Developing and using the Tshivenda scientific register for Physical Science

by

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21 OCTOBER 2022

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DEDICATION

I dedicate this work to my loving husband, Phumudzo Ramashau, my children Wavhutali and Watshilidzi Ramashau for being patient and allowing me to focus on my study. Thank you very much my family.

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This journey was not an easy one for me to work and complete by myself, and so I would like to acknowledge all those who have assisted me get here.

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ABSTRACT

In South Africa, most learners use mother tongue which is different with the language of learning and teaching which is English. Hence, these learners encounter difficulties in their learning environment. Learners in the Vhembe West District are receiving their physical sciences (PS) education through English medium of instruction even though it is not their mother tongue. The general failure to understand language of science in South Africa is a cause of concern in the teaching and learning. The reason for such situation is failure to understand English as medium of instruction. This research investigated how the use of developed Tshivenḓa physical sciences scientific register (TPSSR) will shape interaction and discourse in PS classroom. Classroom Language Investigative Framework (CLIF) was employed as a conceptual framework for the study. The study employed qualitative interpretative multiple case study design. Three teachers, fourteen parents (School Governing Body) and sixty-five learners from three schools of Vhuronga 2 Circuit in Vhembe West District participated. The following research questions were explored: What are the challenges and opportunities in the development of TPSSR for teaching and learning of PS? What are the challenges and opportunities in the use of the TPSSR for the teaching and learning of PS? How does the use of TPSSR in the teaching and learning of PS influence interaction and discourse? What are the views and perceptions of PS teachers, parents, and learners towards the use of the Tshivenḓa scientific register for PS? Observations, interviews, and diary have been used for data collection. The data revealed that there are insufficient scientific terms in Tshivenḓa. Hence, teachers fail to find some of sciences equivalent words in Tshivenḓa during their classroom practices and end up adopting those words such as aisi (ice), saintsi (science), etc. However, the use of the developed Tshivenḓa physical sciences scientific register (TPSSR) for PS has shown that it can shape classroom interactions and discourses which is significant for meaningful learning which leads to better achievement in the subject. This study, therefore, recommends the development and application of TPSSR for PS focusing on other science topics. Hence, PS teachers need to be developed, trained, and equipped with the necessary language skills so that it

can be possible for them to develop Tshivenḓa scientific language registers on other science topics.

Keywords: Tshivenda Scientific register; Physical Sciences; Challenges; opportunities; perceptions; classroom interaction; discourse.

XIANAKANYIWA

Vadyondzhi votala va Afrika Dzonga va na ririmi ra le kaya leri hambaneke na ririmi ro dyondza na ku dyondzisa. Hikwalaho, vadyondzi lava va hlangana na swiphiqo eka ndhawu ya vona yo dyondza. Vadyondzi eka Vhembe West District va le ku kumeni ka dyondzo ya vona ya sayense ya swilo leswi vonakaka hi ku tirhisa Xinghezi medium of instruction hambi leswi ku ngariki ririmi ravona ra manana. Ku tsandzeka hi ku angarhela ku twisisa ririmi ra sayense eAfrika-Dzonga i xivangelo xa ku vilela eka ku dyondzisa na ku dyondza. Xivangelo xa xiyimo xo tano i ku tsandzeka ku twisisa Xinghezi tanihi xitirhisiwa xo dyondzisa. Ndzavisiso lowu wu lavisisile hilaha ku tirhisiwa ka rhijisitara ra sayense ya tshivenda ya sayense ya swilo leswi vonakaka leyi tumbuluxiweke swi nga ta vumba ku tirhisana na mbulavulo hakona etlilasini ya sayense ya swilo leswi vonakaka. Rimba ra ndzavisiso wa ririmi ra tlilasi ri tirhisiwile tanihi rimba ra miehleketo ya dyondzo. Dyondzo yi tirhisile qualitative interpretative multiple case study design. Vadyondzisi vanharhu, kume mune wa vatswari na makume ntsevu ntlhanu wa vadyondzi ku suka eka swikolo swinharhu swa vhuronga swifundzha swimbirhi eka Xifundzha xa Vhembe va nghenelerile. Ku tirhisiwile swivetiso swa ndzavisiso leswi landzelaka: Hi yihi mintlhontlho na minkarhi eka nhluvukiso wa rhijisitara ra sayense ya tshivenda yo dyondzisa na ku dyondza sayense ya swilo leswi vonakaka? Hi yihi mintlhontlho na minkarhi yo tirhisa rhijisitara ra sayense ya tshivenda yo dyondzisa na ku dyondza ti rhijisitara ra sayense ya tshivenda? Xana ku tirhisiwa ka rhijisitara ra sayense ya tshivenda eka ku dyondzisa na ku dyondza sayense ya swilo leswi vonakaka swi khumba njhani ku tirhisana na mbulavulo? Hi wahi mavonelo na mavonelo ya vadyondzisi va sayense ya nyama, vatswari, na vadyondzi eka matirhiselo ya rhijisitara ra sayense ya tshivenda sayense ya swilo leswi vonakaka? Swibumabumelo,mimbulavurisano na dayari swi tirhisiwile ku hlengeleta datha. Dyondzo yi paluxe leswaku a ku na marito ya sayense lama eneleke eka tshivenda. Hikokwalaho, vadyondzisi va tsandzeka ku kuma marito man'wana lama ringanaka na sayense eka tshivenda hi nkarhi wa maendlelo ya vona ya tlilasi ivi va hetelela va amukela marito wolawo yo fana na aisi (ice), saintsi (science), etc. Hambiswiritano, ku tirhisiwa ka rhijisitara ra sayense ra tshivenda ra sayense ya swilo leswi vonakaka leyi tumbuluxiweke eka sayense ya swilo

swa nyama swi kombisile leswaku ri nga vumba vuhlanganisi bya tlilasi na tinkulumo leswi nga swa nkoka eka dyondzo leyi nga na nhlamuselo leswi yisaka eka ku humelela ko antswa eka dyondzo. Dyondzo leyi hikokwalaho,yi ringanyeta nhluvukiso na ku tirhisiwa ka rhijisitara ra ririmi ra sayense ra tshivenda eka rhijisitara ra sayense ya tshivenda ya sayense ya swilo leswi vonakaka hi ku kongomisa eka nhlokomhaka yin'wana ya sayense. Hikokwalaho, vadyondzisi va sayense ya miri va lava ku hluvukisiwa,ku leteriwa, no hlomisiwa hi vuswikoti bya ririmi lebyi lavekaka leswaku swi ta koteka leswaku va hluvukisa tirhejisitara ta tindzimi ta sayense ta tshivenda eka tinhlokomhaka tin'wana ta sayense.

Marito ya nkoka: tshivenda, rhijisitara ra sayense, sayense ya swilo leswi vonakaka, mintlhontlho na swivandlanene, mavonelo ya vatekaxiave,ku tirhisana ka tlilasi na mbulavulo.

MANWELEDZO

Vhagudiswa vhanzhi vha Afrika Tshipembe luambo lwavho lwa damuni lo fhambana na luambo lune lwa shumisiwa kha u guda na u funza zwikoloni lune lwa vha luisimane . Zwino havha vhagudiswa vha ṱangana na vhuleme musi vha khou funziwa nga ngomu kiḽasini. Vhagudiswa vha Vhembe West District vha khou wana pfunzo yavho ya saintsi ya zwithu zwine zwa vhonala hu tshi khou shumisiwa Luisimane naho lu si lone luambo lwavho lwa ḓamuni. U balelwa u pfesesa luambo lwa saintsi Afrika Tshipembe zwiḓisa mbilaelo kha u funza na u guda. Nyimele heyi i khou vhangiwa nga u kundelwa u pfesesa Luisimane sa lone luambo luno shumisiwa kha u funza na u guda zwikoloni. Ṱhoḓisiso heyi i khou toda u wanulusisa uri u shumisiwa ha rigisiṱara ya saintsi ya Tshivenḓa ya zwithu zwine zwa vhonala yo vhumbiwaho inga thusa hani kha vhushaka na nyambedzano dzine dza itea nga ngomu kilasini. Classroom Language Investigative Framework (CLIF) yo shumisiwa sa conceptual framework kha thodisiso heyi ya pfunzo. Thodisiso heyi yo shumisa qualitative interpretative multiple case study design. Vhadededzi vhararu, vhabebi vha fumi na vhana (SGB) na vhagudiswa vha fumi rathi na nthanu vha zwikolo zwa liisela la Vhuronga ya vhuvhili Vhembe West District vhodzhenelela. Mbudziso dzo shumisiwaho kha thodisiso ndi dzi tevhelaho: ndi vhukondi na mbuelo kana zwivhuya zwifhio zwovhaho hone khau vhumbiwaho ha rigisitara ya saintsi ya tshivenda ya zwithu zwine zwa vhonala khau funza na u guda saintsi ya zwithu zwine zwa vhonala? ndi vhukondi na mbuelo kana zwivhuya zwifhio khau shumisiwa ha rigisitara ya saintsi ya tshivenda ya zwithu zwine zwa vhonala khau funza na u guda saintsi ya zwithu zwine zwa vhonala? U shumisiwa ha rigisitara ya saintsi ya tshivenda ya zwithu zwine zwa vhonala khau funza na u guda saintsi ya zwithu zwine zwa vhonala zwo kwama hani vhushaka na nyambedzano dzine dzavha dzi khou itea nga ngomu kilasini ya saintsi ya zwithu zwine zwa vhonala? Mihumbulo na kuvhonele kwa vhadededzi vha saintsi ya zwithu zwine zwa tou vhonala, vhabebi na vhagudiswa ndi kufhio kha u shumisiwa ha rigisitara ya tshivenda ya saintsi kha saintsi ya zwithu zwine zwa vhonala? Datha kana mafhungo a thodisiso ya hei pfunzo o waniwa ngau tou vhona mudededzi a khou funza, u ita dzi nyambedzano nau shumiya dayari. Thodisiso heyi yo wanulusisa uri huna manwe maipfi a saintsi ane haho nga tshivenda. Zwenezwo zwoita uri vhadededzi vha balelwe u wana manwe a maipfi a saintsi nga tshivenda musi

vha khou funza vha vho fhedzisela vha khou pamba haneo a tshikhuwa nga tshivenda, sa tsumbo as aisi (ice), saintsi (science) na manwe. Naho zworalo, u shumisiwa ha rigisitara ya saintsi ya tshivenda ya saintsi ya zwithu zwine zwa vhonala yo vhumbiwaho yo sumbedzisa zwauri inga vhumba vhukonani kana vhushaka na nyambedzano dzavhudi nga ngomu kilasini zwine zwavha zwandeme khau livhisa u bvelela ha khwine kha thero yeneyo. Pfunzo heyi ndi henefho hune ya tama kana ya ombedzela u vhumbiwa na u shumisiwa ha rigisitara tya saintsi ya tshivenda ya saintsi ya zwithu zwine zwa vhonala yo sedzesa kha dzinwe thero dzire hone kha saintsi. Ndi henefho hune vhadededzi vha saintsi ya zwithu zwine zwa vhonala vhafanela u thusiwa, u pfumbudziwa na u newa zwothe zwoteaho uvha thusa kha u vha na vhukoni siani la luambo uri zwikonadzee khavho zwau vhumba rigisitara dza saintsi dza luambo lwa tshivenda kha dzinwe thero dza saintsi.

Maipfi a vhu thoga: tshivenda, rigisitara ya saintsi, saintsi ya zwithu zwine zwa vhonala, vhukondi na mbuelo dzavhudi , mavhonele, vhushaka na nyambedzano nga ngomu kilasini.

LIST OF ABBREVIATIONS

CALP	cognitive academic language proficiency
CAPS	Curriculum and Assessment Policy Statement
CLIF	Classroom Language Investigative Framework
CONTRALESA	Congress of Traditional Leaders of South Africa
DBE	Department of Basic Education
DoE	Department of Education
ESR	English language register
ESL	English second language
FET	Further Education and Training
HED	higher education diploma
IRE	Initiation, Response, and evaluation
IRERE	Initiation, Response, Evaluation, Response and Evaluation
L1	First Language
L2	Second Language
LiEP	Language-in-Education Policy
LoTL	Language of Teaching and Learning
LTSM	learning and teaching support materials
NCS	National Curriculum Statement
PanSALB	Pan South African Language Board
PED	Provincial Education Department
PS	Physical Sciences
SASA	South African School Act
SGB	School Governing Body
TPSSR	Tshivenḓa Physical Sciences Scientific Register
UNESCO	United Nations Educational, Scientific, and Cultural Organisation

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CHAPTER 1: INTRODUCTION AND OVERVIEW OF THE STUDY

1. Introduction

In South Africa, there are 11 official languages and learners are currently receiving their primary education through their mother tongue instruction until in Grade 3. Thereafter, starting from Grade 4 and onwards, teachers are required to use English or Afrikaans as language of teaching and learning (LoTL). This means that most learners in South African schools are receiving their primary, secondary and tertiary education through language which is not their mother tongue. Consequently, this has an influence on learners' performance in subject like Physical Sciences (PS).

The study developed Tshivenḓa Physical Sciences Scientific Register (TPSSR: Appendix S, page 259) and inspected the application of TPSSR in the learning and teaching of Grade 10 PS. Additionally, teachers, learners and parents' perceptions in the TPSSR from three secondary schools in Vhembe West District were noted. This section consists of the research background, problem statement, research questions, research objectives of the study, rationale of the study, delimitation, outline of the structure of the research, and summary of the chapter.

1.1. Research background

Language is one of the key components which has a significant impact within the education system. Learners and teachers use language as a communication tool to engage in teaching and learning. According to Mudenda (2017), language is a primary medium in the learning process that a child at any level uses to read or hear. Therefore, it is important that every child be given an opportunity to be taught in a language that they can write, read and understand. Gleaner (2017) asserts that a language register is a variety of language choices existing to be used in dissimilar circumstances. Furthermore, language register is the formality and informality of language that can be used in communication, i.e. in writing and speaking (Gleaner, 2017). The focus of this study was to develop TPSSR and its application to teach and learn Physical Sciences (PS). In this study, the researcher refers a scientific register as a register that is developed by academic using a preferred official indigenous language to teach and learn a certain subject. Therefore, the researcher developed scientific register for physical sciences in Tshivenda (TPSSR: Appendix S, page 259) and referred it as Tshivenda Physical Sciences Scientific Register (TPSSR). The researcher developed TPSSR for it to be employed by both teachers and learners during the entire physical sciences lessons in their classroom setting. The researcher use TPSSR (Appendix S, page 259) to examine its impact on learners' participation and performance.

Tuesday, September 24, 2019, on national Heritage Day celebrations that was held at Mxolisi Jacobs Stadium in Upington, Northern Cape, the President of the Republic of South Africa Mr Cyril Ramaphosa said that South Africans should embrace their indigenous languages. He further indicated that South Africans should learn their languages so that they can know and understand their identities. "There is no language in South Africa which is superior to another and every single language which is spoken within the country has equal value and equal worth'', said the President of South Africa Mr Cyril Ramaphosa. This means that all the languages are equally good and effective in communication; none is superior and none is inferior.

The President said: "Language is the great transmission line that binds us to our forebears." This means that through language we can understand where we come from, and where we are heading". Moreover, the President said: Over the last fewer years, the government reduced the number of public schools that do not teach African languages from 2 500 schools to just over 460. He further indicated that by the end of 2020 the aim is to ensure that all South African's 23 000 public schools offer African languages. Therefore, this indicates that the government is intending to promote and preserve all languages. As the President revealed in his address, it is true that there is now some commitment towards improving the status and use of indigenous languages by the public schools.

Language has always been a major issue in South Africa. The issue of language has caused death of many African youth in 1976 during the protest when

Afrikaans language was made to be compulsory at schools by the apartheid government. According to Probyn (2005), Afrikaans in South Africa was established from colonial language of Dutch. De Wet (2002) posits that when the infamous policy of apartheid (which is an Afrikaans word for separatism) introduced in 1948, mother tongue principle was used to separate South Africans. De Wet (2002) further maintains that home language had a bad image among most indigenous African language speakers because it was associated with the inferior Bantu education. Hence, De Wet (2002) reports that most of the parents choose English as the Language of Teaching and Learning (LoTL) because they see it as a gateway for better education and empowerment. This is confirmed by Maluleke (2019) who concurs that some of the parents consider English as a language which is superior to any other languages because it allows people with opportunities that they would not have otherwise.

Before democracy in 1994, Afrikaans and English were two official languages that were used in South Africa. Therefore, these official languages had greater status when compared to other African indigenous languages. Changes are clearly stipulated in the Constitution of South Africa (1996) that all 11 official languages are equal. According to Department of Arts and Culture (DAC) National Language Policy Framework (NLPF) (2003) about 25 different languages which are spoken within South Africa, of which only 11 languages, namely, English, IsiNdebele, Xitsonga, Sesotho, Afrikaans, Tshivenḓa, Setswana, Sepedi, Siswati, IsiZulu and Isixhosa have been granted official status in terms of section 6 of the Constitution (Act No. 108 of 1996), on the grounds that their usage includes about 98% of the total population. Barkhuizen and Gough (1996) report that each province was permitted to select which of the official languages to declare as their official languages at regional level. Additionally, these official languages are spoken in different provinces and in provincial borders.

According to Madiba (1999), some of these official languages are used as home languages in neighbouring states, for instance, siSwati in Eswatini, Sesotho in Lesotho, Setswana in Botswana, isiNdebele and Tshivenda in Zimbabwe. According to Mabiletja (2015), South African official languages are regionally based. This means that there is a dominant official language in each area. Mabiletja (2015) reports that each province of South Africa has a dominant official language, for example isiNdebele and siSwati in Mpumalanga, Setswana in Northwest Province and Northern Cape, Sepedi (Northern-Sotho), Tshivenḓa and Xitsonga in Limpopo Province, isiZulu in KwaZulu-Natal, isiXhosa in the Eastern Cape, Sesotho (Southern-Sotho) in the Free State and Afrikaans mainly in the Western Cape. Mabiletja (2015) further maintains that in Gauteng Province, 11 official languages are spoken.

Madiba (1999) indicates that English language is spoken across the country and mostly in urban areas. Two official languages, namely Afrikaans and English which were used during the apartheid government are mostly used in business and other communication in different organisations compared other nine official languages. Webb and Kembo-Sure (2000) disclose that Afrikaans and English are practically and officially used in business and other communication over South Africa's, the courts of law, education, administration, commerce and the media, and African indigenous languages are used in primary domains such as interpersonal communication, and for cultural and religious purposes.

International Mother Tongue Day is observed every year on 21 February to promote linguistic, cultural diversity and multilingualism. During the 2017/18 financial year, as part of Language Activism month, Pan South African Language Board (PanSALB) hosted various activities in all the provinces, namely, the International Mother Tongue Day Celebration and Linguistic Awareness Campaigns in Limpopo and Gauteng. The objectives of the Linguistic Awareness Campaigns were to create awareness about Pan South African Language Board (PanSALB) and multilingualism to make people aware of their language rights, educate people on the procedures to follow when lodging linguistic human rights complaints at PanSALB and encourage people to use their mother tongue (PanSALB Annual Report, 2017-2018). On Thursday of 01 February 2018, PanSALB launched the ''28 days of language activism' campaign with a purpose of promoting indigenous languages or mother tongue in South Africa. This campaign initiates at a time when mother tongue languages were facing several challenges-ranging from mutilation at the expense of other languages, like English-to, in severe cases, threat of extinction.

“Africans languages, and other indigenous languages must be preserved to have a sustainable and progressive education system,’’ the Gauteng Department of Education said. In addition, the Minister of Basic Education Angie Motshekga said, ‘’it is imperative that all the eleven (11) official languages be taught at school level to promote cultural diversity’’.

One of the South African provinces that qualify for promotion of cultural diversity is Limpopo Province. During teacher’s classroom practices it is very likely that a teacher will speak more than one language. This is because there are several languages that teachers can use during lessons, especially in rural schools (Rikhotso, 2014). Tshivenḓa, Xitsonga and Sepedi are among the languages used in Limpopo Province. Limpopo Province is predominantly rural, and it comprises of five districts, namely, Waterberg, Sekhukhune, Mopani, Vhembe and Capricorn.

This study was conducted in the Vhembe District, which is the northern district of the country that shares its border with Beitbridge District in Matabeleland South, Zimbabwe and the east with Gaza Province in Mozambique. The district being studied is made of four municipalities, namely, Musina, Thulamela, Makhado and Collins Chabane. Vhembe District consists of all territories that were part of the former Venda Bantustan. Vhembe District was originally settled by the Venda and they are still predominant in the district.

In 2002 the province was changed its name from Northern Province to Limpopo Province. Before the renaming of the province, Vhembe was presented to the province legislature as one of the preferred names for the province and majority of members of Legislature voted against the name Vhembe in favour of the name Limpopo. Boer settlement of the territory began in the late 18 century and increased throughout the 19th century in Vhembe District. Hence, the Soutpansberg was then taken from the Venda rulers by the Boers. During the apartheid years, the homeland of Venda was established in the eastern part of the Vhembe area and was reintegrated into the country in 1994.

