng, 2015). Although CST was found to improve LLS of post-secondary school students, mostly in business studies, law and arts, it was never experimentally trialled in Physical Sciences classrooms at secondary school level. The study investigated the effects of CST on learners' LLS in Physical Sciences classrooms at secondary school level in Sekhukhune East Education District of Limpopo Province in South Africa.

Definition of Language Literacy Skills

The literature generally defines language literacy skills (LLS) as the ability to read any written text with comprehension and to effectively communicate orally and in writing (Grant, Gottardo & Geva, 2012; Shanahan & Shanahan, 2008). Furthermore, Facione (2015) defines LLS as the ability to apply the critical thinking process which involves comprehension, breaking down and attaching meaning to data, drawing inferences and communicating conclusions that is derived from data with justification. Banditvilai (2020) observed that the reading comprehension and other LLS of the learners improves at a higher rate when learners are involved in reading exercises This implies that a pedagogy that aims to improve learners' LLS should encourage them to read actively. This is in line with Rhodes and Feder (2014) and Demirdag (2014) who recommended that Physical Sciences teaching should encourage learners to read, write and talk like scientists. According to Liao et al. (2015), those pedagogies should foster learners' individual dispositions, which also nurtures the reflective and self-regulation domains of metacognition skills, while reinforcing interactions among the learners.

Relationship between Language Literacy Skills and Science Learning

The interdependence between LLS and the effective science education is well-established, with research highlighting the pivotal role language literacy skills play in enhancing scientific literacy and communication of scientific concepts (Prastyaningrum et al., 2024; Saputra, 2023). The literature indicates that proficiency in LLS enables learners to articulate ideas clearly, engage in scientific argumentation smoothly, and integrate complex information from diverse sources with easy (Jang et al., 2024; Pringle, 2020). In addition, Vygotsky's (1969) social constructivist theory underscores the importance of language literacy skills in cognitive development, postulating that social interactions and communicative engagement are fundamental in constructing scientific knowledge. Similarly, Piaget's (1952) theory of cognitive development explains how LLS can influence children's ability to understand and internalise scientific concepts at different developmental stages. Given that language literacy practices mirror scientific inquiry, integrating language instruction in science education enhances learners' ability to conduct investigations and effectively communicate findings (Sun & Chan, 2024). It can then be argued that integrating LLS into science classrooms is vital for fostering scientific literacy and addressing disparities in science learning, particularly among marginalised groups like rural learners.

Case Study Teaching (CST) as a Pedagogical Tool

A case study can be defined as an anecdote with a message that can be utilised in the teaching of the subject content under any learning environment (Herreid, 1997). Hence, within the context of this study, Case study teaching CST is defined as a pedagogy that encompasses providing learners with a story related to the topic that is learned and asking them questions based on the story (Beckisheva, Gasparyan and Kovalenko, 2015; Herreid, 1994). CST can improve learners' LLS as it encourages them to read actively in and outside their classrooms. In addition, CST prompts individual dispositions while affording learners an opportunity to engage in group and class discussion. In addition, studies in science education indicate that strategies that involve learners in some degree of inquiry are effective in enhancing learners' LLS (Putra, Widodo, & Jatmiko, 2018). Generally, strategies that can be used to embed the teaching of LLS skills in Science classrooms are: Applying inquiry-based learning; using context-based teaching methods; enabling learners to read about science; involving learners in science talks (argumentation); allowing learners to work in small groups and to write about Science; encouraging learners to communicate in the language of learning and teaching (LoLT) at all times; using technological applications to enhance word meanings and assessing learners' language difficulties during science lessons (Elliott, 2010; Carrier, 2011). The researcher of the study argues that the implementation of case study teaching in Physical Sciences classrooms has a potential to engage learners in all of the abovementioned activities.

Case Study Teaching (CST) in Physical Sciences

The implementation of Case Study Teaching (CST) in Physical Sciences classrooms can significantly enhances the learning outcomes by fostering engagement, critical thinking, and problem-solving skills. Research at the post-secondary school level indicates that CST allows university students to connect physics concepts to real-world applications, thereby increasing their interest in learning science and understanding of the science contents (Amos, 2021; Ambarita & Sani, 2013). For instance, CST was found to improve the post-secondary school students' ability to solve contextual physics problems and develop critical thinking, outperforming their counterparts taught through the traditional teacher-centered methods (Ambarita & Sani, 2013). In addition, inquiry-based laboratory case studies can improve learners' attitudes towards Physical Sciences and enhanced their problem-solving skills (Arion et al., 2000). Overall, CST can serve as an effective pedagogical strategy in Science Education to holistically develop learners' science process skills, language literacy skills and scientist literacy.