Thohoyandou is the seat of Vhembe, which is the former Capital of the former Venda Bantustan. Census (2011) discovered that most of the Vhembe residents, about 800 000, speaks Tshivenḓa as their mother tongue, while 400 000 speaks Xitsonga as their mother tongue. In the Vhembe District, English, Afrikaans, Tshivenḓa, Xitsonga, and Sepedi are the most spoken languages. Tshivenḓa is spoken by 67.2%, Xitsonga 24.8%, Sepedi 1.6%, Afrikaans 1.3%, English 1.1%, and others 4% (Census, 2011). These statistics show that Tshivenḓa is the most spoken language in the Vhembe District compared to the other three African indigenous languages.

This study is a product of what the researcher had observed in her past few years of her teaching experience. The researcher, an experienced and qualified teacher, who is currently teaching Grade 10 to 12 physical sciences (PS) noted that English as a medium of instruction for PS is a barrier to some of English second language (ESL) learners as they are finding it difficult to understand some science concepts. English as a second or third language for learning is generally used in the context of poverty where there is already poor-quality learning and teaching in English (Koti, 2016). Additionally, Kim, Hutchison and Winsler (2013) in their study witness that learners with limited English Proficiency live in poverty and that many of their parents have low education.

Baker (2011) and Van Laere, Aesaert and van Braak (2014) point out that the language used at home which is different from the language used as medium of instruction (English) at schools is one of the key factors which is associated with learners' achievement gap at their school subjects. In addition, learners who are learning through a language which is not their own face with greater difficulties in attaining the same level in physics education than those whom their mother tongue is similar to the language of instruction (Martin, Mullis, Foy, & Stanco, 2012). Hence, Koti (2016) reports that South African learners experiences some difficulties in science learning when their mother tongue is not compatible with the language of science. UNESCO (2005) indicated that in Africa, more than half of the continents' population learn in a language other than their home language.

Msimanga and Lelliott (2014) report that English second language (ESL) learners experience a dual task in the learning environment, which is that of learning English as a medium of instruction while simultaneously having to use the same language which they are still not proficient in to learn science concepts. In addition, Sierens and Van Avermaet (2010) indicate that it is not surprising that ESL learners run a greater risk of under achievement or worse drop out at schools. Consequently, the language which is employed in the learning and teaching of science has an impact on learners' academic performance. Some of learners are finding it difficult to understand questions they are asked and failing to communicate their thought verbally or in writing when language used as medium instruction is not the language they use in their homes. Moreover, the researcher has experience of having taught all grades, i.e. Grade 8-12 in a secondary school. Being a qualified teacher empowered the researcher to have an interest of conducting a research on practical teaching, basically on language used for teaching and learning PS.

Smith (2010) indicates that learners who are not using the language they are familiar with while learning, especially their mother tongue, are underprivileged and unlikely to perform to their best of their abilities. This means that the use of English as LoTL in education has a significant impact on learners' performance. However, Nyati-Saleshando (2020) reported that the more learners in Africa experiences the negative effects of monolingual English medium of instruction in schools, the more policy makers on the continent seem to understand the need for multilingual education, not only for the sake of education, but also for political reasons such as nation-building. Nyati-Saleshando (2020) further give an example of the African Union which adopted the Languages Plan of Action in 1986 that was reviewed in 2006. Hence, the Plan outlines clear goals to be achieved by member states in the promotion and recognition of African indigenous languages (Nyati Saleshando, 2016). The purpose of the Plan to develop African indigenous language and their use in critical social domains such as government, media, education, etc (Nyati-Saleshando, 2020). In support of the use of African indigenous languages the policy guide was established and implemented in 2010 in order to integrate African languages and cultures into the education systems of member states (Nyati-Saleshando, 2020). Recently, Aspirations 3 and 5 on Agenda 2063 are evidence of good the intention to use African languages in education by African governments. Therefore, implementation of African indigenous languages in education is the catalyst for multilingual education in African classrooms (Nyati-Saleshando, 2020). However, the use of African indigenous languages in some of African countries, however, continues to show very little, if any, improvement in the development and use of African languages in education and other critical domains (Nyati-Saleshando, 2020).

The researcher observed that both rural and town schools produce better pass rates in Tshivenḓa than in other curriculum subjects such as English, Mathematics, Sciences and Social Studies. This means that Tshivenḓa as one of 11 South African official languages should be considered as medium of instruction to curriculum subject like Physical Sciences to improve learners pass rate.

In addition, Mutasa (2003) reports that mother tongue (mother tongue) as LoTL could result in the improvement of learning achievements, better adjustments to school as learners can be comfortable, cultural preservation and have self-confidence. Chavez (2016) asserts that learners should be taught in language they know best as they will develop their competences and aid them to fully comprehend expressions and to express themselves competently and confidently. According to Botha (2022), mother tongue can assist with learner-centred teaching approach which is effective, and encourage learners to be active participants during their classroom learning experiences. Mother tongue or home language is a language a person has been exposed to from birth or a language one first learns. Tshivenḓa is one of 11 South African official languages, if languages like English and Afrikaans are used in the teaching and learning PS at schools, why not Tshivenḓa?

Chiwome and Thondhlana (1992) reported that learning takes longer when first language mother tongue is not used as LoTL. Scholars (Bamgbose, 2011; Batibo, 2013 & Chebanne, 2010) have discovered some of the reasons why African indigenous languages linger to have low socio-economic status and reported Globalization and urbanization as one of the many factors responsible for this state of affairs. However, Nyati-Saleshando (2016) contended and stipulated that Globalization and urbanization do enable diversity as people come together from different backgrounds. Hence, this was also interesting and requires certain explanation. As far as Vhembe District is concerned, African indigenous languages that are dominant in the districts are hardly used in written communication. Teaching and learning at schools from Grade 4 are done in English or Afrikaans except when teaching Home language e.g. Tshivenḓa as a subject. Strevens (1976) asserts that Afrikaans and English are two languages in South Africa that have scientific registers.

According to Department of Basic Education (DBE, 2010), the Constitution of Republic of South Africa (RSA) expected languages which are official to be treated likewise and there is no language which is superior other languages. However, the existing curriculum and assessment policy statement (CAPS), support neither teaching through the home language (where this is not English or Afrikaans) beyond Grade 3 nor bilingual education. CAPS, therefore, work against people's constitutional right and the national language policy. Additionally, the Constitution allows school children the right to receive their education through languages of their choice. The Tshivenḓa language is as good as any other language; all it needs is to be given the chance and room to function and develop.

The study mainly focused on development and application of TPSSR (Appendix S, page 259) in the teaching and learning curriculum subject, i.e. Physical Sciences. It investigated how the use of TPSSR influence interaction and discourse. Therefore, this is an interpretative qualitative case study conducted in the Vhembe West district in Limpopo province, South Africa. The participants of this study include physical sciences teachers, physical sciences learners, and parents (School Governing Body s') from selected three public secondary schools positioned in the Vhembe West district. Additionally, senior citizens of Vhembe West district were considered during the process of developing TPSSR. The data of the study obtained through diary, interviews and lessons observations. The study proposes Classroom Language Investigative Framework (CLIF:Figure 1) as the conceptual framework to guide the study and to explore the significant of language use within the learning environment.

The researcher noted that indigenous languages like Tshivenḓa is given little value in the education system of South Africa. Hence, such concern gave the researcher an interest to investigate the challenges and opportunities in the development and application of TPSSR to teach Physical Sciences in some of South African schools. The target group for this research was Grade 10 Physical Sciences class. This grade was chosen because it is the first grade where PS is offered at secondary level.

1.2. Problem statement

According to Wellington and Ireson (2008), the goal of language in science learning and teaching attracted many scholars' interest with the principle that language is most vital medium and a main barricade in learning science. The problem of this study is related to English as LoTL for PS, basically in Vhembe West District, Limpopo Province. Vhembe West District is a multilingual region that uses English as LoTL for curriculum subjects like PS at schools. According to Koti (2016), availability of best resources, curricula, management and so on in the learning environment can be unproductive if both teachers and learners are incapable to communicate well; then, all the other enhancements are in vain. Though learners are expected to be taught and learn through English, some teachers and learners are not proficient to learn in English (Nel & Muller, 2010). This means that there are teachers and learners facing difficulties in the teaching and learning through English language.

Msimanga and Lelliott (2014) assert that most of sciences learners and teachers in mutilingual contexts encounter challenges of learning and teaching of science in a language that is not learners' home language. Therefore, scholars (Adler, 2001; Probyn, 2004; Taylor, Muller, & Vinjevold, 2003) lament that this rises some concerns on learners meaningful engagement in the subject matter when they are not proficient in language used; development of conceptual understanding; performance in high stakes examinations and general preparedness for tertiary education.

Tshivenḓa is a dominant language in the Vhembe District (Census, 2011). This shows that majority of learners at schools that are located within the Vhembe District faces a linguistic problem. This is because learners do not get same exposure to English instruction; hence learners whose home language is English have an advantage (Madima & Makananise, 2020). To get clarity of learners learning problem, one can take a look at learners' academic performance in home language and compare such learners' academic performance with their performance on other curriculum subjects (e.g. Mathematics, sciences) that are being taught through English instruction. In 2020, the DBE released a document displaying the performance of Grade 12 learners who sat for Tshivenḓa and PS examinations in 2019.

Table 1 beneath displays the performance of Grade 12 learners in Tshivenḓa home language from 2017-2019.

Table 1: Performance in Tshivenḓa Home Languages from 2017 to 2019

Category	2017	2018	2019
Number of candidates	18 733	17 574	19 451
Pass	18 704 (99.8%)	17 554 (99.9%)	19 432 (99.9)
Fail	29 (0.2%)	20 (0.1%)	19 (0.1%)

Table 2: Performance in Tshivenḓa Home language and physical sciences from 2016 to 2019

	2016		2017		2018		2019	
Subjects	Total wrote	% achieve	Total wrote	% achieve	Total	% achieve	Total wrote	% achieve

Tshivenḓa home language	22 049	99.9	18 733	99.8	17 574	99.9	19 451	99.9
Physical sciences	192 618	62.0	179 561	65.1	172 319	74.2	164 478	75.5

Table 1 and Table 2 show that in secondary schools pass rate in home language is a lot higher than in the other subjects taught using English as a medium of instruction. Hence, such difference in performances is most likely caused by language barrier. According to Madima and Makananise (2020), some learners experience challenges of understanding and using English instruction in communication and discourses. Secondary schools in South Africa offer compulsory seven subjects in the Further Education and Training (FET) phase, six are taught in English and one by learners' home language. This reveals that majority of learners in South Africa are being taught almost 87% of their school curriculum in a language that is not their own. Furthermore, for most learners, English is a second language they first come across at their schools and they barely use it at home.

Physical science textbooks that are currently available are not written in African indigenous languages like Tshivenḓa, Xitsonga, etc. Semeon (2015) reported that science textbooks that are currently used are written either in Afrikaans or English. This shows that there is a gap of the use of African indigenous language (e.g. Tshivenḓa) as LoTL in school setting which requires a considerable attention as it is one of official language in South Africa. This means that official languages like Tshivenḓa in South Africa are not being put to maximum use in the education system.

Tshotsho (2013) reports that the South African government has not delivered the human resources and physical resources required to encourage mother tongue education and English still has hegemony when compared to other indigenous languages in South Africa. This means that teachers are anticipated to educate

PS LoTL. On the other hand, learners are expected to use either English or Afrikaans to communicate and write activities for curriculum subject. Therefore, it is a reality that none of the South African schools offer Physical Sciences in Tshivenda of have scientific register for Physical Sciences in Tshivenda. Scientific register in this study referred to a register which the academic developed in a certain indigenous language to be used in a classroom setting to teach and learn a specific subject as mentioned in the research background section (first paragraph, page 1). The researcher, as a Physical Sciences teacher, has seen learners struggling with the understanding science terminology. In addition, based on my past teaching experience I have noted that some of the learners have difficulties in learning science to the best of their abilities because they are not good in English which is the language used to learn other curriculum subjects beside their home language. Thus, such concern resulted in researcher desire to develop a scientific register of Physical Sciences in Tshivenda which the researcher referred to as TPSSR (Appendix S, page 259).

Taylor and Prinsloo (2005) identified the language of instruction as the main factor affecting learners' performance at school. Accordingly, learners in PS classroom are not only faced with the challenge of subject matter; they also must cope with understanding the language of instruction. Hence, linguistic problem can be reduced and overcome if learners' mother tongue can be used as language of instruction. According to Nyaungwa (2013), children have many terminologies in their mother tongue than English.

It is also essential to teach science using a language that learners know well in order to implant interest and improve their results. This shows that there is a need to teach PS to learners in their mother tongue like Tshiveṋḓa. This can be conceivable if official languages have equal opportunity in the education system by the Department of Education (DoE) stakeholders. The use of Tshiveṋḓa instruction in education can result in a double advantage. Firstly, the teachers will be comfortable and teach effectively as they will communicate to learners without difficulties. Secondly, learners will understand both the teacher and content better during the learning process.

According to Setati, Adler, Reed and Bapoo (2002), in South Africa, some of secondary schools teachers are working in class setting where English is officially used as LoTL which is not the first language (L1) of both teachers and learners. Hence, these teachers face challenges when teaching PS subject to ESL learners because they require additional support to learn and understand the language of science. A plethora of studies have been conducted in PS, but they did not focus on Tshiveṋḓa scientific register (Charamba, 2017; Mogofe, 2016; Ncube, 2016; Semeon, 2015; Hlabane, 2014; Singh, 2014).

Charamba's (2017) study focused on language as a factor which contributes on Southern Sesotho physics learners' academic performance. He further maintains that approaches of translanguaging, where languages of input and output languages are intentionally substituted, proved to be a valuable pedagogical strategy as learners have an opportunity to learn in their home language. Furthermore, this leads to an enhancement in learners' academic performance in Physics. Mogofe (2016), study which was conducted in Riba Cross District, South Africa focused on integrating language literacy skills in the teaching of PS and reported that some schools in Riba Cross District are doing well whereas some are not doing so well in integrating language literacy skills in teaching PS. Ncube's (2016) study focused on examining the use of language by physical science teachers' during their classroom practices and reported that teachers overlooked explanation of some technical words as well as some non-technical words used in science context.

Semeon's (2015) study focused on exploring learners of Grade 12 PS' construction of meanings on day-to-day words when employed in the science context and reported that learners encounter problems with meanings of day-to-day words when employed in science context. Furthermore, Semeon (2015) maintains that some of PS teachers are not alert that day-to-day words are misinterpreted by learners when they are educating them. Hlabane's (2014) study focused on investigating the effects of incorporating English language teaching in PS education and reported that incorporating language teaching in science lessons improves learners' academic performance, comprehension skills and encouraged the application of learner-centred methods of teaching. It was therefore imperative for the research to explore the possibility of developing and application TPSSR to teach and learn PS in some secondary schools positioned in the Vhembe West District as this has never been attempted before.

1.3. Research questions

- ❖ What are the challenges and opportunities in the development of Tshivenḓa Physical Sciences Scientific Register (TPSSR) for teaching and learning of Physical Sciences?
- ❖ What are the challenges and opportunities in the use of the Tshivenḓa Physical Sciences Scientific Register (TPSSR) for the teaching and learning of physical sciences?
- ❖ How does the use of Tshivenḓa Physical Sciences Scientific Register (TPSSR) in the teaching and learning of physical sciences influence interaction and discourse?
- ❖ What are the views and perceptions of physical sciences teachers, parents and learners towards the use of the Tshivenḓa scientific register for physical sciences?

1.4. Research objectives

- ❖ To investigate the challenges and opportunities in the development of TPSSR for teaching and learning of physical sciences.
- ❖ To investigate the challenges and opportunities in the use of the TPSSR for the teaching and learning of physical sciences.
- ❖ To investigate how the use of TPSSR in the teaching and learning of physical sciences influence interaction and discourse.
- ❖ To explore the views and perceptions of physical sciences teachers, parents and learners towards the use of the Tshivenḓa scientific register for physical sciences.

1.5. Rationale of the study

This present study is important to sciences teachers and anyone who wants to teach PS at FET Phase to see the important and possibility of using Tshivenḓa as medium of instruction to teach science at schools. Previous researchers such as Makgato and Mji (2006), Rammala (2009), Zisanhi (2013), Sethusha (2015) and Ngema (2016) have investigated and reported contributing factors that cause learners' poor academic performance in sciences, the main among them being the language of instruction (English). Nomlomo (2007) and Sibanda (2013) wrote extensively on the application of English and isiXhosa in the teaching and learning of science. However, none of the above-mentioned scholars focused on developing and using the African indigenous languages scientific register, especially Tshivenḓa in the learning and teaching of PS subject in schools. This is the gap that was left by previous researchers that this study intends to fill.

Language of instruction is a key influence in learners' academic performance in subjects such as sciences. This research attempted to explore the effects of using learners' mother tongue (i.e. Tshivenḓa) as LoTL Physical Science. The Constitution of the RSA (1996) stipulates that every learner has a right to receive education in any of the official languages in public schools. However, Botha (2022) reports that even though the choice to learn through mother tongue is being offered, there are still multiple cases where learners are not being educated in their mother tongue. This means that it is a reality that some South African learners are still taught with a language which is not their mother tongue. Although this study may be limited on the use of developed TPSSR in the teaching and learning of PS in some South African schools, it also examined the status of Tshivenḓa in education system.

The research also studied the assertiveness of both learners and teachers towards the use of TPSSR (Appendix S, page 259) in the teaching and learning at schools and find out how they view TPSSR in the teaching and learning of PS. Since the determination of the study was to develop and use TPSSR for PS, the study examined the use of Tshivenḓa in physical science teaching and how teacher and learners interact in PS lessons when TPSSR was employed.

This study also aims on providing possible solutions to help teachers cope with PS teaching to assist their learners to acquire and comprehend the PS concepts. The findings of this study will inform every member within the education system of whether parity of esteem and equality among the official languages exist or not. The outcomes of this study will raise concern to the Department of Basic

Education (DBE) stakeholders since they will be aware of the current situation in schools.

Additionally, the research would also support policy creators in creating effective monitoring and evaluation mechanisms regarding policies of languages in South Africa. Therefore, the education system may be of support to the learners' education by finding a way to enable the use of African indigenous languages by means of developing the language policy of each and every district within the province of South Africa. By so doing, learning and teaching may be operative in the schools of every district and learners will receive proper education. Moreover, it is envisaged that the results of the research will also conscientize teachers and may encourage them to attend professional training clustered and provincial workshops organised by the educational department so that they can be able to share their ideas on language related issues in PS education.

1.6. Delimitations

This study was conducted in other secondary schools within Vhembe West District in Limpopo Province. The focus of the study was on PS teachers, parents (SGB) and learners who are second language speakers of the English LoTL of instruction in the Vhembe District, Limpopo Province. The fact that the research focused only on PS teachers, learners and parents in Vhembe West District may be regarded as a delimitation of the research. Nevertheless, the discovery may be applicable to other districts with similar contexts. The study will also pay attention to the use of Tshivenḓa at schools.

1.7. Outline of the structure of the research

This section highlights how the chapter in this study are organised.

Chapter 1: Introduction

The introduction provides an insight of what this study is all about. Furthermore, this chapter comprises of the following: the research background, problem statement, research questions, research objectives of the study, rationale of the study, delimitation, outline of the structure of the research, and summary of the chapter.

Chapter 2: Literature review

This chapter provides detailed discussions on reviewed literature linked with the study. In this chapter, the following aspects are discussed: History of language in the education of South Africa, language policy and legislation in education of South Africa, mother tongue education, LoTL, PS subject in CAPS, language of instruction and its impacts in science education, code-switching, language of textbooks for teaching and learning, Tshivenḓa language at schools, and chapter summary.

Chapter 3: Theoretical framework and conceptual framework

This chapter presented detailed discussion of the theoretical and conceptual framework that will be used in this study. Furthermore, the summary of description and application conceptual framework is also explained in detail followed by chapter summary.

Chapter 4: Research design and methodology

This section will present detailed discussion of the research design and methodology that will be employed for the study. Furthermore, the following will be included: research approach, area of the study, sampling, credibility, data management, ethical procedures that will be followed for this study will be highlighted followed by chapter summary.

Chapter 5: Development of Tshivenḓa Physical Sciences Scientific Register

This chapter presents data obtained from the participants and other people who assisted in the development of the register. The data discussions and findings from the participants are presented in this section.

Chapter 6: Application of Tshivenḓa Physical Science Scientific Register

This section presents discussions and findings of the study obtained from PS teachers, PS learners, and parents (SGB)

Chapter 7: Conclusion and recommendations

In this chapter, answers to the research questions, contributions of the research together with recommendations of the research will be presented.

1.8. Summary of the chapter

In this section, an introduction of the research is presented. The main aim of the research was to develop TPSSR and inspect the application of developed TPSSR during Grade 10 PS teachers' classroom practices. In this chapter, it was revealed that English is the language that is mostly used in different organisations, e.g. courts, education, etc. English is the LoTL in almost the entire subjects taught at schools. This means that official languages like Tshivenḓa continue to be marginalised in schools but mostly used outside the schools' premises. The rationale for the study and delimitation of the research was also discussed. In conclusion, the chapter that follows will present reviewed literature connected to the research.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

This chapter presents a reviewed literature on the language of instruction in relation to the teaching and learning school with reference to PS subject. The literature reviewed for this study was obtained from the language policy documents and related topics conducted by other academics. The researcher sought to know and understand how South African learners and teachers are dealing with LoTL at schools.

There are several factors that are involved in quality of school education. However, language is a key factor that is involved in delivering proper education to learners in their learning environment. South Africa is a mutilingual country which is currently using either English or Afrikaans as LoTL at schools setting. The use of language that is neither of a teacher nor learners at schools had impact in the teaching and learning (Magwa, 2008). This means that teaching and learning of PS can be difficult to some of the teachers and learners whose home language is not similar with that of medium of instruction.

The literature review for this study will be discussed in the following sequence, and will be discussed further in sub sections below:

- ❖ Scientific language register will be presented.
- ❖ The history of language in the education of South Africa will be reviewed.
- ❖ Language policy and legislation in education of South Africa is presented.
- ❖ The views of several researchers on mother tongue education are presented.
- ❖ The discussion on LoTL at schools succeeds Mother tongue education discussions.
- ❖ The discussions which highlight (PS in CAPS is presented.
- ❖ The discussions on language of instruction and its impacts in science education presented. Although the discussion on language of instruction and its impacts in science education is presented sixthly, its impact should not be taken lightly because it is the basis on which the vital aspect of this study is rooted.

- Code switching
- Discussion on language of textbooks for teaching and learning presented
- Tshivenḓa language at schools is presented.
- Language use in other countries or part of the world

2.2. Scientific language register

Yule (2010) defines register as a conventional way of using language that is suitable in specific context, which can be identified as situational, occupational, or topical. Kabellow, Omulando and Barasa (2019) report that learners might employ certain registers within their learning environment which are unique to them to exclude their teachers from hearing and understanding what they are saying. Kabellow et al. (2019) maintain that some teachers mostly use formal English that can be understood by all the learners in the class and they sometimes employ informal English as an alternative when explaining certain concepts to the learners for them to understand what is being taught. In this study, a scientific register for PS in Tshivenda will have Tshivenda lexical entries or terms that will be used by PS teachers to teach PS concepts.

Some studies have been done in the development of registers in other indigenous languages (Ntuli, 2022; Orji & Udeze, 2021 and Msila, 2021) , but they did not focus on Physical sciences teacher classroom practices. Ntuli (2022) study focused on the development of scientific language register for natural sciences in isiNdebele and its application in some classes of the siyabuswa 2 circuit and reported that the lack of scientific terms in isiNdebele is negatively affecting the use of the language in the teaching and learning of Natural sciences. Orji & Udeze (2021) study focused on the use of indigenous languages in tertiary education in nigeria and reported a higher percentage of students either consider it difficult coping with the indigenous language used for instruction in their language courses or show indifference in learning their indigenous language in the course of their language courses.

Gondo & Gondo (2020) study focused on the possibilities of creating a Shona language register for elementary primary school mathematics using a systematic functional linguistics approach: a case for Masvingo urban and peri-urban schools and reported that Zimbabwean teachers are already creating usable shona mathematical terms as they have reserted to finding new shona elementary mathematical words that have not been used before. Msila (2021) study focused on using an Indigenous Language to Teach Natural Sciences and Technology: Opportunities and Challenges in Two Primary Schools and reported that teaching in local African indigenous languages require huge shifts in how teachers perceive teaching hence they would need to be supported. Accordingly, it was the purpose of the study to develop TPSSR (Appendix S, page 259) and implement it in FET Phase physical sciences teachers' classroom practices in some of the secondary schools of the Vhembe West district.

2.3. History of language in the Education of South Africa

DBE (2011) defines language as a tool for thought and communication. Oyoo (2007) views language as a system of sounds, meaning and structure through which individuals can make sense of the world around them. According to Mammino (2010), language is a fundamental tool which enables a more detailed, complete and complex communication than any other communication tool. This means that people can be able to communicate their thoughts or ideas verbally and physically by using language. Moreover, the language that we use in everyday life is part of who we are as it makes us unique. Shohamy (2006) argues that language use is a unique phenomenon as it is personal and differs from one individual to another. This means that people of different African indigenous languages speak differently.

In 1652, the Dutch Boer settlers arrived and made a great impact on the development of languages in South Africa. Bekker (1999) points out that Dutch was used as language of instruction for Khoi and San children during the 16th century. Once the British, English replaced Dutch when the British government took over the control of the Cape Colony and the new policy of Anglicization was then adopted between 1806 and 1848 (Mabiletja, 2015). Hence, both English and Dutch were recognised as languages which were official in South African Union in 1910 (Mabiletja, 2015). From the time of the first occupation by Dutch in South Africa in 1652, through successive periods of British rule, South African Union, and subsequently the establishment of the RSA and the apartheid regime, government language policy and the power elite failed to recognise South Africa's linguistic diversity (NLPF, 2003). This revealed that other African indigenous languages were neglected as they were never employed as LoTL at schools of South African before democracy.

Studies conducted by Bekker (1999) and Hartshorne (1992) reported that in 1925, Dutch was replaced by Afrikaans and it was used together with English. According to de Wet et al. (2015), Afrikaans is regarded as a daughter of the Dutch language or a vernacular of a Dutch language because about 95% of the Afrikaans words were derived from Dutch.

Hartshorne (1989) indicates that in 1948, the policy of mother tongue education policy was presented following the National Party’s ascendancy to power and the introduction of Bantu Education in 1953. Mabiletja (2015) points out that the policy of mother tongue was disallowed by the African language speakers as they regarded it as a means of promoting ethnic divisions and imposing Afrikaans on education for the Africans. Subsequently, new policy of language passed where curriculum subject like PS were taught either in English or Afrikaans.

DBE (2019) indicates that the curriculum in secondary schools takes English and home languages as compulsory subjects up to Grade 12. This is an optimistic progress as home languages had been compulsory up to Grade 12. Furthermore, the time allocated for teaching home languages and English is the same. However, home language like Tshivenḓa was made compulsory up to Grade 12 only as subject to some learners but according to policy the LoTL at school starting from Grade 4 to 12 English is medium of instruction. This resulted in English being the dominant compared to indigenous languages as it is also used in examining learners in all other curriculum subjects like PS.

Bantu Education Department stipulate that Afrikaans and English must be on equal basis be the languages of instruction at school and such decree resulted in learners felt as being forced to use Afrikaans instruction and think that their mother tongue were being undermined. Mabiletja (2015) reports that the policy led to the resistance to Afrikaans as language of instruction which in turn had resulted to the Soweto uprising in 1976. Consequently, learners had protested the decree of language of instruction and some of young South Africans lost their lives in the process of fighting for their right to attain a quality education in their home languages. The previous policies resulted in the language status inequalities, the development and domination of English, the rejection of Afrikaans by Africans, the development of Afrikaans, the marginalisation of African indigenous languages, as well as the racial and class inequalities (Mabiletja, 2015).

According to Macdonald (1990) and Hartshorne (1992), the use of language in South African schools revolves around English, Afrikaans and also African indigenous languages. This means that most of the schools in South Africa are being faced with a problem of English instruction which is not the home language of teachers and learners.

2.4. Language policy and legislative in education of South Africa

According to Torbe (1977), language policy is a document which contains a series of strategies in the classroom and consequently the whole school. DBE (2010) indicates that the policies of language for all learning organisations in South Africa including that of the schools are directed by the principles enshrined in the Constitution of the RSA (1996) and South African School Act (SASA) (1996). The DBE (2010) postulates that Language in Education Policy (LiEP) advocates the use of home languages as medium of instruction in the early years of learning, while providing access to an additional language(s) which are usually Afrikaans or English for future learning.

According to the Department of Basic Education (DBE, 2010) LiEP consists of the following conditions:

- All learners should learn one official language as a subject in Grades 1 and 2.
- From Grade 3 onwards, learners should learn one additional approved language as a subject in addition to their LoTL.
- All language subjects must have reasonable time and resource allocation.
- Learners are required to select their LoTL during the admission application on their preferred school. The schools which are using the language of learners

as LoTL and there is availability of space in the relevant grade, the schools should admit the learners.

- If there is no school within the district which is offering the language that a learner desired as LoTL , a learner would be allowed to make a request from the provincial education department (PED) to make provision for instruction of a preferred language. Therefore, the PED should make copies of the learner request and make it available to all schools in the relevant school district.
- The PED must keep a record register of requests by learners for teaching in a language or medium that cannot be accommodated by schools.
- It is practical to offer education with a LoTL if there are least 40 learners in Grades 1 to 6 or 35 learners in Grades 7 to 12 request it in a particular school.

The DBE’s National Curriculum Statement (NCS) (2010) promotes the teaching of African indigenous languages in both primary and secondary schools and identifies the significant of additive multilingualism which is demonstrated in the following statements:

> *Each and every learners must learn their home language and one additional language as language subjects from Grade 1, all learners should have studied an African language for a minimum of three years by the end of the General Education and Training (GET) band* (DBE, 2010 pp.7).

Consequently, South African educational policy of languages endorses the use of learners’ home languages in both primary and secondary schools as well as acquisition of an additional language of communication to cater for learners from different cultures, race and regional divides at the same juncture promoting respect of other languages (DBE, 2010).

There are 11 official languages and such languages are recognised by the South African Constitution, namely, English, Siswati, Tshivenḓa, IsiXhosa isiNdebele, Sepedi, Sesotho, Setswana, Xitsonga, Afrikaans, and isiZulu. Moreover, the

South African Constitution (1996) stipulates that the citizens in South African public schools should receive education in any official language(s) of their choice. Tshivenḓa is one of the official languages in South Africa and should be allowed for use in any of official matter as stipulated in the Constitution of South Africa (1996). The DBE (2010) and South African Schools Act (SASA) (1996) posit that it is upon the shoulders of the school governing body (SGB) to decide the language policy of the school. However, they need to consider the language policy prescribed by SASA (1996) and the Constitution of South Africa (1996) when constructing the language policy of school.

According to Probyn (2005), South Africa is a multilingual country and it has 11 official languages. Hence, Afrikaans and English are former colonial languages whereas the other nine languages are African indigenous languages. Most South African schools use home language to be LoTL in the foundation phase, which is Grade 1-3 and starting from Grade 4 onwards English is used as LoTL. Some of the learners' secondary schools are learning PS in their second language which is either Afrikaans or English. According to Taylor and Prinsloo (2005), English as LoTL is a key factor delaying the progress of learners at school because these learners are required to learn and write in a LoTL, which is not the language they use at their homes. Consequently, some teachers are facing challenges when teaching PS to learners whose mother tongue differs from the language used in school education. However, these learners need to be assisted to learn LoTL and the language of science simultaneously (Ferreira, 2011).

Msimanga and Lelliot (2014) assert that there is also a concern of whether these learners are actively involved in the subject matter when learning science education through English instruction of which they are not proficient. Moreover, Oyoo (2012) also accentuates that learning of science ideas is affected in spite of the argument that learning of science is more than just proficiency in the LoTL. Brock-Utne (2014) avers that some learners in South Africa and other countries do not learn science in their home language.

2.5. Mother tongue education

The DBE (2010) defines mother tongue as a language that a learner has attained in their early years, which has generally become the learner's natural instrument of thought and communication and is well-known worldwide. Duquette (1995) argues that mother tongue education is meaningful and relevant to the child, and it also facilitates the transfer of first language skills to the outside environment. Moreover, it is also connected with better educational attainment (Bunyi, 1997; Hameso, 1997). The Bill of Rights, section 29(2) which forms part of the South African Constitution of is unequivocal about the right of south African citizens to obtain their basic education in the official language of one's choice in any public educational institutes where such education is reasonably practicable (DBE, 2010).

Nikki (2017) notes that there are arguments regarding the language learners must choose as a medium of instruction at school. However, Nikki (2017) suggests that both parents and learners must consider the following aspects when selecting LoTL at schools:

- ❖ Learners must be comfortable with language of instruction to be able to understand curriculum subjects' concepts. Some people select a learner's home language as LoTL not only for the purpose of learners being able to understand content in other subjects more easily, but also for parents to have the opportunity to assist their children with homework, attend and participate in parent meetings, and communicate with teachers in a language in which they are comfortable.
- ❖ Some of the parents and learners think being fluent in English can benefit them since English is a language which is mainly used in higher education and being of essential for most types of future employment. Therefore, parents and learners prefer English as LoTL.
- ❖ Since English has a greater status in education organisations and in the job market, learners who their LoTL is not English will often choose English as their first additional language. This allows them to achieve a high level of proficiency in English, without compromising their ability to grasp the subject matter in their other learning areas, or their parents' ability to participate in their education. This might have a major impact on the outcome for this

research. It is therefore important for this research to unpack all the benefits associated with home language instruction so that both parents and learners sees teaching and learning in a different perspective. Furthermore, there seems to be prevalent gratitude in laws and policies of the benefits of home-language instruction. However, this does not change the fact that the Constitution of South Africa guaranteed learners an opportunity to choose the language in which they wish to receive their education.

The South African Constitution recognises 11 languages, nine being African indigenous languages (i.e. Tshivenḓa, Xitsonga, Sesotho, Setswana, Sepedi, Siswati, IsiZulu, IsiNdebele and Isixhosa) have been added to Afrikaans and English as official languages. In support of this constitutional provision, the national Department of Education’s LiEP (Department of Education, 1997) promotes multilingualism at schools. Stoop (2017) asserts that mother-tongue education is viewed as an imperative issue in South Africa and in developed countries such as Germany. It is therefore necessary and acceptable to provide learners with mother tongue education if there is a demand for the provision of such education (Stoop, 2017).

The effort should be made to provide education in mother tongue and learners must start their schooling through mother tongue as the medium of instruction because they understand it best (UNESCO, 1951). Magwa (2009) argues that mother tongue as language of instruction can help learners with a better understanding between school and home. More importantly, Benson (2004) and Webb (2002) contend that the use of African indigenous language, for example, Tshivenḓa as LoTL can increase parental support in learner’s education. Additionally, Dutcher (2003) posits that most of the learners who begin their school education in their mother tongue make a better start, demonstrate increased self-confidence and continue to perform better compare to those who start school in a language that is not their own. Researchers like Baker (2000), Cummins (2000) and Skutnabb-Kangas (2000) asserts that the use of mother tongue in schools can assist in developing learners’ mother tongue and also the learners’ abilities in the majority school language.

Cummins (2001) highlights that bilingual learners can do well at school if the school effectively teaches the mother tongue. Furthermore, Cummins (2001) reports that discouraging the usage of mother tongue may results in learners' personal and conceptual foundation for learning being undermined. Hence, the use of mother tongue at school must not be excluded as the learners may feel being rejected and such may result in learners' hindrance to be actively involved and be confident in the learning environment. Msimanga and Lelliott (2014) suggest that getting learners to talk and think through scientific concepts effectively in English instruction which is not a language of all the learners maybe challenging in achieving meaningful learner participation in the classroom of science. Oyoo (2009) reports that learning the language of science seems to be a challenge in most learners because science has its own very specific register and discourse.

Researchers such as Baker (2000), Cummins (2000), and Skutnabb-Kangas (2000) suggest that teachers need to be hands-on and be resourceful to affirm learner's linguistic identity by means of having posters of several languages employed in the community nearby the school, inspiring learners to write in their mother tongue in addition to the majority school language, and generally create an instructional climate where the linguistic and cultural experience of the whole child is actively accepted and validated. However, Stoop (2017) points out that it is not always easy to practice mother tongue education as there might be times of certain difficulties and hindrances in the implementation and realisation of the "mother tongue education ideal" occur. Furthermore, Stoop (2017) notes the lack of funding, shortage of skilled teachers and inadequate resources as obstacles in the provisions of mother tongue education. However, Stoop (2017) reports that such shortages may not be considered as sufficient reason for failing to offer mother tongue education.

Nzimande and Pampallis (1992) argue that English language is viewed as being more imperative than other African indigenous languages as it is mostly used in different organisation of South Africa, e.g. Industry, School, etc. A study conducted by Tshotsho (2013) reports that some of black South African have elected English as medium of instruction at school and by so doing they demoralise the survival of African indigenous languages and reduces chances of African indigenous language like Tshivenḓa as an alternative language of instruction at schools. In support of statement, for the past few years of my teaching experience I have noted that some of the parents register their children to English instruction schools. Therefore, it is a reality that the preference of English demoralises the policy of government to endorse equal opportunities of all languages granted official status in South Africa (Chaka, 1997).

Moreover, the education system is also alert of this present condition and seems not to be doing something about it. The national Department of Education (1998) reports that majority of South African learners have selected English as medium of instruction and by so doing they established inadequate opportunities to learning and teaching which will perpetually weaken the success of bilingualism.

Pandor (2005) point out that the Minister of Education has indicated that English as instruction was going to be non-compulsory, but in the same breathe reversed the word by saying that English will continue as LoTL in education system while waiting for African indigenous languages such as Tshivenḓa to be sufficiently developed. Furthermore, the DAC representative in 2004 at the South African Linguistic Association Conference (SAALA) indicated that the government was doing everything to sponsor the African indigenous languages by funding language centres in nine tertiary institutes in South Africa (Tshotsho, 2013). According to Tshotsho (2013), equal chance in education is a significance for the government. On the contrary, African indigenous languages that were granted official status in education has not received the attention it deserves.

In spite of government policy of multilingualism, there are still no either programmes or teaching materials developed for African indigenous languages for learners to receive education through the use of their mother tongue. Consequently, these disadvantaged learners whose mother tongue is not English as non-English learners are also examined in English instruction in all curriculum subjects beside on home language (e.g. Tshivenḓa) as a subject. According to Chivhanga (2012), mother tongue instruction can only be effective if there are availability of appropriate sufficient resources materials and trained teachers to employ African indigenous languages as LoTL.

Researchers like Barry (1999) and Heugh (2005) exposed the relation of language and achievement by saying the use of English as LoTL in South African schools contributes to the high failure rate and dropout rates among black learners. However, if schools' practice what the South African Constitution (1996) stipulates that pupils have a right to receive education in the official language of his or her choice, high failure rate and dropout of learners may decline.

Researchers such as Afolayan (1976), Bamgbose (1976), Adegbija (1994) and Mutasa (2004) in their studies accentuated that mother tongue education guarantees learners' performance at the greatest ability and mental support. However, there are still no PS teaching and learning materials written in African indigenous languages (e.g. Tshivenḓa), which can be used at schools to promote mother tongue education. Gupta (1997) reports that the language that is used in the government schools is a major part of many countries' language planning policies. Furthermore, in South Africa, most learners attend government schools in the sense that they are wholly, largely, or partly funded by government agencies, and that the ruling government (whether national, state, or local) exercises some degree of control over them (Gupta, 1997). Hence, Adler (2001) and Probyn (2006) report that many schools elects English as a language of instruction whereas most of learners and teachers are not English speakers. Msimanga and Lelliott (2014) assert that science learners and teachers in mutilingual settings confronted with dual challenges in science learning and teaching, which is learning English as LoTL and learning science language through LoTL.

Msimanga and Lelliott (2014) report that some of the teachers during lesson introduction and feedback they use English as medium of instruction. Nevertheless, Msimanga and Lelliott (2014) further maintain that though English used during teachers' classroom practices, some teachers and learners code-switch to their home languages to articulate their understandings of difficult science concepts. Furthermore, it was noted that when a teacher initiated discussion within the classroom setting both the teacher and learners used mostly the English language as a medium of communication whereas in small group discussions, learners mutated to their home languages but reported their finding to class through English instruction (Msimanga & Lelliott, 2014).

Previous scholars in science education such as Oyoo (2012), Setati, Chitera and Essien (2009), Tobin and McRobbie (1996), Turkan and Liu (2012) stipulate that language is a resource which facilitates learner engagement with science concepts, basically in multilingual contexts. Therefore, studies have exposed the persistent debates around the choice of the LoTL, the difficulties of teaching and learning science in a second language, teacher and learner strategies for coping with teaching and learning science in a language that is not their own, and learner general performance in science in a situations of second language teaching and learning.

The use of one or two languages and ignoring other languages resulted in partitions, inequalities and inequities since it means that millions of people – around the globe are enforced to learn or to teach through language in which they are not proficient (Stoop, 2017). Therefore, it is imperative to consider the use of mother tongue language as instruction at school curriculum to achieve equality and liberation and to increase the incidence of high-performance education systems in a multilingual world.