However, the effect of CST on secondary school learners' LLS in Physical Sciences classrooms remains underexplored. This is despite the fact that there is empirical evidence indicating that CST enhances learners' critical thinking skills and engagement in the secondary school Physical Sciences classrooms (Mogofe & Athiemoolam, 2023; Amos, 2021), the specific impact on LLS is less clear. I addition, the literature sheds a light about science teachers' struggle to incorporate LLS effectively into their science teaching, with a significant percentage of them not engaging learners in necessary literacy practices like report writing (Kibirige & Mogofe, 2021). Furthermore, while integrating English language teaching has been linked to improved academic performance and heightened comprehension in science (Hlabane, 2014), the effect of CST on LLS development remains inadequately explored. The identified gap highlights a need for further research to understand how CST can be tailored to enhance language literacy skills alongside scientific literacy in diverse classroom settings.

Study Purpose

To investigate the effects of CST on learners' LLS in secondary school Physical Sciences classrooms.

Hypothesis

Case study teaching improves learners' language literacy skills in Physical Sciences classrooms.

METHODS

This study employed a mixed methods design in which a non-equivalent (pre-test and post-tests) control-group quasi-experimental design was used to collect the qualitative data, which was explained through a qualitative data collected through a face-to-face interview. Experimental design was chosen because this study evaluated the effectiveness of a teaching method. Furthermore, quasi experimental design was adopted because random assignment and control over the experimental environment were impossible (Brink, van der Walt, & van Rensburg, 2012).

The population for the purposes of this study were all Grade 10 learners studying Physical Sciences (through their second language – English) in the secondary schools of Sekhukhune East) District in the Limpopo Province of South Africa. Four schools (two rural and two urban) participated in the study with a total of 122 learner participants distributed as indicated in figure 1.

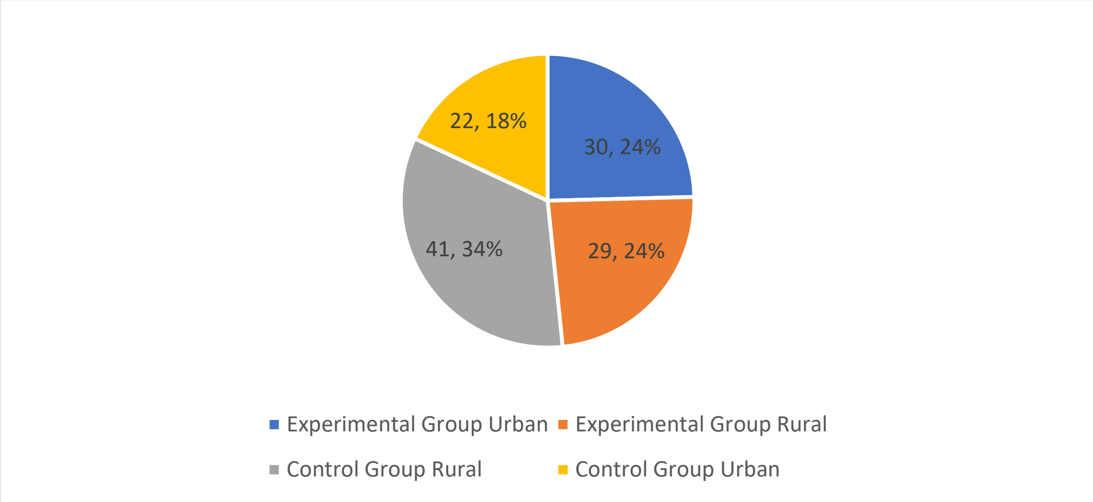

Figure 1. Distribution of participants per group

This study consisted of two experimental groups (rural and urban schools) and two control groups (also rural and urban schools). In terms of gender, the number of males was slightly larger than that of their female counterparts as the following pie chart indicates:

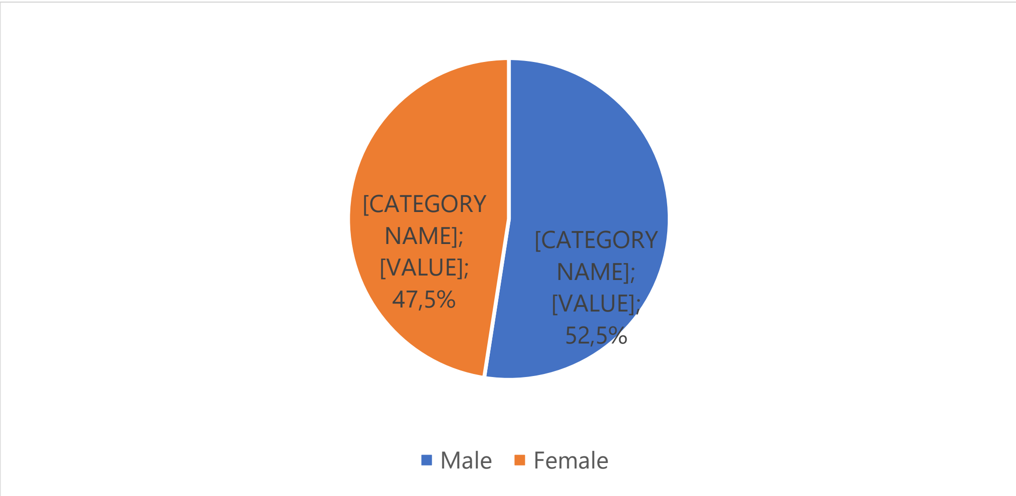

Figure 2. Participants in terms of gender

The number of males who participated in the study was 64 (52,5 %) while the number of female participants was 58 (47,5 %).

This study used a reading comprehension test to collect data, The reading comprehension test used for the purposes of this study was a 15-items multiple choice test adapted from the website: http://www.marin.edu/~don/study/7read.html and validated by four language experts with the content validity index (CVI) of 100 %. The test was piloted with a Grade 10 Physical Sciences class from the district, who were not part of the main study. The test was marked and the results were analysed through PSPP statistical pack (freely available online) for internal consistency reliability. The table 1. indicates the results from the Cronbach's alpha test.

Table 1. Cronbach's alpha value for the reading comprehension test

Cronbach's Alpha	*N of Items*
0,74	15

Table 1 indicates that the Cronbach's alpha value for the reading comprehension test was 0,74, which is greater than 0.7, which indicates that the tool was reliable and ready to be used. The comprehension test was given to the participants as pre- and post-tests; and for the post-test, the order of the questions was changed.

Data collection process

The control groups (CGs) were taught in the traditional ways of teaching Physical Science while the experimental groups (EG) were taught using CST. Case studies, in the EG, were used both as a tool to introduce lessons and as home activities. At the start of the each lesson, learners were given time to read case studies and allowed another time to respond to the accompanying questions. They were then encouraged to share their understanding of the cases and discuss their views in their groups. After the group discussions, a member from each group was allowed to present their collective views to the whole class. The teacher then consolidated the presentations and linked them to the Physical Sciences content to be learned. A classwork was used to assess the learners, and at the end of the lesson, learners were given another case study to read and respond to the related questions at home. Both experimental and control groups were taught by the researcher using English as the LoLT. Five case studies were included in the teaching of the Experimental Group (EG). Both EGs and CG were taught Electricity and Magnetism which forms part of the work that was prescribed for Grade 10 learners. Data collection lasted for a period of 9 weeks. Participants, in both EGs and CGs, were given a reading comprehension test at the beginning of the study as a pre-test, followed by interventions and concluded by giving participants the reading comprehension test as the post-test.

Test scripts were marked, and the results were analysed both descriptively (means and percentage) and inferentially (parametric t-test and Cohen's d value) were used. The statistical values were computed through PSPP statistical package (available freely online). On the other hand, the qualitative data was analysed thematically using the coding methods where were employed on a sentence-by-sentence basis.

RESULTS AND DISCUSSION

General findings: The effects of case study teaching on language literacy skills

The group performance of the learners in the reading comprehension pre-test were analysed. Table 2 shows the mean performance of the learners in the pre-test of the reading comprehension.

Table 2: Mean performance of the combined groups in the reading comprehension pre-test

Group	*Mean*	*N*	*Std. Deviation*
Experimental group	*4,17*	*59*	3,71
Control Group	*3,79*	*63*	2,87
Total	*3,98*	*122*	3,29

The mean performance for the experimental groups (EGs) was 4,17 which is larger than the mean performance 3,79 in the control groups (CG). Furthermore, the general mean performance of all the participants (both experimental and control groups) was 3,98 out of a total of 15 which can be converted to percentage as 26,53 %. This clearly shows that reading comprehension of the participants, in both EGs and CGs, was poor before the commencement of the intervention. The table 2 also indicates the difference in means between EGs and CGs, which indicates that the difference is significant. To check the comparability of the groups at the beginning of the process in terms of the reading comprehension scores, a two-tailed t-test was performed with the following hypotheses.