2.6. LoTL at schools

Summers (1995) defines LoTL as a medium of instruction which is a vehicle and ideal means through which data are conveyed. According to Engelbrecht, Yssel, Griessel and Verster (1983), medium of instruction is employed to direct views. Prah (2003) defines LoTL as a language in which basic skills and knowledge are communicated to learners. According to Probyn (2004), most learners in South Africa are studying a wide variety of school subjects using LoTL which is not their own. Consequently, these learners are required to comprehend subject matter content though they had challenges when they switch to LoTL from their mother tongue instruction in their early years of schooling.

Teaching and learning at schools in South Africa is still operating in one or two languages even though it is a multilingual country. This simply shows that South Africa is still lagging behind on implementation of policies that will accommodate all 11 official languages. Nigeria and Tanzania just like South Africa are also multilingual countries. However, these two African countries have been using mother tongue as a LoTL and English as a subject for the past four decades. According to Khosa (2012), in Nigeria the official policy on mother tongue of instruction was officiated in 1977, and Tanzania declared Swahili as the only LoTL at primary levels in 1965. Khosa (2012) maintains that these two African countries fully support long-term development of mother tongue teaching and learning. This should be a lesson to South Africa that any further delay to the development and application of policies on mother tongue instructions will lead to learners being incompetent in their mother tongue.

The Constitution of South Africa (1996) reveals that officials' languages, of which Tshivenḓa is one has right to be used in education or to be utilised as a LoTL (medium of instruction). This above clause stipulates that learners have right to obtain their education in any of South African official language of his or her choice (Constitution of South Africa, 1996).

SASA (1996) section 6 deals with the policy of language in public schools by means of the stipulations that follows:

- Subject to the SASA and Constitution of South Africa, the Minister can determine norms and standards for language policy in public schools with notice in the Government Gazette in consultation with the Council of Education Ministers.
- The SGB of a public school should determine the policy of language in their schools subject to the Constitution, SASA and any other provincial law that are applicable.
- There shall be no form of racial discernment to be practised in the application of determined policy under this section.
- Sign Language is recognised at public schools as it has the status of any official languages for purposes of learning.

According to the Constitution of South Africa (1996), SASA (1996) and Nikki (2007), the SGBs are expected to encourage the best interests of the community in which the school is located and it has the power to regulate language policy but such school policy should therefore limited to the following stipulation:

- The policy of language should be consistent with the norms and standards, as determined by the Minister.
- The policy of language should not discriminate against learners on the grounds of their race.
- The policy of language should allow access of school to learners in the community (and not just the particular group of learners enrolled at the school at the relevant time), and also be approachable to what the community's needs and desires in relation to the LoTL.
- The policy of language should endorse the superlative interests of the broader community.

The SGB should regulate the policy language at schools as it was stipulated in SASA (1996) and the Constitution of South Africa (1996) that SGB should decide on the policy of language at school but they must construct such policy. Moreover, medium of instruction at public schools should be any of official language (SASA, 1996). Hence, learners who their language is an official have an advantage of using their mother tongue as medium of instruction in their learning environment.

2.6.1. Language of instruction in public schools

The language of instruction is the language that teachers are expected to use during their classroom practice whereas the learners will be required to use it throughout their learning process in their schools. When the language of instruction is Tshivenḓa, for example, this means that the teacher will have to teach curriculum subjects such as PS in Tshivenḓa. Therefore, learners will be assessed on the subject matter knowledge of PS and not the language of instruction itself. Learners will therefore be assessed in Tshivenḓa. However, learners need to be proficient on Tshivenḓa instruction so that they can find it easily to grasp the subject matter knowledge of all the subjects that are offered through language of instruction at their schools.

The Department of Education Provincial Language in Education Policy (2001) advocates that grades R and 1 LoTL must be mother tongue or more of the official languages. This clause stipulates that any other official language can be employed as a LoTL. In public schools, the present position of LoTL is mother tongue in foundation phase, that is grade R to 3. Consequently, Tshivenḓa is used as LoTL in some of the schools where many of the learners speaks Tshivenḓa as their mother tongue up to Grade 3. However, from Grade 4 upwards, LoTL is English.

In countries like Kenya, English is taught as a subject starting in the first year of schooling and is a LoTL starting from Grade 4 until post school education (Ogutu, 2006). This shows that language policy is not implemented as prescribed in Constitution of South Africa (1996). The study by Vambe (2006) found that learners manage to do well in the learning environment when languages spoken at their homes are those employed in learning at school. In other words, multilingualism is not only limited to Africa; in fact, the United States has 325 languages which has necessitated the introduction of bilingual education (Nyati-Saleshando, 2018). Therefore, the presence of English should not necessarily dictate the exclusion of other languages; neither should the multilingual nature of Africa be an impediment to the use of her languages in education. The main reason for the non-use of African languages are foreign policies which regulate the languages that are recognised for use in important social domains, thereby creating linguistic hierarchies, social strata and stigmatization,In the case of schools where majority of learners speak Tshivenḓa, learning could be easier using Tshivenḓa instruction in the classroom.

2.6.2. Language of instruction in independent schools

According to Murwamphida (2008), most of the independent schools are using English as LoTL. This was confirmed by PANSALB (2000), as they indicated that most learners in South Africa are either bi- or multilingual and attend their school education in a language that is not their first language or their mother tongue. Some of the parents, especially educated parents choose to register their children in independent schools that are using LoTL. These parents think that independent schools offer quality education and that teachers from such schools work harder compared to those working in public schools. Tshivenḓa speaking learners are enrolled in independent schools even though their mother tongue which is Tshivenḓa is not used as medium of instruction. This clearly indicates that Tshivenḓa is not yet fully practised as recommended by Constitution of South Africa (1996).

In general, learners' study and learn best through their mother tongue (Murwamphida, 2008). Additionally, De Wet, Nieman and Matsela (1999) assert that when mother tongue is used, learners are psychologically at ease and learning is therefore facilitated. In addition, using of African indigenous language as a language of instruction at education is an advantage (Murwamphida, 2008). De Wet, et al. (1999) found that some of teachers and learners' English knowledge is generally inadequate for its use as an optimal and valuable language of instruction. The four scholars, namely, Marais, Conradie, Malan and Schuring (1994) realised that it is a reality that more than half of Black South Africans are incompetent in speaking, reading or writing English which then resulted to a position which can obstruct the progression of learning (Murwamphida, 2008). A research conducted by De Wet, et al. (1999) point out that education through English medium of instruction and the capability to speak English is not an assurance for economic empowerment.

2.7. Physical Sciences subject in CAPS

According to DBE (2011), PS deal with society's need to know physical environment. Curriculum Assessment Policy Statements (CAPS) Grades 10 – 12 PS (DBE, 2011) describes PS as a subject which focuses on investigating physical and chemical phenomena through scientific inquiry, theories, application of scientific models, and laws in to search for explanations of the events in the physical environment. Moreover, PS encourage awareness and skills of scientific enquiry and problem solving; an understanding of the nature of science and its relation to technology, society, and the environment as well as the creation and application of scientific and technological knowledge (DBE, 2011).

PS provide learners with the opportunities of being aware of the environment around them and enable learners to ask questions related to physical and chemical phenomena which could lead to further exploration. PS curriculum consists of six knowledge areas which are Chemical Systems, Mechanics, Wave, Sound and Light Matter and Materials, and Electricity and Magnetism and such knowledge areas are used in arranging the content of PS subject (DBE, 2011). In South Africa, PS is allocated four-hours of instruction weekly (DBE, 2011). This requires PS teachers to be actively prepared so that they can be able to teach the hours allocated in the subjects to cover the content as prescribe by policy.

According to Koti (2016), effective preparation needs availability of resources like PS CAPS policy document, laboratory apparatus, a work schedule, a programme of assessment, prescribed textbooks, lesson plans and assessment tasks. To achieve the goals of PS curriculum as specified by the DBE through NSC, Koti (2016) suggest that teaching must be done by means of lecturing, demonstrations, illustrations using appropriate textbook. Koti (2016) further reports that investigations, posters, experiments, models, and practical, can be used for problem solving. Therefore, learning PS develops pupils cognitive and improves thinking skills.

Muzah (2011) avers that it is known that scientific data attained through observation and experimentation are consistent because it is the verified knowledge and resultant from facts of experience acquired. PS CAPS document stipulates the structure and direction on how educators should plan to teach PS and outlines what it is expected from them in terms of the curriculum (Koti, 2016). Furthermore, Koti (2016) reports that teaching of PS to learners in the classroom setting needs skills which will allow them to notice the aim behind the lesson they are taught. Therefore, teachers who are knowledgeable on the subject matter and instruction can make PS teaching and learning to be effective in the schools setting.

Palmer (2007) advocates that the methods to be used in PS should be creative, interesting, beneficial, encouraging, and provide tools that can be used by learners in real life situations. Techniques that can assure success includes teachers stating the goals and objectives at the beginning of the lesson, initiate simple and clear explanations, ask learners to express their comments during the lesson, ask questions and provide hands-on activities as often as possible (Koti, 2016).

The knowledge that learner attains at school, basically in science curriculum, allows each learner to understand the ideas of science and improve learner reasoning skills which may assist a learner to participate effectively in the modern world. Millar (2004) posits that modern society requires understanding of the nature of scientific knowledge to provide the fundamentals for more advanced study in science and evaluate claims that may affect their everyday decisions and to reach informed views of public policy. The learning of PS benefits the lives of learners owing to its impact on the scientific and technological development which underpins in the country’s economic growth and social well-being of our community (Singh, 2014).

According to DoE (2003), PS play vital role in the lives of South Africans, and it contributes towards the holistic development of learners by means of the following:

- It provides learners with the capacity to work in scientific ways.
- It stimulates learners’ interest.
- It deepens learners’ attention to natural and physical world in which they live.
- It develops skills and attitudes that prepares learners for several life circumstances such as employment and entrepreneurial skills.
- It enhances an understanding that the technological applications of PS should be employed correctly towards social, human environmental and economic development both in South Africa and globally.

2.8. Language of instruction and its impacts in science education

Language is imperative in our daily life and plays a very significant role in the teaching and learning of curriculum subjects (e.g. physical science) at schools.

Jawahar and Dempster (2013) reports that most schools have chosen English as LoTL while few have chosen Afrikaans LoTL. English is still the most popular language used in schools of South Africa even though most of non-English learners had difficulties of learning science through English instruction (Jawahar & Dempster, 2013). Similarly, teaching and learning of PS in South African secondary schools is done through either in Afrikaans or English. Probyn (2001) indicates that the language that is being used in some learning environments is not always English but a mix of English and mother tongue. Ferreira's (2011) study reports that some learners are not familiar with the language of science and vocabulary faced in the subject is problematic to master and understand. In addition, some of the concepts are abstract and are hard to describe to learners who their home language is not medium of instruction (Ferreira, 2011).

According to Howe (2005), learners whose mother tongue was either English or Afrikaans LoTL attained higher scores than those whose mother tongue was different. This means that in PS classroom, some learners are required to learn the subject matter through English as a medium of instruction even though it is not their first language. Taylor and Prinsloo (2005) assert that proficiency in the LoTL is an issue that has an influence in learner's academic performance at school. In addition, Ferreira (2011) also points out that learners are learning English as a subject. Consequently, learners are not only communicating with English during teacher classroom practices, but also using English instruction to learn most of their curriculum subjects beside home language as a subject.

Wellington and Osborne (2001) point out that learning of the language of science is a major challenge that learners' experiences in the classroom. Science is found to be difficult subjects by learners, especially learners whose mother tongue is not the LoTL science (Johnstone & Selepeng, 2000). Consequently, such learners have to deal with the language of science and that which is used as the medium of instruction. Studies conducted by scholars (Janssen & Crauwels ,2011; Martin, Mullis, Foy, & Stanco, 2012) report that speaking of a language which is different from LoTL has negative correlation with academic success of learners in science. Furthermore, Goldenberg's (2008) study on science achievement points out that learners whose their mother tongue is different from

LoTL are facing double challenge, that of acquiring academic knowledge and skills through a decontextualised school language and they must do this through a language that they have often not yet fully mastered.

According to Chamot and O'Malley (1994) and National Research Council (2000), academic language in science contains collecting and interpreting data, drawing conclusions, formulating hypotheses, designing investigations, and communicating results. Science requires learners to interpret diagrams and communicate the data from the diagrams in words (Hlabane, 2014). Scholars such as Schaffer (2007), Jaipal (2001), Wellington and Osborne (2001) also point out that it is important to pay attention to language used for the purpose of improving the quality of science education and suggested that every lesson should by implication, be a language lesson.

According to Oyoo (2012), language is important in all the activities which aims at supporting science effective teaching and learning. Muralidhar (1991) and Oyoo (2007; 2009; 2010) said that, not only learner's proficiency in LoTL allows learners to grasp scientific concepts, but also their understanding of senses of ordinary words when used in science context. However, Oyoo (2007) indicates that the learners' proficiency in any instructional language is the primary step for all learning processes.

Setati (2011) and Hlabane (2014) report that lack of proficiency in English hampers learners' ability to communicate their ideas and understanding about science content. It is significant for learners to understand the LoTL because they are expected to read the texts, analyse and come to conclusions (Hlabane, 2014; Quinn, Lee & Valdes, 2012). However, the general difficulty of the LoTL as used by science teachers in their classroom practices as is evidenced by the challenges faced by learners with meanings of everyday words when used in science context cannot be ignored (Oyoo, 2007).

Henderson and Wellington (1998) indicate the greatest barrier to learning for many learners in South Africa is language used in the learning environment. This is because African countries like South Africa teach science either in English or

Afrikaans. Education Foundation (1994) postulates that in the Eastern Cape (EC) of South Africa, 86% of people speak isiXhosa and most likely study English as a second language. Therefore, most of learners may not understand what is written on science textbooks or what is being taught during the lesson and often resort to memorising the content taught (Singh, 2014). Furthermore, problems arise from the difference between the usual scientific English that demands clarity and the common English language usage (Muwanga-Zake, 1998).

In South Africa, language barrier could account for the poor performance in PS (Prinsloo & Rogers, 2013). Additionally, Hlabane (2014) indicates that lack of proficiency in English also results to poor learners' academic performance since learners need to comprehend the concepts to apply them in solving problems. Even though some research conducted suggested proficiency in the LoTL could result in good academic performance, scholars like Spurlin (1995), Setati (2011) and Hlabane (2014) oppose with this finding contending that science has its own language and a learner must be proficient in both science vocabulary and English as the LoTL in order to be succeed academically.

Setati (2011), Lebata (2014) and Hlabane (2014) report that learners are examined in English whether they are English first or second language learners, and if they cannot understand some of the questions asked, they will not be able to provide the correct answers. In addition, Howie in Probyn (2005) argues that most of the learners are finding it difficult to understand questions as well as failing to articulate their open-ended responses. This is an indication of the significant role played by language in science learning.

English as LoTL to learners whom the language is not their own find it difficult to engage themselves to whole or small group classroom discussions. Scholars such as Rojas-Drummond, Perez, Velez, Gomez, and Mendoza (2001) and Rojas-Drummond and Zapata (2004) report that ESL learners first encounter difficulties in building registers for the LoTL before participating and engaging in classroom discussion or formulate high quality arguments on science concepts. Additionally, researchers like Rollnick and Rutherford (1996) and Setati (1998) revealed that some of non-English learners who appear to be experiencing difficulties with science concepts manage to do well if they are provided with an opportunity to engage in their home language.

2.9. Code switching

Maluleke (2019) indicates that code switching is a second language teaching technique that is mostly used globally to dissect the curriculum content to learners in a language they are familiar with while keeping the integrity of English as LoTL. According to Setati and Adler (2000), code-switching and transliteration practices are common in some of South African classrooms setting as both learners and teachers employ code switching to facilitate communication and interaction among themselves. This is confirmed by Maluleke (2019), when reporting that some teachers during their classroom practices draw on code switching as a method of teaching to support their learners in learning and understanding the ideas of the lesson taught without difficulties. However, code switching during teachers' classroom practices is not authorised since it cannot be carried out in a systematic way.

Previous studies (Adler, 2001; Fleisch 2008, Muthivhi, 2008) reported that some teachers in multilingual classrooms translate English concepts to home language spoken by most learners in class. This is referred to as code switching. Scholars (Cook, 1991; Milroy & Muysken, 1995) define code switching as a teaching method where speakers switch from one language to another in mid-speech. However, code switching requires a teacher to be good in both learners' home language and English LoTL. In case of Tshivenḓa language, code switching is employed in a classroom situation where LoTL is either English or Afrikaans, and learners home language is Tshivenḓa. Situation like these needs teachers to be good Tshivenḓa language speakers to improve classroom teaching and learning of the context. Rollnick and Rutherford (1996) point out that the usage of learners' home language during classroom practice is a powerful means of getting learners to express their thought on the content taught. Furthermore, without the use of code-switching during teacher classroom practices will results in some learners developing alternative conceptions that could remain unexposed (Rollnick & Rutherford, 1996).

PS expect learners to interpret and explore science ideas in a comfortable environment. Therefore, enabling learners to express their science ideas in their home language can assist learners to learn and is where misconceptions are more likely to be revealed. However, Fleisch (2008) argues that code switching overloads the time available for teacher and learners in the teaching and learning, generally lessens concepts from one language context to the other, often misrepresent the original concepts and essentially engaging learners in learning through one language while assessing them in the other, resulting in a mismatch that further contributes to poor schooling and learning failure. Furthermore, code switching can result in teachers failing to cover the expected content within the time allocated because of repetition of ideas in learners' home language.

2.10. Language of textbooks for teaching and learning

Summers (1995) points out that a textbook contains data of subject that need to be learnt by people. Teachers require materials to assist them in their teaching practices and learners require materials to support their learning process. When learners read materials written in a language which is different from theirs are faced with extra task of dealing with the processing of new terminology and new grammar in trying to know and process new concepts (Macdonald & Burroughs, 1991). According to Spurlin (1995) and Ferreira (2011), it is a reality that there are some science learners experiencing challenges in understanding English medium of instruction. Moreover, science learning materials are written in LoTL and learners are examined in the same LoTL. Some learners who lack proficiency in language of science language and LoTL may see science as a difficult subject. A subject like physical science places particular demands on learners because it requires formal operational reasoning (Ben-Zvi, Eylon & Silverstein, 1988, Herron 1975).

Spurlin (1995), Setati (2011) and Hlabane (2014) buttress that science has its own language; therefore, a learner who is familiar with two languages, that of science and that which is used as medium of instruction can easily succeed academically. This means that learners can be able to understand and analyse scientific concepts if science term and medium of instruction is being taught to learners (Ngema, 2016). Moreover, textbooks for example, of PS are not written in the mother tongue and some of learners are sometimes missing out on imperative PS concepts since they are not written in their own language. Therefore, teachers felt compelled to clarify some of science texts in the mother tongue first and then return to English more especially in schools in rural areas where majority of learners speak the same home language. Nevertheless, code switching is not in the language policy of education but some teachers felt compelled to switch to home language to explain concepts in PS textbooks because some learners will just sit and look at the teacher as an indication that they do not understand.

Murwamphida (2008) asserts that availability of some textbooks which are written in a language that the learner is comfortable with, reading and learning are without barriers. Murwamphida (2008) maintains that there should be availability of learning and teaching support materials (LTSM) in Tshivenḓa, for learners who are Tshivenḓa speakers to be comfortable with their learning. English is a language of instruction in curriculum subjects such as Economic Management Sciences (EMS), Technology (Tech), Social Sciences (SS), Mathematics (Maths), Natural Science (NS), and Life Orientation (LO) (Alexander, 1989).

It is already indicated that teaching and learning in foundation phase is supposed to be done through mother tongue instruction. This means that Tshivenḓa should also be used in writing materials for foundation phase learners. The study conducted by Murwamphida (2008) reveals that the number of textbooks written in Tshivenḓa is extremely low compared to English textbooks (e.g. there are 4 Tshivenḓa numeracy textbooks and 18 English numeracy textbooks; Tshivenḓa has 4 Life skills books and English has 28). This is an indication that there is an insufficient resource available in Tshivenḓa. Grade 10 and 11 PS LTSMs are written in either Afrikaans or English and there are 45 in English and 13 in Afrikaans (Murwamphida, 2008). This is an indication that PS textbooks written in Tshivenḓa have not yet begun. There are ten Grade 12 PS textbooks written in English and four are written in Afrikaans (Murwamphida, 2008). However, there is no Grade 12 science textbook written in Tshivenḓa.

2.11. Tshivenḓa language at schools

Nababan (1981) indicates that the child's home language also referred to mother tongue lays the basis of a person's world view and perception. LiEP and NCS promote the use of home language as LoTL in the early years of schooling. The home language is one of the subjects taught at school. Home language is a language which learners seem to be comfortable with when reading, writing and speaking at schools. Moreover, it is a language which they mostly used at their homes. Ozfidan (2017) says home language education increases social skills and provides individuals with the confidence they need to feel secure in their identity because language is etched in who people are. However, home language taught to the learners at schools is often but not always the same as the language the learner speaks at home. This means that primary schools are allowed and encouraged to employ home language as LoTL in foundation phase.