Table 3: T-test results for reading comprehension pre-test

		Levene's Test for Equality of Variances		T-Test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Reading Comprehension Pre-test	Equal variances assumed	0,70	0,403	0,63	120,00	0,531	0,38
	Equal variances not assumed			0,62	109,32	0,535	0,38

The probability value for Levene's (F) test when equal variances are assumed was 0,70 (high) and the p-value was 0,403 which is greater than the significant value ($p > 0.05$) which means a null hypothesis, which states that the two groups have approximately the same variance cannot be rejected. In this case, the t-test results that assume equal variances are considered and the ones that do not assume equal variances are disregarded. From the t-test, the p-value measured at a confidence interval difference of 95 % and significant level of 0,05 (5 in 100 chances of being wrong) is 0,53 which is greater than 0,05. The p-value is greater than the significant value, which means the null hypothesis that states that there is no statistical difference in the performance of the EGs and the CGs in the reading comprehension pre-test cannot be rejected. This means that the learners in the experimental groups were not significantly different, prior to their participation in the study, in terms of their reading comprehension skills, to their counterparts in the CGs. Therefore, any difference in their reading comprehension after the interventions will be attributed to the interventions provided during the study.

The means for comprehension post-tests were also analysed for EGs and CGs. Table 4 indicates the results.

Table 4. T-test results for reading comprehension post-test for combined groups

	Group	**N**	**Mean**	**Std. Deviation**	**S.E. Mean**
Reading Comprehension Post-test	Experimental group	59	6,44	3,53	0,46
	Control Group	63	3,87	2,62	0,33

The mean score of the EGs is higher than the mean score of the CGs in the reading comprehension post-test as the mean for EGs is 6,44 and the one for the CG is 3,87, with all showing improvement. A two-tailed t-test was performed to test if the difference in means was statistically significant and Table 5 shows the results.

Table 5. T-test results for reading comprehension post-test for combined groups

		Levene's Test for Equality of Variances				T-Test for Equality of Means	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Reading Comprehension Post-test	Equal variances assumed	4,83	0,030	4,58	120,00	0,000	2,57
	Equal variances not assumed			4,53	106,73	0,000	2,57

Levene's test results indicate a significant difference in the variances of the two groups because the p-value (p = 0,03) is less than the critical value of 0,05. In this case the t-test results that do not assume equal variances are considered. The p-value when equal variances are not assumed is 0,00 with the degree of freedom (df) 0f 107. This means that the null hypothesis is rejected and the alternative hypothesis, which states that there is a statistically significant difference in the means of the EGs and CGs, is accepted. This means that case study teaching (CST) has an effect on learners' reading comprehension, and the effect size can be calculated as follows:

$$Effect\ size = \frac{(Mean\ of\ Experimental\ group) - (Mean\ of\ control\ group)}{standard\ deviation}$$

$$= \frac{6{,}44-3{,}87}{3{,}34} = 0{,}77$$

The effect size is 0,77 which is between medium (0,5) and large (0,8), which means the effect of CST on learners' reading comprehension is medium to large and leaning more towards the large side as 0,77 can be rounded to 1 decimal place as 0,8. From this, one can conclude that learners who were taught through CST improved their reading comprehension at a higher rate than their counterparts who were only taught in the traditional way of teaching Physical Sciences which focuses on the direct teaching method.

This study was guided by the following hypothesis*: Case study teaching improves learners' language literacy skills in Physical Sciences classrooms.* The unstated and profound null hypothesis for the above mentioned hypothesis (alternative) was that case study teaching does not have an effect on learners' language literacy skills in Physical Sciences classrooms. The results from the study sustained the rejection of the null hypothesis and the acceptance of the alternative hypothesis. This is because the study found that case study teaching improves learners' language literacy skills of Physical Sciences learners. It is worth mentioning that the results from the reading comprehension pre-test indicate that the reading comprehension of all the learners who participated in the study was acutely low. The mean reading comprehension pre-test score is 3,98 out of 15. In terms of percentage, that is 26,53 %. This reaffirms the views of the Department of Basic Education who asserted, in the annual National Senior Certificate's (NSC) diagnostic reports that one of the reasons for learners' failure to respond to examination questions is that they fail to read them with comprehension (DoBE, 2017). This also resonates with international studies that found that South African learners' reading comprehension is behind that of their counterparts from well-performing countries (Howie, et al., 2017). The results of the pre-test reveal that South Africa is lagging behind in terms of developing learners' language literacy skills.