According to Nortje (2014), Tshivenḓa is offered as a LoTL in some low-grade primary schools i.e. Grade 1 to Grade 3. Tshivenḓa as a language of instruction ends at foundation phase and from intermediate phase until Further Education Phase Tshivenḓa is offered as a subject. This means that from Grade 4, Tshivenḓa is learnt as a subject whereas other subjects are learnt through English medium of instruction. A research conducted by Sethusha (2015) reported that there are some teachers who are using home language i.e. Tshivenḓa, to clarify some of science concepts in their classroom practices because their learners are not good in the LoTL. Consequently, it is a reality that some teachers use learners' home language to facilitate the teaching and learning of PS and English simultaneously. Consequently, learners are being taught bilingually. Chavez (2016) indicates that learners who are taught in their home language can express themselves more freely and improve their self-confidence and thinking skills.

A study conducted by Muthivhi's (2008) in rural schools in South Africa reveals that there are some teachers who are incorrectly translating concepts from English to Tshivenḓa wrongly and that their lessons did not facilitate the learning and development of subject matter concepts and knowledge on the part of their learners. Translation can be made either for the purpose of explaining difficult concepts to learners so that they can understand or be motivated by lack of proficiency in English instruction as well as failure to explain ideas exclusively in that language.

The shift from home language to English instruction seems to be a problem to majority of learners. Fleisch (2008) reports that in most schools where learners in their early schooling employed mother tongue and make the transition to English instruction seem to experience difficulties connected with the change of language medium. Fleisch (2008) further maintains that the problem seems to be associated to the instructional activities carried out in the learners' mother tongue, before the transition is made, as much as it also implicates the increased cognitive demands of the subject matter, which learners are expected to master in a language they have barely mastered.

This research sought to contribute to knowledge about mother tongue (Tshivenḓa) instruction and its effectiveness towards learners' academic performance. The challenges regarding the change from mother tongue (Tshivenḓa) instruction to English instruction in South Africa has an influence on learners' education. In contradiction of the background of the problems associated with the use of home language as LoTL in the learning environment, code switching and the shift of mother tongue to English outlined above, the study examined the effectiveness of learning through Tshivenḓa mother tongue instruction. Consequently, the problems of LoTL can be overcome if the education policies endorse the use of home language instruction in all schools' phases. This study employed empirical data in demonstrating the theoretical point which derived from theories and models used in bilingual education.

2.12. The use of indigenous languages in other countries or part of the world

Australia

Australia is a multilingual country in which the use of Indigenous languages is limited as it used by few people even though most people within the country have such languages as their mother tongue. English is a language that is dominant compare to other language used in Australia (Clyne, 1998). Clyne (1998) further indicated that few of indigenous language of Australia are taught at schools for the reason that some the parents who came to Australia devoted to assimilation. Mabiletja (2015) reported that French, Latin and German are the main languages which are offered in Australia. According to Clyne (1998) indigenous languages in Australia are not generally taught which resulted in some learners went to their schools on weekends to learn their communities language surreptitiously. This is an indications that it is a reality that indigenous languages are still destabilize within the education system

Clyne (1998) reported that some learners who used German, Italian and Russian in their examinations were discriminated. Clyne (1998) further indicated that such learners who were not proficient in English were disciplined by means of translations. These reveal that there are learners who are being All students are enforced to receive their school education through English medium of instruction not considering that they are not competent in such language. Mabiletja (2015) indicated that some learners dropped their mother tongue and chose to use English in order to evade discernment.

According to Clyne (1998) the birth of Multicultural Policy in 1973 had resulted to the introduction of many languages to be used at school as a subject including indigenous languages of Australia. A study conducted by Clyne (1998) reported that the National Policy on Languages of 1987 accentuates competence in English and the maintenance, the development and the use of other language beside English and the opportunities for second language learning. Therefore the education programmes between 1973 and 1987 aimed at language maintenance and in the 1990s the programmes aimed at bilingualism (Mabiletja (2015)

Mozambique

Mozambique is an African country situated on the continent's extreme southern east coast. This country is dominated with black people (African World Population Prospects, 2019). Chimbutane (2009) reported that there are sixteen nationwide languages and none of these languages are either official or medium of instruction. This country is still monolingual and Portuguese is the only language employed as medium of instruction at primary schools, secondary schools and tertiary education institutions (Lopes, Brackett, Nezlek, Schütz, Sellin & Salovey, 2004). Nevertheless, the implementation of bilingual education in Mozambique is critical, but it is gradual which resulted to a lack of supporting materials in the teaching and learning (UNICEF, 2017). Also, the country's economic condition is very important and Mozambique is one of the poorest country of Africa. Therefore, launching bilingual education in this country and assimilating other languages on an equal basis remains a substantial problem (Chimbutane, 2011).

The schools in Mozambique continue to offer school education in one language even after they were given freedom by Portuguese rulers in 1992 (Ngoenha, 2000). According to Canhanga (2017) the country has limited budget which hinders the amendment of curriculum in the Area. Mozambique has approximately 16 indigenous languages including Xishangana, Cinyanja, and others. However, these indigenous languages are not used in the teaching and learning at schools. Hence, Portuguese was the only official language in Mozambique and such language is not even one of the indigenous languages in the Mozambique. According to Henriksen (2010) Portuguese was imposed as a language of teaching and learning in Mozambique to develop literacy skills not considering language's competency level. It is a reality that majority of learners in Mozambique are receiving their education through Portuguese as medium of instruction. Additionally, UNICEF (2017) reported that learners who attend at bilingual schools are also learning curriculum subjects in Portuguese such as mathematics.

Brazil

Brazil is the South American country consists of diversity languages. According to Rodrigues (2012) Brazil is a country which has approximately 220 languages, comprising immigrant languages and indigenous languages and their variants excluding Libras, other sign languages and Brazilian Portuguese. Most of the indigenous languages in Brazil are seriously endangered, either because their use presents symptoms of progressive decline, such as reduction in the contexts of use, or because they are no longer being transmitted to new generations (Benjamins, 2016).

Regardless that Brazil is a country with the richest linguistic diversity it uses one of the indigenous languages in the teaching and learning at schools and other associations (Liu, 2019). Liu (2019) further indicated that Portuguese which is the most spoken language in Brazil is the official language and language of instructions at schools in Brazil. These means that learners in Brazil are taught and learnt in Portuguese medium of instruction. According to Finardi (2016) teaching and learning using languages such as English, Italian, and French it is seen as an additional activity rather than a requirement of public education in this Brazil. The use of these language as medium of instruction accounts for a negligible portion of the Brazilian curriculum (Ntuli, 2022). According to Rajagopalan (2003) some people in Brazil have fear that their indigenous language used as medium of instruction will be replaced by English as English is used in other countries, and will have a detrimental effect on the Portuguese educational system, as they have in a number of African countries.

Benjamins (2016) reported at present, in Brazil each and every Department of Education in the States with indigenous populations provides programmes to indigenous teachers at the high school level; some public universities, in these same states, have Intercultural Indigenous Programmes. This is an indication that stakeholders within the education system in Brazil are doing their best to promotes the use of indigenous languages. In support of the use of indigenous languages in Brazil, the most vital policies under Brazilian Law described in a study conducted by Benjamin(2016) are presented below:

- The Federal Brazilian Constitution (1988), which guarantees to the indigenous people’s rights to their own social organization, customs, languages, beliefs and traditions.
- Presidential Decree no. 26 (1991) – which transfer the coordination of educational activities from the Ministry of Justice (FUNAI) to the Ministry of Education; the implementation of these actions is assigned to States and Municipalities.
- Law no. 9,394 – Law of Guidelines and Bases for National Education (1996), establishing the provision of bilingual and intercultural education as a duty of the State.

- Resolution no. 3 (CEB/CNE, 1999), which establishes national curriculum guidelines and standards for the recognition and operation of indigenous schools.
- The National Guidelines for Indigenous Education (1993), for differentiated, bilingual and multicultural education of indigenous peoples and training of indigenous teachers.
- The National Curriculum Guidelines for Indigenous Schools (1998), which provide insight and guidance on the preparation of indigenous education programmes to meet the aspirations and interests of indigenous communities, with regard to the principles of cultural equity among all sections of Brazilian society, as well as the development and production of teaching materials and indigenous teacher training.
- The Indigenous Teachers Formation Guidelines (2002), whose objectives are to contribute to the creation and implementation of initial and continuing training of indigenous teachers in State education systems, and programmes to meet the demands of indigenous communities

2.13. Summary of the chapter

This chapter explored the language policy in education, the language employed at school education as well as the impact of current language of instruction in the school setting. From the foregoing discussion it was noted that in the South African context, English is still dominant as LoTL compared to other African indigenous languages in spite of the fact that the African indigenous languages have been granted official status. Moreover, it was also revealed in the literature that English LoTL which is not either teachers or learners home language have an influence on the teaching and learning process. Consequently, the study focuses on developing and using Tshivenḓa scientific register in PS education. In the next chapter, theoretical framework and conceptual framework underpinning this study will be presented.

CHAPTER 3: THEORETICAL AND CONCEPTUAL FRAMEWORK

3.1. Introduction

The main concern of Chapter 3 is to discuss a theoretical and conceptual framework which will guide the study. The study purpose was to develop and use TPSSR (Appendix S, page 259) for PS teaching (outlined in Chapter One), the problem statement and rationale (outlined in Chapter One) of the study are connected to inform the theoretical and conceptual framework of this chapter. The important features of the study associated with the work of Cummins (1978), Skuttnab-Kangas and Garcia (1995), Skuttnabb-Kangas (1988) and Luckett (1993). Therefore, this study comprised ideas that form the conceptual and theoretical framework for the study, which are, Cummins' threshold and interdependence theories (1978), bilingual education models by Skuttnab-Kangas and Garcia (1995), additive and subtractive bilingualism Skuttnabb-Kangas, (1988) and Luckett (1993). The work of the above-mentioned scholars is vital in this study as they promote the use of indigenous languages in the teaching and learning environment.

Cummins' theory emphasizes the important of skills learned in first language(L1) which is mother tongue that can be useful to second language(L2) which is English but skilled learned in second Language (L2) cannot be applicable in First Language (L1). In addition, scholars (Skuttnab-Kangas and Garcia, 1995; Skuttnabb-Kangas, 1988 and Luckett, 1993) in their models are in support of bilingualism education. This is an indication that mother tongue is vital in the teaching and learning environment. First, the researcher discussed the theoretical and conceptual framework of which the study is based. A brief summary on the description and application of Classroom Language Investigative Framework (CLIF) which this main framework which guided the study is provided.

3.2. Theoretical and conceptual framework

Theoretical and conceptual framework underpinned this study adapted from theories and models used in bilingual education. According to Jones and Brader-Araje (2002) language creates foundation of person's conceptual ecology and conceptual growth. Koti (2016) reported that though the schools may have appropriate materials, syllabuses, and administration, if both teachers and learners are incompetent to understand the language of science and communicate effectively, science performance will decline.

English as LoTL is a barrier for teaching and learning to be operative specifically to the conceptualisation of the complicated science ideas that calls for the mastery of the LoTL (Koti, 2016). This study aims on filling the gap of the use TPSSR (Appendix S) to teach Physical Science in South African schools, preferably in the schools positioned in Vhembe district where majority of Venda people resides. According to census (2011) Tshivenḓa is the most dominant official language in Vhembe district which contribute 67.2% of the total population. Mutasa (2003) reported that mother tongue instruction is imperative for learners as it will improves their learning achievements, allow them to adjust well at school, implant cultural preservation and self-self-assurance in learners.

According to Hlabane (2014) majority of learners in South Africa are obtaining their school education using second language; however, that does not mean they are able to use English to learn cognitively demanding subjects like PS. Hlabane (2014) further reported that Physical sciences need learners to have higher cognitive and academic language skills as it is a subject with its own language.

A study by Ngara (1982) found that Portuguese, French, English, or any other language of wider communication should work in conjunction with indigenous languages. The study underscores the use of indigenous languages as medium of instruction in all primary school grades. However, Magwa (2009) suggests that African indigenous languages should be employed in all levels within the education system. Magwa’s study is similar to this study as the researcher aimed at exploring the possibility of using TPSSR in the teaching of PS. The Constitution of RSA (1996) stipulates that individuals can learn and use any of the official language at school. This means that all the official languages indicated on the Constitution should be employed as LoTL as it is the right of every learner.

Nyaungwa (2013) concedes that it is the right of indigenous people to employ their languages for judicial, cultural, administrative, and other purposes. According to Phillipson (1992), learners are given the opportunity to access their education with the use of their own languages. Moreover, Nyaungwa (2013) maintains that every learner has a right to be educated in the language in which they are fluent, familiar, effectively brilliant and fully understand. Hence, scientific evidence advocated that educating learners with mother tongue sustains their identity and is a good basis for their intellectual development and economic development (Chirinda, 2011).

Hypotheses that may benefit learners in a multilingual education environment are readily available in the literature. In 1978, Cummins developed the two hypotheses, namely threshold and interdependence, which are the main basics of the theory. This hypothesis of threshold is imperative as it predicts the mental and academic outcomes of numerous programmes related to multilingual skills (Baker, 1988). Additionally, hypothesis of threshold stipulated that a strong foundation for learners L2 development is informed with the development level of learners' L1 (Cummins, 1978). This means that learners can attain academic achievement in second language (L2) after attaining threshold level of competence in their first language (L1). Therefore, when this happens, a learner attained optimistic bilingualism and can be proficient in both languages (Mabiletja, 2015). However, threshold hypothesis shows the possibility of a learner to attain low competence in L1 and L2. Therefore, if L1 is inadequately developed then L2 will deteriorate (Mabiletja, 2015).

Cummins (1978) described interdependence hypothesis as the affiliation among language expertise and academic success. According to the interdependence hypothesis, L2 progress is critically influenced by the extent to which first language (L1) has established. This means that the knowledge, values, skills, and attitudes maintained in the L1 deepen the progress of the L2. Therefore, a learner's high level of capability in L1 will lead to a learner's high level of capability in L2. In contrast, a learner's low level of L1 capability will then lead to a learner's low level of L2 capability.

It is imperative for a learner to obtain Cognitive Academic Language Proficiency (CALP) in L1 to transfer such skills in L2 (Cummins, 1978). Moreover, this could assist a learner to attain a high level of capability in both languages. The hypothesis also indicated that if L1 capability cannot be well established before introducing a learner to L2 instruction, both languages may not develop to allow learners to achieve high academic success (Cummins, 1978).

Researchers like Nyaungwa (2013) reveal that Cummins’s theory excludes additional issues that can disturb learner success such as social, political, cultural, and attitudinal factors. Additionally, Cummins’s theory treats schools equal because socio-economic differences of schools are not considered though it does have an impact to academic success of learners. Studies conducted by Canale (1984), Genesee (1984), Spolsky (1984) Troike (1984) and Wald (1984) report that Cummins’s theory suggested that a solid foundation in the L1 prepares learners in learning English and stress that a learner should first know their mother tongue as it will then be easier for them to accomplish a desired goal of learning and teaching through English.

Scholars (Skutnabb-Kangas & Garcia, 1995; Skutnabb-Kangas & Cummins, 1988; Macdonald, 1990) described five multilingual education models, which are, two-way bilingual education immersion model, transitional model, plural multilingual model, maintenance model and the submersion model. Plural multilingual model is a model where learners of dissimilar backgrounds language and ethnic group employ various languages of learning and teaching. In this model, each learner is exposed to several languages. However, the purpose of the model was to help learners to become multilingual to partake in different domains. Skutnabb-Kangas and Garcia (1995) refer to *plural multilingual model* as mainstream bilingual model which is a form of additive multilingualism. In the two-way bilingual education immersion model*,* both majority and minority groups of learners study together in the classroom to develop multilingual fluency in both languages and promote cultural gratitude. Moreover, Skutnabb-Kangas and Garcia (1995) maintain that the model aims to make learners multilingual and bi-well-educated

In the model of maintenance, this is where minority learners will have to first employ their mother tongue as language of learning and teaching and change to the majority language where both languages are employed as language of learning and teaching. This means that there are subjects which are taught with learners' L1 and L2. Hence, minority learners continue to study their mother tongue as subjects to guarantee that they obtain sustained support to become academically knowledgeable in their mother tongue. Skutnabb-Kangas and Garcia (1995) refer to the maintenance model as additive bilingual education, language shelter or heritage language model.

Macdonald (1990) reports that in the transitional model, this is where learners are first educated in their L1 while they are being familiarised to L2. Thereafter, learners' transition into L2 (English) only classes will then take place after three years. This model was employed in different countries and has been successful as teachers had adequate expertise in L2. Hence, in this model, there is a high level of parental involvement and acquisition of initial literacy in L1. L2 before being used as LoTL is first introduced as a subject. In the submersion model, this is a type of model where learners are forced to be educated through languages they do not understand. Hence, Macdonald (1990) points out that minority language learners in their schooling employed the language of majority of learners. Consequently, the transitional model approach promotes subtractive bilingualism.

Subtractive bilingualism refers to the inadequate form of bilingualism often associated with negative outcomes (Lambert, 1975). The term is applicable to a context in which speakers of usually low-status languages are expected to become expert in a L2 (English). Lambert (1975) further maintains that it is applicable to a background in which speakers of generally lower-status languages such as Tshivenḓa in the post-Foundation Phase expected to become expert in an L2, which is usually a dominant language of higher status (such as English in the post-Foundation Phase).

According to Mwamwenda (1996), subtractive bilingualism results from a condition where L2 is learnt without obliging the language skills that have previously been developed in the L1. Therefore, learners L1 skill is substituted by the L2 skills which then resulted in conflict of linguistic and cultural systems instead of supplementing each other. Baker (2000) points out that the academic capability for a learner depends on attaining CALP in L1. Therefore, one can argue that approach of subtractive bilingual disadvantage L1 learners as learners switched to LoTL when CALP is not well underdeveloped.

The learners who participated in this study are from communities where Tshivenḓa is a home language/mother tongue. Hence, these learners exposed to Tshivenḓa language from the time when they were still infants. Furthermore, Tshivenḓa is LoTL learners are exposed to in the first three grades. However, as learners proceed to Intermediate Phase (IP) there is a sudden shift from Tshivenḓa to English as the LoTL. At this stage, learners learn home language (Tshivenḓa) as a curriculum subject and use English as LoTL across all other curriculum subjects. This means that learners have to cope with LoTL at the expense of their home language.

On the contrary, additive bilingualism is defined as bilingualism related with a well-developed expertise in two languages, with positive cognitive outcomes (Lambert, 1975). This type of a model is implemented to a condition in which learners of any language are introduced to a L2, which is then used as LoTL other curriculum subjects beside learners' home language (Sibanda, 2013).

3.3. Description and application of Classroom Language Investigative Framework (CLIF)

Theories and models employed in education mostly focused on learning through two languages, L1 and L2. In this study, imperative theories and models developed by the previous researchers will be considered since the focus of this study was on the development and application of TPSSR to teach PS. CLIF is a conceptual framework that underpinned this study. CLIF (**Figure 1**, page 63) was consider appropriate in this study as it is a diagnostic tool for classroom analysis that can be used to evaluate the language used by both teachers and learners within the classroom environment and also examine teacher and learners classroom interaction and discourse. Additionally, it will provide aid with information to assist in professional training development of in-service teachers. The Classroom Language Investigative Framework (CLIF) has been adopted to guide the study because involves physical sciences teachers' classroom practices for this study However, this proposed framework was informed by Cummins theories, social constructivist theory and models of bilingual education.

The CLIF (Figure 1, page 63) consists of two main components, namely, school setting and classroom environment. depicts the school setting as the main component that describes the school defrayals (i.e. the settlement of the school), school magnitude (i.e. the size of the school, how big or small the school is) and population groups (i.e. the kinds of people found within the school). In this study, the researcher referred school setting to the background of the school which includes the above-mentioned components. Therefore, after the researcher obtained access to the schools, description of the schools and participants of the study was presented in detail. Classroom setting is where the target individuals of the study was found. This is where the investigator was able to recognise and comprehend what is truly happening in PS classroom setting. Additionally, the language/s employed by learners and their teacher and its efficiency in learners schooling were observed. As displayed in the Figure 1 (page 63), classroom setting is shared with two sub-components, namely, learners and teacher. Every single component includes language, social, subject matter, and classroom language analysis.

In this study, language is essential tool to examine effectiveness of instructions. CLIF assisted the researcher to determine whether teacher and learners are used TPSSR (Appendix S) and language of PS appropriately. Wellington and Osborne (2001) report that science comprises words and terminology which can either be technical or non-technical and not a single person cannot separate science from words. Hence, it is essential for learners to understand the language of science besides learning LoTL. However, this can result in either subtractive or additive bilingualism. Subtractive bilingualism as defined as limitation form of bilingualism which is often connected with negative results and it applies to ESL learners (e.g. Venda learners) as they are anticipated to become expert in English as medium of instruction (Lambert, 1975).