The post-test results reveal that learners who were taught through CST outperformed their counterparts who were taught in the traditional way of teaching Physical Sciences. Learners who experienced CST, outperformed their counterparts in the control groups, because CST is a pedagogical strategy that complies with the network theory of learning which emphasizes the use of stories as contexts in the teaching of science so that learners are able to relate what they are learning to their day-to-day life, which is familiar to them (Shunk, 1996). Case studies served to provide learners with a context in which they could link the new information they acquired to that which already existed in their schemata. This also resonates with the findings by Podschuweit and Bernholt (2017) who found that contextualised teaching and learning improves the educational outcomes irrespective of the form it takes. Podschuweit and Bernholt (2017) went on to state that contextualised learning can be a better bridge between the knowledge that exists in learners' cognitive structure and the new information learners are expected to learn. In this study, case studies served as a context through which their existing knowledge could be linked to the new knowledge they were required to learn.

Explanation of how case study teaching improved learners' language literacy skills

Qualitative data of the study was used to explain why case study teaching improved learners' LLS. For this purpose, learners were asked two questions: "Mention anything that you enjoyed during the lessons and explain why that is so"; and "Do you think the stories helped you in any way? Explain." From the interviews, it emerged that CST improved learners' language literacy skills because of its real-life relevance and comprehension, engagement through surprise element, group discussion and argumentative skills, constructive arguments and language comprehension.

The findings of the study reveal that case studies used assisted learners to connect complex Physical Sciences content to real-world contexts, which enhanced their understanding. *Participant IL1* remarked, *"I understand science better when it's connected to something real like the environment or the Maglev train."* The participant's view echoes well with findings by Sunyono et al. (2021), who argued that real-life examples not only engage learners in meaningful learning but also deepen their comprehension by giving them a platform to apply the complex scientific knowledge in real life. This further aligns with Piaget's (1952) theory of constructivism, which postulates that learners can actively construct knowledge by interacting with their environment. In addition, a recent study by Farran (2024) found that case-based learning improves learners' ability to grasp abstract scientific concepts by providing real-life applications.

The study also found that the element of surprise, such as the unexpected applications of electromagnetism in the Maglev trains example, was highlighted as a key factor in learner engagement. This supports Vygotsky's (1969) social constructivist theory, where the zone of proximal development (ZPD) is crucial. The theory asserts that when learners are presented with surprising or novel content, they are prompted to engage at a higher cognitive level, stimulating curiosity and encouraging deeper processing. In addition, Koch et al. (2024) found that such surprising elements maintain learners' attention and enhance the development of language literacy and critical thinking skills. Furthermore, Participant *IL2* stated, *"The surprising part about the train made me think a lot more deeply about how things work in science."* This mirrors Koch et al. (2024) who argued that novelty and surprise foster active learning and greater engagement, which resulted in a significant development in language literacy skills.

CST adopted in the study involved participating learners in group discussions, which enhanced learners' language skills and ability to articulate their thoughts to their peers and the teacher during lessons. This was expressed by Participant *IL14* who noted, *"We discussed the cases in groups, and it helped me explain better, especially when my peers gave feedback."* Similarly, *IL1* added, *"Talking with others about the case studies helped me understand the concepts better and made me feel more confident to argue my point."* This is in line with Vygotsky (1969) who argued that social interaction is central to learning, as learners construct knowledge collaboratively. Moreover, recent studies reinforce this view by showing that peer discussions promote both language acquisition and critical thinking. Additionally, Putra et al. (2018) found that group discussions encourage learners to improve their language literacy skills by negotiating meaning with peers. These responses further align with Gonzalez et al. (2020), who found that peer interaction during group discussions significantly develops learners' academic language skills, which is closely linked to reading comprehension. *Participant IL14* also reflected, *"I had to argue my point, and that really helped me think more logically about the cases and use the right words to explain myself."* This mirrors findings by Webb et al. (2016), who found that CST, which incorporates argumentation talks, helps learners to develop language literacy skills such as reading comprehension, especially in the science classrooms. Finally, while many learners reported improvements in language comprehension, some participants expressed challenges with the complexity of the language used in some of the case studies used in the study. For example, Participant *IL2* stated, *"Some of the language was difficult for me, but the more I read, the more I understood it."* This is in line with Fixen (2024) who noted that complex academic language can initially present barriers to learners, but persistent exposure to academic language in context, such as in case studies, gradually improves learners' reading comprehension skills. This also resonates well with Peng et al. (2020) and Hussin et al. (2024) who found that learners' language proficiency improved with continued exposure to complex academic texts, even when they initially found them challenging.

CONCLUSION

Case study teaching improved learners' language literacy skills as the reading comprehension of learners in the EGs showed greater improvement than that of their counterparts in CGs. Although this study is a step in the right direction in an endeavour to solve language issues in the teaching of sciences, the results still need to be verified with bigger samples, different Physical Sciences topics, different grades and different secondary school subjects.

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