Additive bilingualism connected with a well-advanced expertise in dual languages, together with optimistic cognitive outcomes is functional in a context in which learners of any language are introduced to L2 in addition to the sustained educational use of the home language of the learner as the LoTL (Lambert, 1975). Moreover, CLIF (Figure 1) also assisted the researcher to know how well learners understand science language through the developed TPSSR in the learning and teaching of PS. Therefore, the researcher prepared lesson observation tools for the purpose of being able to give responses to research questions and accomplish the objectives of this study. Cummins provided several studies on bilingual education which are related to language expertise in either L1 or L2 to academic success.

There are two types of hypotheses, the threshold and interdependence. The threshold hypothesis focuses on the level of development of learners' L1 forms a solid basis for their L2 development (Cummins, 1978). This is where learners can obtain academic achievement in L2 after attaining threshold level of competence in their L1. In support of Cummins theories, Murwamphida (2008) asserts that mother tongue language skills must be shaped as they form the foundation on which one can build understanding of principles of English language learning. Learning of language occurs in all phases of learning namely, Intermediate Phase, Senior Phase, Foundation Phase Tshivenḓa physical sciences scientific register, Further Education and Training Band (FET), and other higher institutions of learning (Murwamphida, 2008).

Cummins on his theories suggested that a learner must first attain solid foundation in mother tongue instruction before being introduced to English instruction. He further reveals that for a learner to achieve high level of competence in both L1 and L2 depends on how well a learner mother tongue was develop before introduced to English. Cummins (1978) explains interdependence hypothesis as the relationship between language proficiency and academic achievement. As indicated earlier, learner's high level of competence in L1 will results in learner's high level of competence in L2 and a learner's low level of L1 competence will then resulted to a learner low level of L2 competence (Cummins, 1978).

Cummins maintains that a learner must first have a CALP in the mother tongue instruction to transfer such skills to English instruction. Learners who are well developed and acquire CALP in mother tongue achieve high achievement in English. However, if mother tongue is not well developed that can results in learners' low level of competence in both mother tongue and English. All four frames, namely, language, social, subject matter and classroom language analysis are reliant and form a continuous frame. Each phase is elucidated in the next sub-sections. Moreover, the use of CLIF (Figure 1, page 63) was of success as the researcher was able to examine effectiveness of TPSSR (Appendix S, page 259) during teacher classroom practices. The propose framework enables the researcher to diagnose how the language use in the classroom influences interaction and discourses between teacher and learners, among learners themselves and the content taught. Therefore, with the use of CLIF in the classroom where TPSSR was implemented learners were excited as the scientific register used in physical sciences lessons was written in indigenous language i.e. Tshivenda which was their mother tongue. Thus, teacher-learners classroom interaction and discourse was satisfactory and most of learners were able to participate without experiencing difficulties in understanding the language used in TPSSR.

3.3.1. Frame A: Language

The objective of this frame is for a researcher to identify the language challenges from teacher and learners during learning process and to diagnose how teachers develop learners' awareness of the use of LoTL and language of science in the learning process. To address this, a teacher does language checks across the PS classroom, for example, teacher conducted baseline assessment to discovery learners' level of ability in language of science. Therefore, the teacher must come up with appropriate methods he/she think can improve language skills in the classroom of science, by so doing the teacher would be able to plan for the next frame.

By using CLIF, the researcher evaluated or noted the following in the frame of language:

- ❖ Proficiency of learners in LoTL i.e. English.

- ❖ The language employed by learners and their teacher in PS lessons (e.g. English or African indigenous language (Tshivenḓa) or both.
- ❖ Learners' ability when using language of their own (Tshivenḓa) in the learning of PS with the developed TPSSR.
- ❖ Learners' level of participation when the developed Tshivenḓa PS was employed during teacher classroom practices of PS compare to English LoTL
- ❖ Learners' understanding of PS subject when English and TPSSR was used.
- ❖ The impacts of language/s i.e. Tshivenḓa and English used on learners' learning
- ❖ Understanding of science language through English and Tshivenḓa register.

3.3.2. Frame B: Social setting

Social setting involves interaction, motivation and participation. It is imperative for a teacher to interact and motivate his/her learners in the learning environment. Therefore, the teacher must do preparation on how he/she can motivate the learners to learn and participate in the learning process. A teacher can nurture science learning in learners by motivating them to learn the language of science. The easiest way to do this is by giving learners an opportunity to discuss and debate the ideas of science in the classroom. The teacher should note that if learners show excitement about their own ideas about science, learners also will become enthusiastic about science language. In addition, teachers must also have time to talk and interact with learners about important of language and what benefits the learners can obtain if they learn science with understanding, for example, for information they can employ for future use, enjoyment, etc.

Teacher must choose topics that are appropriate for learners' age and that could possibly speak about what learners are experiencing in their everyday lives. The objective of second frame is for a teacher to examine classroom interaction and to provide necessary support. By so doing, learners' language skills and interaction among themselves and their teacher will be improved. If this frame is well done, teachers will be able to plan science lessons and focus on teaching science ideas with better results in his/her mind.

Under social frame the following was examine:

- Interactions between the teacher and the learners when TPSSR and English register was employed in the learning and teaching of PS.
- Interactions between learners when TPSSR and English register was employed in the learning and teaching of PS.
- Motivation and confidence of learners when TPSSR and English register was employed in the learning and teaching of PS.

According to Leach and Scott (2003) in social constructivist theory, interactions among teacher and learners, learners among themselves and the social milieu are the essential basis for knowledge construction by learners. The social frame also influences the level of participation of learners when learning in small or large groups. The social setting of the classroom assisted the researcher in determining the language teacher use when motivating and encouraging the learners to learn the subject of PS.

3.3.3. Frame C: Subject matter

Since learning language of science is a challenge, therefore, it must be taught. It is true that in South Africa, some teachers are facing challenges when teaching science to ESL learners because such learners need to learn LoTL and the language of science simultaneously (Ferreira, 2011). Learners need to be instructed in a variety of methods of learning science ideas. It is significant for the teacher to give learners opportunities to employ various strategies in a variety of concepts. Additionally, a teacher must work with every learner in science classroom.

To encourage learners learning science language of the variety of concepts they will encounter, a teacher needs to equip learners with hand-on activities, e.g. experiments, investigations, projects, etc. The objective of frame C is for a teacher to teach and facilitate science subject matter knowledge lessons. Learners can listen to the teacher teaching science ideas and using variety strategies for meaningful learning. The role of a teacher is to teach science ideas in such a way that learners can be able to connect what they learn in classroom of science with the real-life situation in the world in which they live. During teacher classroom practices of science, learners should be reminded about what they already know on a particular topic and then the teacher should use such knowledge to link with present data in order for his/her learners to acquire science knowledge. By so doing, teachers will be giving his/her learners an opportunity to exercise their prior knowledge, listen attentively, pace questions, and understand content taught. Leaners should be able to connect their science ideas with what is written in their science textbook. After teaching, the teacher must teach learners how to reflect on what was taught, summarise the lesson, respond to question through discussions, etc.

During this frame, it is the teacher's role to check whether learners have achieved what was required from them in frame A and to assess if learners understand language of science, and diagnose gaps, misunderstanding as well as misconceptions.

Subject matter frame is important in assessing teacher and learners understanding on the language of science subject. During subject matter frame, the researcher evaluated both teacher and learners. From the teacher perspective, the subject matter frame evaluated how the teacher uses the language and experience to teach. From learners' perspective, this frame evaluated how learners use language of instruction (English) and TPSSR and prior knowledge to approach learning. If frame C is done successfully with the teacher, learners can learn the ideas of science without difficulties.

3.3.4. Frame D: Classroom language analysis

Classroom language analysis is influenced by what happens in previous three frames. Therefore, if all the three frames are done well, learners will be motivated and actively participate in learning the ideas of science, they will be positive to continue with science even at tertiary levels and they will be able to interact with subject content. Accordingly, the connections among all the components are indicated in Figure 1 by means of arrows. Consequently, this study focused on the views of previous researchers and educational policies and special attention will be given to Tshivenḓa position in education.

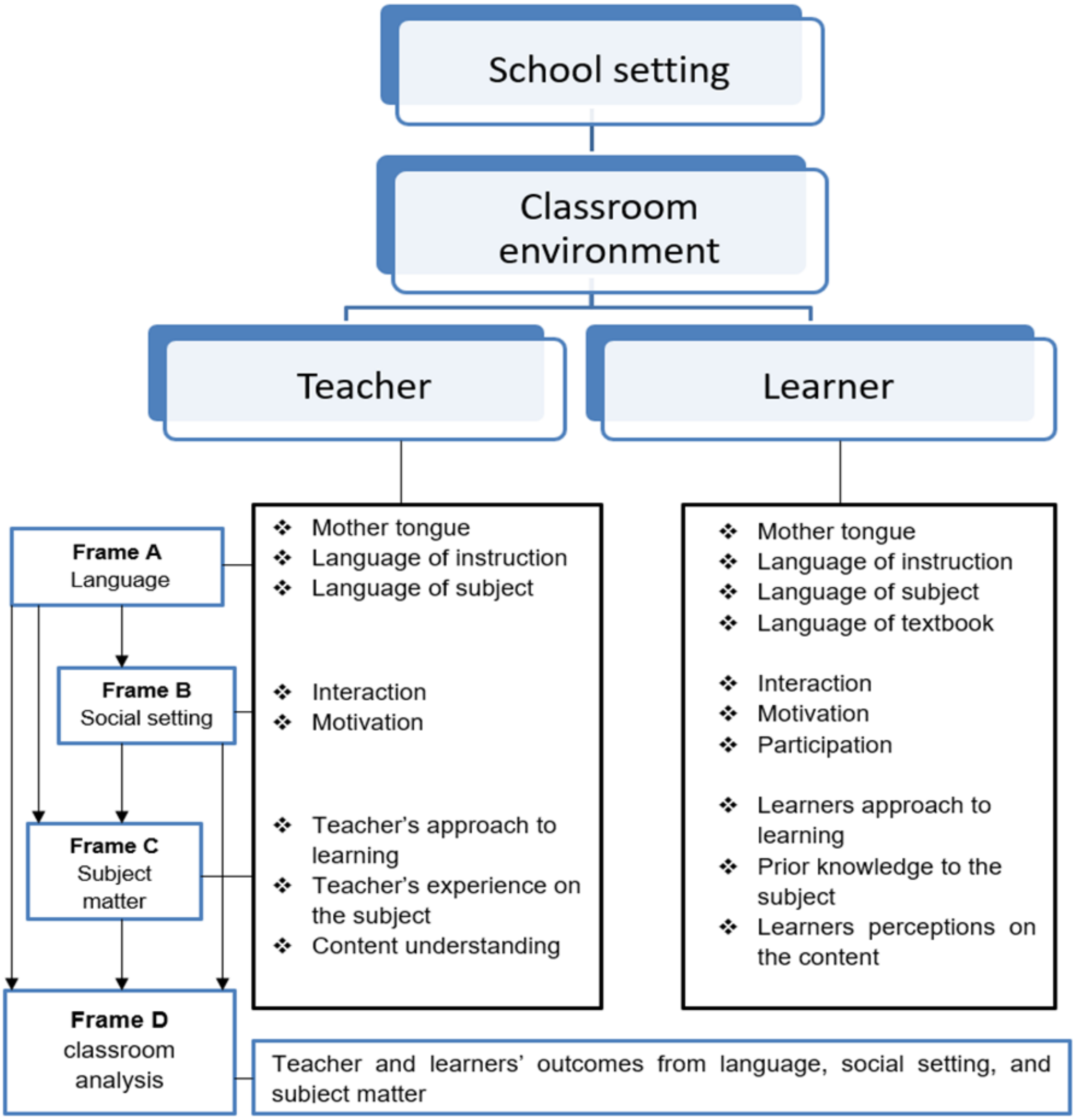


Figure 1: Classroom Language Investigative Framework (CLIF)

3.4. Summary of the chapter

This chapter discussed the conceptual and theoretical frameworks for the study based on related theories. Threshold and interdependence hypotheses as presented by Cummins are discussed. Cummins' in his theories emphasises attainment of language expertise and the imperative of sustaining L1 to be able to transfer language skills to L2. Bilingual education models (BOM) were also discussed. The models that follows, that is, plural multilingual model, two-way bilingual education immersion model, transitional model, maintenance model and submersion model focus on the implementation of multilingual education in different countries. Therefore, both models and theories would assist the researcher in analysing and comprehend the study findings.

The framework also shows teachers the steps to consider when teaching the ideas of science. The aim is for teachers to support learners during their learning process. The discussion in Chapter 3 demonstrated researcher's understanding of theories discussed and how these theories can be helpful in teaching PS ideas especially to Tshivenḓa-speaking learners.

In the next chapter, research design and methodology that was employed during the process of conducting the study will be described.

CHAPTER 4:

RESEARCH DESIGN AND METHODOLOGY

4.1. Introduction

This section proceeds from reviewed literature presented in chapter 2 and theoretical framework presented in chapter 3. This chapter provides a detailed description of how the research was carried out. In this chapter, the following aspects will be addressed: research design and methods, research context and sampling, stages of the research, data collection methods, research rigour; data coding, analysis and interpretation, presentation of data, discussion and findings and ethical considerations.

The research methodology and research design will assist the researcher in answering the following research questions:

- What are the challenges and opportunities in the development and use of the Tshivenḓa physical science scientific register for the teaching of physical science?
- What are the challenges and opportunities in the use of the Tshivenḓa scientific register for the teaching and learning of physical science?
- How does the use of Tshivenḓa language in the teaching and learning of physical science influence interaction and discourse?
- What are the views and perceptions of physical science teachers, parents, and learners towards the use of the Tshivenḓa scientific register for physical science?

Table 3. shows the methodology that was followed when conducting this research.

Table 3 : Step by step structure of the research

Step 1: Developed Tshivenḓa Physical Science Scientific Register (TPSSR: Appendix S, page 259) on matter and materials knowledge area focusing on content of states of matter and the kinetic molecular theory in consultation with Tshivenḓa language teachers. Step 2: Presented developed TPSSR and data collection instruments, i.e. observational guide, and interview guide to the supervisor for review. Step 4: Application of TPSSR commence once the supervisor approved the Tshivenḓa register. Step 5: Obtained an ethical clearance from UNISA College of education that was used as a permit to conduct research. Step 6: Permission requested from Limpopo DoE to conduct research in secondary schools positioned in the Vhembe West District. After obtaining access to conduct research at schools the following steps were followed: Step 7: Permission requested from circuit manager of Vhuronga II Circuit to conduct research in secondary schools offering PS. Step 8: A formal meeting with secondary school principals and PS teachers of Vhuronga II Circuit was organised to request permission, discuss a purpose of study and how the study will be conducted. Step 9: Pilot study was carried out with one school that did not participate in the main study and the proposed instruments, i.e. observation guide and interview guide was tested with relevant participants (physical science teacher, parents, and learners). The main study commenced once the researcher and the supervisor was happy with the outcomes of the pilot study. Step 10: The researcher gave teachers TPSSR that assisted them in preparing matter and material lessons to teach PS using Tshivenḓa instruction. However, beside lesson preparation using TPSSR, teachers were also given English Scientific Register (ESR: Appendix T, page 287) for PS. Step 11: School hours afternoon studies were used to conduct classroom observations on three PS teachers and their learners.

Step 12: PS teachers were interviewed before and after the lesson, learners were interviewed after the lessons whereas parents i.e. school governing body (SGB) members were also interviewed.
Step 13: Data analysis and interpretation was done on the information gathered by means of interviews, classroom observations and diary.
Step 15: Validity check was done on the information collected and the instruments used to ensure that they measure what they are intended to measure.
Step 16: The research findings communicated to the University of South Africa in the form of a thesis.

4.2. Qualitative case study approach

Case study was used as a research mechanism to provide possible explanation of phenomena under study. Case study is a qualitative approach that scholars selected for the purpose of attainment an in-depth understanding of participants to explore for a particular reason. Additionally, a case study enables rigorous data collection, employing various methods (triangulation), and enables a situation to speak for itself instead of being mostly interpreted by the academics (Sitsebe, 2012).

Case study is researcher-centered and implicates observations of participants with the intention of providing an understanding of the research scenery. The researcher was required to keep a close interaction with the selected participants to produce information that assisted in answering the research questions of the study. Thus, a qualitative case study approach investigation was carried out in order to discover the Further Education and Training (FET) Physical Science (PS) teachers and learners' experiences when the TPSSR (Appendix S, page 259) and English language register (ESR: Appendix T, page 287) were employed to teach PS. Additionally, the researcher developed understanding on FET teachers' and learners 'practices when TPSSR and English Scientific Register (ESR) were employed in the teaching and learning PS.

Hofstee (2006) points out that case studies are valuable if comprehensive data are needed of any case, for whatsoever motive. In this research, comprehensive knowledge of both teachers and learners' language practices and experience in the teaching and learning using TPSSR was required. The study comprises three secondary schools in the Vhembe West District. Since three schools were selected, a multiple case was used. From selected schools, PS teachers and Grade 10 learners at FET band and SGB members formed part of each case. This was so because participants came from dissimilar backgrounds and had different experiences which makes them to be unique (Stake & Schwandt, 2006). Since each school was considered as a case, such enabled the researcher to examine participants perceptions on the use of TPSSR (Appendix S) in addition to how the TPSSR shape classroom interactions and discourses.

Teachers and learners' interviews questions mainly focused on their experiences, perceptions and feelings on the application of TPSSR for teaching and learning PS. The parents were also interviewed to know their views and perceptions on the application of TPSSR in the learning and teaching and learning of PS. The study focus was not to compare the participants of the study but to understand participants' viewpoint on phenomenon under investigation. Consequently, the case study approach considered to be appropriate in this study.

4.3. Nature of the research

The study adopted a qualitative approach that supported by an interpretative paradigm to gather and analyse data to give responses to the research questions. According to Merriam (1998), qualitative research is an umbrella concept covering various systems of inquiry that assist researchers in understanding and elucidation the meaning of social phenomena with as little disruption of the natural setting as possible. Furthermore, Denzin and Lincoln (2005) point out that a qualitative approach can make it possible for researchers to study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them. In this study, a qualitative approach employed to examine the opportunities and challenges in the development and application of TPSSR. This was done to participants perceptions of the use of Tshivenda as language of instruction in physical sciences classroom practices. Additionally, to understand how TPSSR for Physical Sciences in indigenous language (Tshivenda) shape classroom interactions and discourses. Thus, the researcher relied upon participants' i.e. teachers, learners and parents' views on the phenomenon under investigation and recognises the impact on the research with the focus being on how the participants experience and understand the particular situation.

In relative to interpretive paradigm, qualitative research emphasises the dynamic, holistic and individual aspects of human experiences and endeavours to capture the very same aspects in their entirety, taking into account the environment of the participants (Silverman, 2000). Willis (2007) reports that interpretivists are interested in the meaning that people give to a phenomenon and require a detailed and thorough analysis of social situations and require first-hand knowledge. Therefore, this qualitative study was exploratory as it examined the depth of the underlying phenomena, which are the perceptions of participants' in using Tshivenda as the language of teaching and learning physical Sciences (Cresswell, 2017).

A qualitative approach occurs in a background that is natural where events arise virtually. In this study, teachers were observed during their physical sciences classroom practices implementing both Tshivenda and English scientific registers for Physical Sciences. It is also notable by a focus on the viewpoints of participants in a situation under examination. As an outcome, it employs interviews as part of the data collection method, permitting participants to share their practices with the situation. Hence, participants of the study discussed their insights on using TPSSR in their classroom practices. This approach is further categorized by the use of a small sample size so that the information gathered can be controllable. Therefore, purposively sampled number of physical sciences teachers, learners and parents (SGBs') were used as the participants of the study.

A qualitative approach was preferred as it supported the researcher in gathering first-hand data from participants through diary, observations and interviews for the reason that it dealt with how individuals understand the world and make sense of their practices. Additionally, qualitative data videos and audios during the entire research process from participants. This enabled the researcher to analyse the use of TPSSR (Appendix S, page 259) in Grade 10 FET phase physical sciences lessons. This type of data was appropriate because qualitative methods such as observations, interviews and diary provided the researcher with the opportunities to extend the type of information to be collected as well as understanding the meaning of participants’ actions towards a phenomenon under exploration.

The qualitative methods allowed a researcher to apprehend the challenges and opportunities in the development and application of TPSSR in the teaching and learning. Additionally, the approach was relevant because the researcher wanted to understand how the use of TPSSR will influence interaction and discourse, how teachers, parents and learners experience and feel about the use of TPSSR in the teaching and learning of PS, and why they experience it this way and feel the way they do.

4.4. Research context and sampling

4.4.1. Research setting

This research was conducted in the Limpopo Province, South Africa. Limpopo Province comprises five districts, namely, the Waterberg District, Vhembe District, Capricorn District, Mopani District and Sekhukhune District. The setting of this research was in Vhembe West District (see Figure 2) under Makhado Local Municipality in Vhuronga II Circuit. The Vhuronga II Circuit was chosen because it is conveniently close to where the researcher resides and performance of PS of some schools found in the circuit has declined for the past three years as indicated in 2019-2021 NSC school performance reports. In addition, Vhembe West District was selected because quality of education of some of rural schools found in the district is negatively affected by language of teaching and learning PS (Sethusa, 2015).

The research was conducted from three public secondary schools positioned in Vuwani cluster (Figure 3). Moreover, the focus was on Grade 10 PS class which is the lowest grade whereby PS is introduced. This gave this research a good starting point to investigate the use of TPSSR. In 2022, School A consists of one PS teacher and three grades for PS, namely Grade 10, 11 and 12. The school had 60 PS learners from Grade 10 to 12. School B consists of 3 Physical Science teachers and three grades for PS, namely Grade 10, 11 and 12. The school had 45 PS learners from Grade 10 to 12. School C consists of one PS teacher and three grades for PS, namely, Grade 10, 11 and 12. The school had 57 PS learners from Grade 10 to 12.

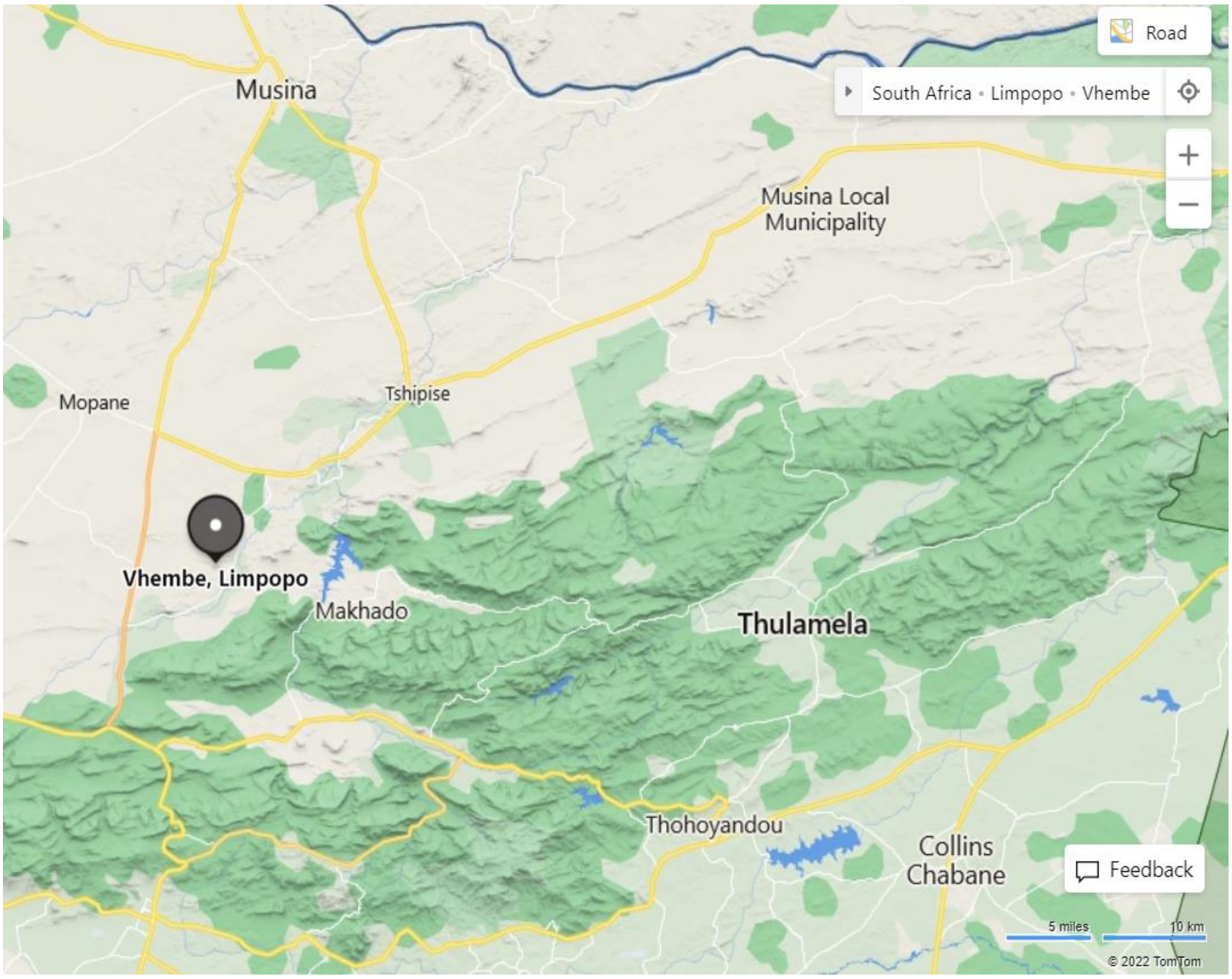


Figure 2: Map Showing the Location of Vhembe West District

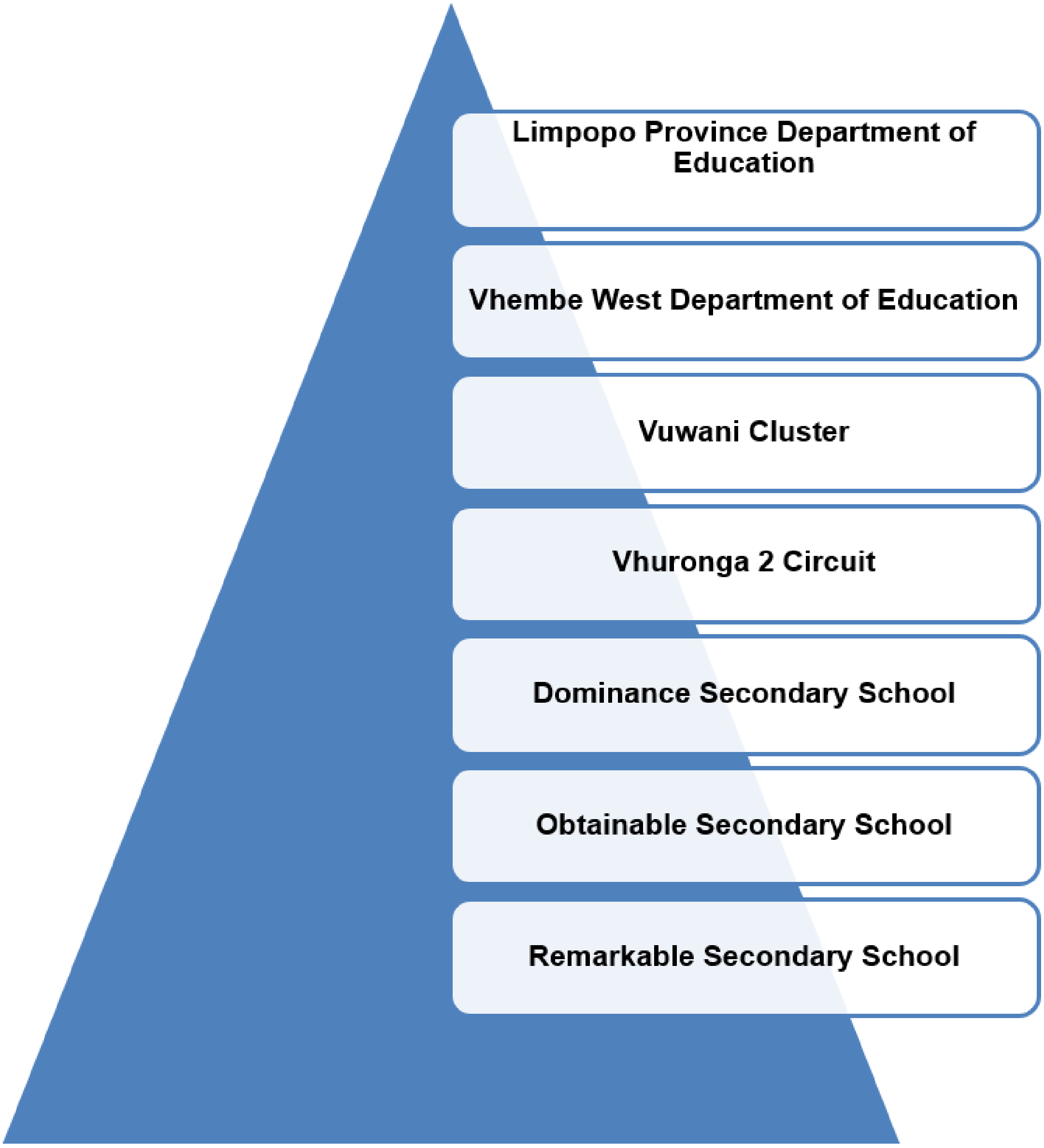


Figure 3: Research setting

4.4.2. Population and sampling

Bell (2011) describes population as a specific group of people to which participants or characteristics of participants are being referred. According to Johnson and Christensen (2000), sampling is a way of demonstrating a sample of population for study purpose. In addition, Johnson, and Christensen (2000) argue that sampling requires the study of the characteristics selected from a large group to understand the characteristics of the larger group. On the contrary, Turner (2020) defines sampling as the selection of a subgroup of the population of interest in a study. In this qualitative study, purposive sampling was employed when making selections of participants for this study. This type of sampling was suitable for this study as McMillan and Schumacher (2001) reported purposive sample as the superlative selection of evidence-rich cases for an in-depth study using participants who are well-informed about the phenomenon under exploration. It was not possible for the researcher to get the entire Vhembe West District PS teachers, learners, and parents (SGBs') to participate in the study owing to population size. Hence, purposive sampling was the most suitable sampling which ensured the researcher that only appropriate participants take part in the study.

The study targeted participants who were currently teaching physical Sciences and competent in Tshivenda, as well as physical sciences learners in the FET phase, as they were thought by the researcher to be information-rich sources that offered valuable understandings in answering the research questions of this study. The parents (SGBs') of the learners were also part of this study. For the possibility of the study, a purposive sampling of three Physical Sciences teachers in each of the three selected secondary schools, one class of physical sciences learners from each selected school, and maximum of five parents (SGBs') from each selected school participated in the study. The researcher elected this number of participants to assure that the data collected was controllable. Data was collected from Physical Sciences teachers and learners using interviews and observations. However, data also collected from parents (SGBs') using interviews.

Purposive sampling was used in the selection of the participants for this study. The sampling done based on the criteria that follows:

- ❖ Participants (teachers) must be teaching physical Sciences in FET phase schools, particularly in the Vhuronga 2 circuit.
- ❖ Participants (both teachers and learners) must be competent in Tshivenda.
- ❖ Participants eager to participate in the entire study.
- ❖ Only parents (SGBs') from the selected schools.

The above brief overview reveal how participants of this study were selected to obtained data assisted in answering the research questions of the study. Table 4 below indicates the summary of study sample.

Table 4: Study sample

Participants	**Number**			**Instruments used**
Schools	Dominance secondary school	Obtainable secondary school	Remarkable secondary school.	❖ Diary ❖ Observations ❖ Interviews ❖ Recording devices (i.e. audio and video)
Learners	27 physical sciences learners	13 physical sciences learners	25 physical sciences learners	
Teachers	One teacher	One teacher	One teacher	
Parents	Four parents	Five parents	Five parents	

4.4.3. cases

Application of TPSSR was employed in three secondary schools. The researcher observed PS lessons where both TPSSR and English Scientific Register (ESR: Appendix T) were employed, conducted interviews with parents, PS teachers, and learners. Consequently, the study consists of three cases of secondary schools offering PS. The cases are discussed in detail as follows:

A. Dominance secondary school

Dominance secondary school is a rural school which is positioned in village A. Dominance secondary school provides secondary school education to learners around the village and other neighbourhoods. Teachers, parents (SGB members) and learners within the school speak Tshivenḓa and Xitsonga as their home language. Most of the learners admitted in the school live in the village where the school is found. Dominance secondary school had classes of grades 8 to 12, and it has a shortage of LTSM and facilities. The school admitted around 355 learners in 2022 and there is no science laboratory. The school has three Grade 10 classes and one of the classes is for PS with 27 learners. PS at Dominance secondary school is allocated 5 hours of teaching and learning, and one period is 60-minutes long. PS is taught five times in a week at Dominance secondary school. The learners are taught in English as LoTL. Thakhani is an African male teacher with 27 years of teaching PS. He has teaching qualification of Higher education diploma (HED) where he majored in Mathematics and PS. Learners in PS classroom were 17 girls and 10 boys, their age range between 15-18 years. The parents in Dominance secondary school age range between 33-55 years.

B. Obtainable secondary school

Obtainable secondary school is a rural school situated in village B. Obtainable secondary school is offering secondary school education to learners around the village and other nearby villages. Teachers, parents (SGB members) and learners within the school speak Tshivenḓa as their home language. Most of the learners admitted in this school are living in the village where the school is situated. The school admitted learners of grades 8 to 12, and it does not have sufficient resources and facilities to support effective teaching and learning. The school has registered approximately 325 learners in 2022 and does not have science laboratory. The school had three Grade 10 classes and one of the classes is for PS with 13 learners. PS is assigned four periods per week, a period of physical science is of 60-minutes long. PS is taught four times in a week. English is used as LoTL. Takalani is an African male teacher with 21 years' experience of teaching PS. He has a teaching qualification of HED where he majored in Mathematics and PS. Learners in PS classroom were 7 girls and 6 boys, their age range between 15-19 years. The parents in Obtainable secondary school age range between 32-60 years.

C. Remarkable secondary school

Remarkable secondary school is a rural school situated in village C. Remarkable secondary school provides secondary school education to learners within the village and other areas. Teachers, parents (SGB members) and learners within the school speak Tshivenḓa as their home language. Most of the learners admitted to the school living in the village where the school is located. The school admitted grades 8 to 12 learners, and it is having shortage of resources to assist in educating the learners. The school registered roughly 405 learners in 2022 and there is no laboratory. There are four Grade 10 classes and one of the classes is for PS with 25 learners. PS allocated four hours per week and each period is 60-minutes long. PS is taught four times in a week. English is used as LoTL. Leon is an African male teacher and has two years in teaching PS. He has a teaching Bachelor of Education (BeD) majoring in Mathematics and PS. Learners in PS classroom were 14 girls and 11 boys, their age range between 16-20 years. The parents in Remarkable secondary school age range between 35-45 years.

4.5. Stages of the research

The development of TPSSR (Appendix S) presented in two stages:

The first stage focused on the development of TPSSR. The target topic was states of matter and the kinetic molecular theory which the researcher finds interesting and wishes to explore on it. The researcher was assisted by Tshivenḓa and PS teachers, senior citizen, family, and supervisor in the development of the TPSSR. Thereafter, the developed TPSSR was presented to the supervisor for evaluation. Once the supervisor was satisfied with the developed TPSSR, the researcher presented it to PS teachers who participated to the study.

The second stage involved application of the developed TPSSR (Appendix S) in the teaching and learning of PS. This stage commences once the supervisor, researcher, some Tshivenḓa teachers and senior citizens verified that the data on developed register are in line with Tshivenḓa language register. The researcher then provided the participants (teachers) with TPSSR study guide that assisted them in preparing matter and material lessons on selected topic. However, the guide was first discussed with the teachers on how to use it. By so doing, the researcher wanted to invite comments and addition from the participants applicable for the study if there was any. Thereafter, the researcher observed PS lesson when TPSSR was used. Hence, the entire lessons were video recorded. However, the researcher also observed PS lesson when ESR (Appendix T, page 287) was used and all lessons were video recorded.

4.6. Data collection methods

4.6.1. Classroom observation

In this study, developed TPSSR on proposed topic was put into practice. The researcher visited PS teachers in their school setting and three aspects were observed during teacher classroom practice. The three aspects observed during teacher classroom practices when TPSSR were employed were as follows, first aspect observed was interaction and discourse between teachers and learner as well as learners among themselves and content taught, second aspect was assessments where learners were given activities like classwork and homework based on what was taught using TPSSR. The same aspects observed when TPSSR was employed also applied when ESR was used to teach PS. The reason of application of both ESR (Appendix T) and TPSSR (Appendix S) was to check if there will be any differences between the two in terms of learner participation and performance. The third aspects focused on teacher providing learners with feedback and corrections on activities. Additionally, the time for covering the above-mentioned aspects depends on how long each teacher takes to cover the aforementioned aspects.

The activities were essential in noticing learners' understanding as well as interaction and discourse in the learning environment. The researcher used video recording to capture everything that was happening in the lessons as this assisted in analysing the data of the study. This method was considered appropriate as it assisted a researcher in answering research questions such as:

- How does the use of TPSSR in the teaching and learning of PS influence interaction and discourse?
- What are the challenges and opportunities in the use of TPSSR for the teaching and learning of PS?

4.6.2. Interview

In this study, data were collected through face-to-face semi-structured interviews. The purpose of the interview in this study was to attain detail information from the

PS teachers, learners, and parents. This type of data collecting technique considered appropriate for this study as it allowed clarity from participants and provided the researcher with deeper understanding of the study under investigation. During interviews with the participants, audio-recorder was used, and the interviews took 10-20 minutes long. The interviews provided the research with data on features like language policy at school, subject matter, challenges and opportunities in application of Tshivenḓa language register and English language register, classroom interaction and discourse, participants views and perception toward the use of TPSSR (Appendix S) for the teaching and learning of PS.

Teacher and learners interview questions mainly focus on the application of TPSSR in science classroom, whereas parents' interviews will mainly focus on their views and perceptions towards TPSSR. The advantages and disadvantages of TPSSR were explored. Therefore, through semi-structured interviews, the researcher evaluated whether teaching and learning using TPSSR is effective or not. Consequently, semi-structured interviews measured as a vital method for gathering data as it provides qualitative data that were advantageous for the researcher in answering study questions such as:

- ❖ What are the challenges and opportunities in the development of the TPSSR for the teaching of PS?
- ❖ What are the challenges and opportunities in the use of the TPSSR for the teaching of PS?
- ❖ How does the use of TPSSR in the teaching and learning of PS influence interaction and discourse?
- ❖ What are the views and perceptions of PS teachers, parents, and learners towards the use of TPSSR for PS?

4.6.3. Diary

This study also makes use of research diary (Appendix X, page 304) to record information related to the study under exploration. The diary was used to keep a record of the journey in the development of the TPSSR (TPSSR). The researcher wrote notes each time when acquire data that was of assistance in the development of TPSSR. Therefore, the diary consisted of data gathered by means of informal and formal discussions and chats with various people. This information assisted in answering research questions such as: What are the challenges and opportunities in the development of the TPSSR for the teaching and learning of PS? Summary of data collection methods that was employed to assist in answering the research questions are displayed Table 5.

4.7. Tshivenḓa physical sciences scientific register

When the researcher was developing TPSSR (Appendix S, page 259) for PS learning and teaching, the focus was on the knowledge area of matter and materials. The researcher identified one topic from the knowledge area of matter and materials which was states of matter. In the proposed topic, the researcher developed three units namely, properties of three states of matter, physical condition of a substance and phase changes. When developing TPSSR (Appendix S, page 259), the researcher requested Grade 10 PS textbooks from local schools which cannot be named for confidential purposes. The developed TPSSR (Appendix S, page 259) was done in consultation of textbooks obtained, namely, study and master physical science, successful physical science, mind action series physical science, siyavula PS, platinum PS, PS grade 10 book 2 theory and workbook. However, during the process of the developed register, the researcher experienced some challenges in obtaining scientific words. I then reach out to people I thought could come to my rescue such as family, friends, Tshivenḓa teachers, colleagues, senior citizens, translators, and supervisor. These people were requested to assist with the development of scientific words or providing with equivalent scientific words. The researcher then finalised the developed register. Therefore, only people to which the researcher reach out and could assist were given the register to read to check if the words appeared in the register are in line with Tshivenḓa register and rigour. Their involvement and suggestions made it possible for the researcher to finally the developed TPSSR to be employed in the learning and teaching of PS.

Table 5: Summary of data collection methods

Research Questions	Methods
What are the challenges and opportunities in the development of the TPSSR for the teaching and learning of PS?	Diary Interview
What are the challenges and opportunities in the application of the TPSSR for the teaching and learning of physical science?	Interview observation
How does the use of TPSSR in the teaching and learning of PS influence interaction and discourse?	Observation interviews
What are the views and perceptions of PS teachers, parents, and learners towards the use of TPSSR for PS teaching and learning?	Interview

4.8. Research Rigour

In this research rigour was ensured through the following approaches:

4.8.1. Validity

One of the key research components is the validity of the data collected and interpreted. Validity may be explained as the extent at which the results of the research provide a true reflection of the situation (Charamba,2017). This definition emphasises the need for this research to use content and sources that are accurate and consistent throughout. It was, therefore, important for the researcher as the observer, recorder and interpreter of the data to pay a sound attention during teacher classroom practices for PS lessons. In this study, the validity was enhanced by ensuring that the findings of this study focused only on the data collected from the participants. Teachers and learners' interviews were used to triangulate and strengthen the validity of the findings. The interviews questions confirmed the findings from observations.

4.8.2. Credibility

Credibility notifies a reader on researcher confidence on the finding presented. In this study, credibility was ensured by means of designing data gathering instruments which were presented to the supervisor for evaluation. Furthermore, credibility was also ensured by means of conducting pilot study where all instruments proposed for the study were first piloted before employed for gathering data in the main study. By so doing, a researcher gathered relevant data concerning fieldwork and found a better way of handling the main study. Moreover, the researcher presented data collection instruments to those that were elected to participate in the main study. Furthermore, recording devices were used during interview and classroom observation for referral during data analysis.

4.8.3 Pilot study

During the formation of the TPSSR guide (Appendix S) the researcher sent it to the supervisor for his opinion and the guide was modified before being piloted. The researcher also presented the instruments for the study to the supervisor for his remarks and addition where applicable. Thereafter, the instruments were refined and tested with relevant people i.e. teacher, parents and learners who were not part of the main study but similar to the participants from whom data of the main study were obtained.

In the first quarter of 2022 (21 February 2022), the researcher conducted pilot study in one school in one of the circuits, in the Vhembe West District. The school had 27 PS learners in Grade 10. The goal was to pilot the developed TPSSR guide and the instruments employed in the main study. The researcher desired to know how teachers and learners interact in the classroom when the developed TPSSR guide is used in the learning and teaching of PS. The researcher also wanted to know the views and perceptions of a teacher, learners, and parents towards the application of TPSSR in the learning and teaching of PS. Additionally, the researcher needed to know how long will the learners, teachers and parents will need to respond the interviews questions.

The researcher gave the teacher the developed guide and glossary of terms three days before conducting a pilot study. After the guide was given to a teacher, the teacher had to go through the developed TPSSR guide which was based on the states of matter and the kinetic molecular theory topics. The researcher informed the teacher that she expected her to prepare a lesson and activities she will use to assess the learners before or after the lesson. Additionally, the researcher informed the teacher that if there are words/terms on which she needed clarity or that are not on the guide that she thinks must be considered/included on the guide must, she needed to inform the researcher so that such terms/words can be discussed by both the teacher and researcher for consideration if they are appropriate.

The pilot study was conducted after school since it was the only time available. The learners were inspired since matter and material was a unit, they had to study in term 1 and was not a problematic section. The pilot study was also intended at recognising challenging Tshivenḓa scientific words used in the guide. On the day of piloting, the pre-observation interview and post-observation interview was done with a teacher. However, because of time only six learners were interviewed after the lesson. During piloting, it was revealed that some interviews questions were not well organised and there was a necessity to revise such questions.

The questions which were revised and modified are written in italics as follows : *What is your view towards the used of mother tongue instruction in the teaching and learning of physical sciences?- **What is your perception towards the used of TPSSR in the teaching and learning of physical sciences**? (teacher interview question); How do you rate your learners' participation in the learning of physical sciences using Tshivenda instruction? -**How do you rate your learners' participation in the learning of physical sciences using TPSSR?** (teacher interview question); How comfortable are you in learning physical sciences through Tshivenda instruction? - **How did you feel about learning physical sciences through TPSSR?** (learner interview question); Which language do you use to assist your child with his/her homework? -**Which language/s do you use to assist your children with their schoolwork? Please elaborate? (SGBs' interview question)***

Many learners did not struggle with the words used during the lesson since Tshivenḓa was their home language. Almost all the learners in the classroom were excited and there was a maximum participation because majority of learners knew scientific words in Tshivenḓa. However, there were words which learners found them difficult but after some explanation the teacher made, they were all happy. There were concepts that were noted to be difficult for learners to understand during the lesson presented were identified, for example terms like ‘muxwatu (ice)’, ‘Tshinukheleli (perfume)’, ‘mutalombalo (graph)’, ‘tshixwatudzi (fridge)’, and many more. Nevertheless, the learners actively participated in the lesson taught using Tshivenḓa instruction and both teacher and learners found the TPSSR guide stimulating and interactive.

The pilot study assisted the researcher in discovering vocabulary that was not easy to comprehend. However, the questions were planned in such a way that would encourage learners to read through the text and understand their meanings. For example, three phases of matter topic contained four activities while kinetic molecular theory topic contained two activities. The test based on both three phases of matter and kinetic molecular theory designed. The pilot study assisted the researcher in developing and implementation of data analysis scheme (DAS). Lastly, the pilot study provided the researcher a chance to be organised and think of ways to knob the main study

4.8.4. Triangulation

Scholars (McMillan & Schumacher, 2010; Merriam (2009) describe triangulation as the use of different methods or data sources in research to gain in-depth understanding of phenomena under exploration. The researcher will use this triangulation technique to enhance validity of the research findings using different methods of collecting data. The researcher used observation, interviews and diary to collect data. For the purpose of identifying the challenges and opportunities in the application of TPSSR in PS teaching, the researcher substantiated what the teachers and learners whispered in the interviews with what was observed during their classroom practices which is methodological triangulation as confirmed by several scholars (i.e. Gall et al.,1996; and Hitchcock & Hughes, 1995). Teachers were interviewed before and after their classroom practices whereas learners were interviewed after the lessons. Consequently, the researcher allowed participants to go through the data collection instruments to check if what was captured during data collection process was exactly what they said.

4.9. Data collection process

The researcher first applied for Unisa's College of Education to obtain research ethics clearance. After obtaining research ethics clearance, permission was requested from the Limpopo Department of Education (LDE) to conduct research at schools. After obtaining LDE approval letter, researcher proceeded to the circuit manager and presented ethics letter from UNISA, LDE approval letter as well as letter requesting permission from the circuit manager. Thereafter, the researcher visited sampled schools and presented approval letter obtained from UNISA, LDE and circuit manager to school principals. The researcher explained the study purpose and gave school principals a letter asking permission to conduct research in their schools as well as explaining the details of the research. After obtaining permission from the schools' principals, the letters requesting permission to conduct the study and outlining the purpose of the study were given to teachers and parents (SBG members). Moreover, learners also participated in the study as they were available during teacher classroom practice. Therefore, learners who were under 18 were given consent form to ask permission from their parents. Thereafter, the researcher worked with the participants throughout the research process.

The study collected qualitative data by means of classroom observations, interviews, and a diary. Data gathered instruments employed in the study for data gathering were discussed with the participants. Figure 4 shows the summary of the process of data collection.

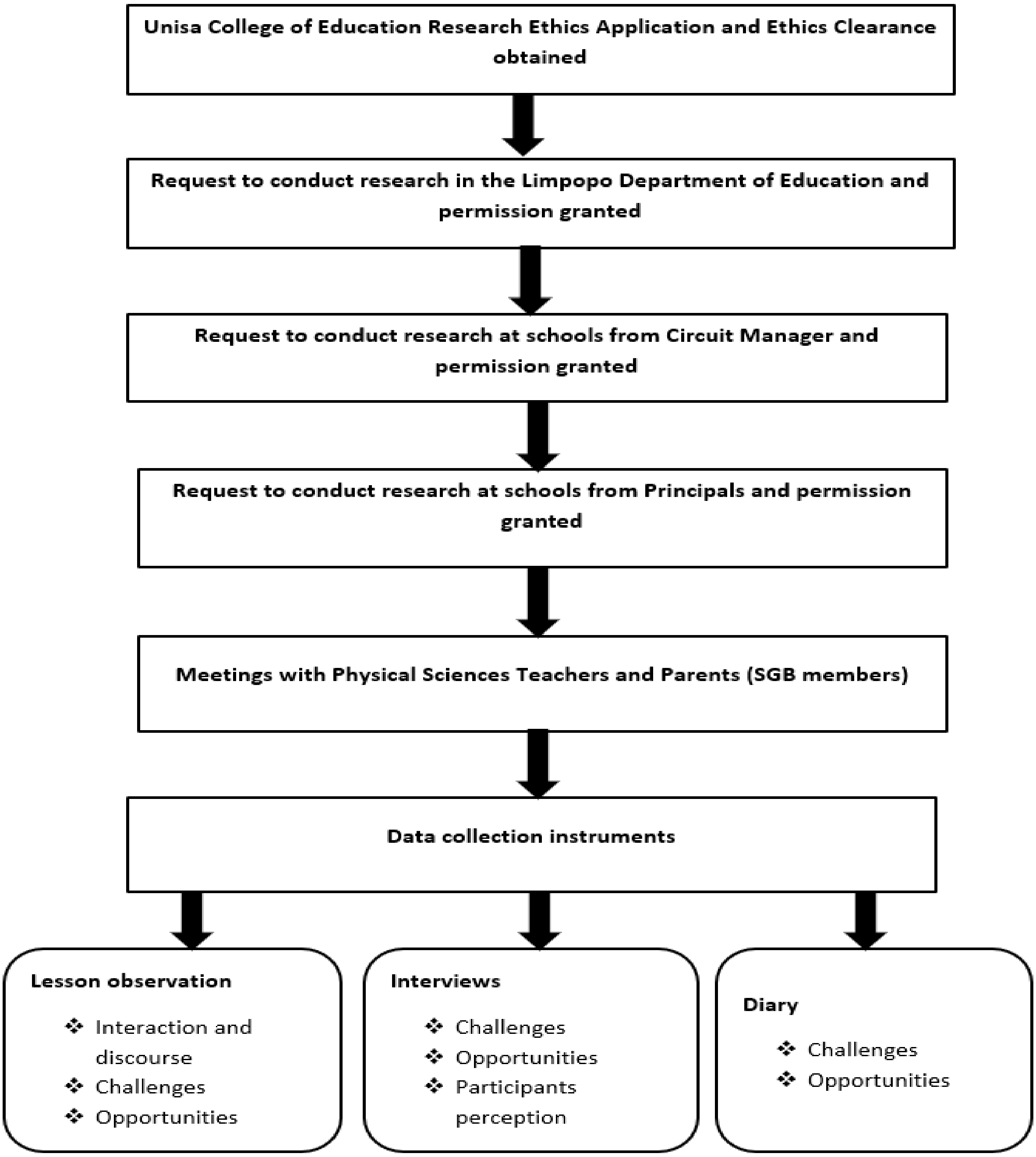


Figure 4: Summary of data collection process

4.10. Data coding, analysis, and interpretation

The findings of the study were analysed using themes developed from research questions and reviewed literature. The themes recommended for the study connect for a researcher to be able to answer research questions and achieve the objectives of the study. The cases of this study were analysed and interpreted separately. The interviews that the researcher recorded the participants using audio-tape recorder were transcribed (Appendix Y) to word document. Once all the data were transcribed, the researcher replayed the audio to verify if the words transcribed matched with the words mentioned on the audio.

The researcher showed the participants their transcribed data for additions, remarks, or corrections before being considered as a final product. Thereafter, the researcher read the transcribed interview data of each case with one theme in mind while coding until they are all finished. The same procedure was applied to the data of all cases that were captured during classroom observations by means of video-recorder. Moreover, the researcher did not correct any grammatical errors that were presented by each case. Figure 5 displays a summary of data analysis and interpretation process.

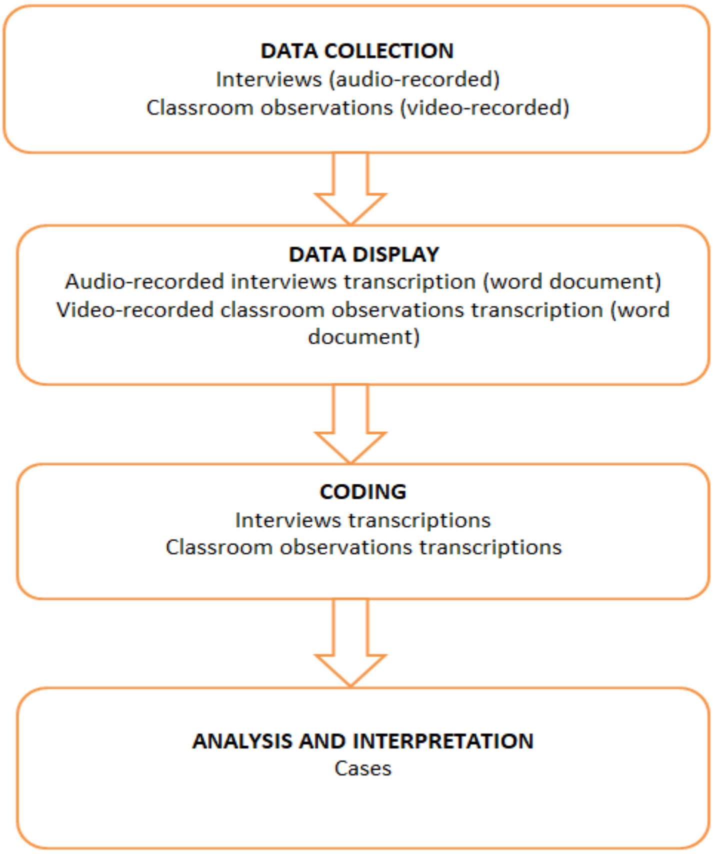


Figure 5: Summary of the analysis and interpretation process

The DAS that was used in the main study was the one applied during piloting. This means that the DAS suggested confirmed during pilot study before being implemented on the main study. The texts that belong to a particular theme were highlighted using same colour and track changes was also used to codify categories and characteristics of a theme. The researcher went through the coded data in order to confirm the transcripts. The data coded were presented. The Figure 6 indicates the coding process.

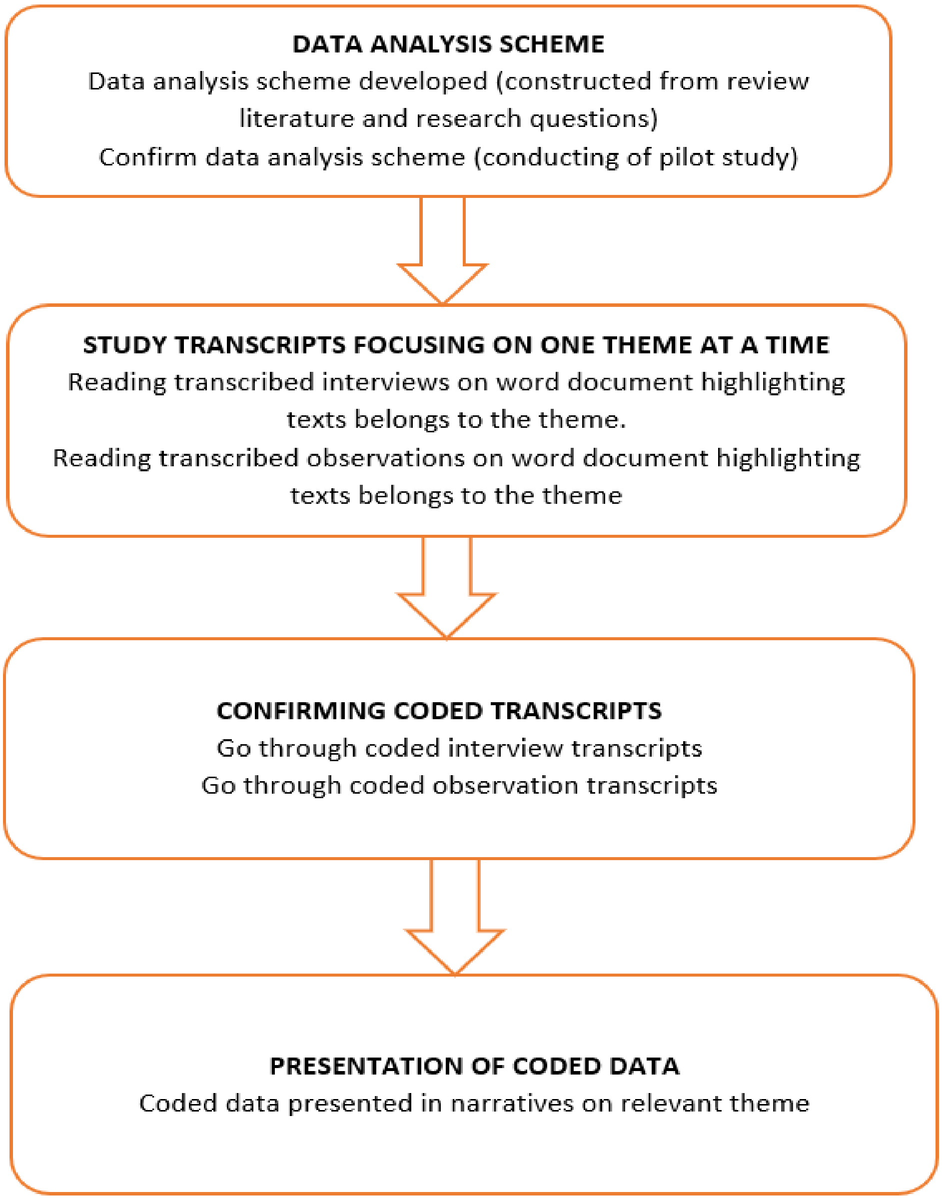


Figure 6: Coding process

All data gathered for the purpose of this study were approached and analysed in light of CLIF (**Figure 1**) as the focus of CLIF is on the language use and the interaction in the classroom where both teacher and learners are find whereas Cummins's theory on transitional bilingual education (1978) and Skuttnab-Kangas and Garcia (1995), Skuttnabb-Kangas (1988) and Luckett (1993) on bilingual implementation models which also focus on the languages to be employed within the classroom setting where learners need to competency in their first language which is their mother tongue e.g. Tshivenda and developed such skilled in their second language which is English instruction. Therefore, the theories proposed in this study are connected since their focus is on the language used in the classroom which was applicable in this study. Furthermore, in this study both TPSSR (Appendix S) and ESR (Appendix T) was employed during teacher classroom practices. This means teachers and learners were observed in lesson presented in both indigenous language i.e. Tshivenda and English instruction.

4.11. Data presentation, discussion and findings

Data analysis scheme (DAS) constructed was used in guiding and organising the findings of this study that were presented and discussed using narratives. All the themes proposed were presented in the table and each theme comprised its categories and characteristics. Moreover, pictures that were captured from the video that were taken during teacher's classroom practice were integrated for the purpose of assisting in reaching the results of the study. Subsequently, the contents of the table were discussed in detail. The findings attained from the analysed and interpreted data were presented. In addition, the researcher used quotes from the cases where applicable for such use.

4.12. Ethical considerations

The study involving gathering information from people requires ethical considerations. Hence, the ethical considerations were followed throughout the research process and the rights of participants as well as their privacy was protected. The researcher was granted permission after sending letters requesting permission to conduct the study and outlining the purpose of the study from the following part or people namely, UNISA College of Education research ethics, Limpopo Department of Education (LDE), circuit manager, teachers and parents (SGB). The researcher assured participants i.e. teachers, parents and learners that the names of the schools and theirs will remain anonymous and confidential. The researcher also seek assistance from a university student who was not part of the main study and the name of the university and her name was not mentioned in this study for confidentiality purposes. Hence, the names of schools and participants that appeared in this study are pseudonyms and all data that were gathered were accessible to the researcher and supervisor only. The participants were informed that participation in this study was voluntary. Moreover, learners who participated and they were under the age of 18 were given a consent form to ask permission from their parents for them to take part in the study. However, learners were also given the choice to rescind from participating in the study even though their parents had signed the consent form on their behalf.

4.13. Summary

In this chapter, the researcher presented methodology and design applicable to the study. The issue of validity to guarantee quality and trustworthiness was explored. The data collection methods include interviews, observation and diary were also discussed under this chapter. Finally, the issues of ethics were discussed. In the next chapter, the researcher presented the data presentation and analysis of findings obtained during the process of development of TPSSR.

CHAPTER 5:
DEVELOPMENT OF TSHIVENḒA PHYSICAL SCIENCES SCIENTIFIC REGISTER

5.1. Introduction

The current study developed TPSSR to teach and learn PS in the Grade 10 classroom. The research was intended to explore the use of developed TPSSR during classroom practices of PS teachers with Grade 10 learners. Hence, the research questions guided this study are as follows:

- ❖ What are the challenges and opportunities in the development of TPSSR for teaching and learning of PS?
- ❖ What are the challenges and opportunities in the use of the TPSSR for the teaching and learning of PS?
- ❖ How does the use of TPSSR in the teaching and learning of PS influence interaction and discourse?
- ❖ What are the views and perceptions of PS teachers, parents, and learners towards the use of the TPSSR for PS?

However, the data gathered and findings that will be presented in this section will be focusing on the following three research questions:

- ❖ What are the challenges and opportunities in the development of TPSSR for teaching and learning of PS?
- ❖ What are the challenges and opportunities in the use of TPSSR for the teaching and learning of PS?
- ❖ What are the views and perceptions of PS teachers, parents, and learners towards the use of TPSSR for PS?

Consequently, in this chapter the researcher explored the opportunities and challenges in the route of developing the TPSSR and its use in the teaching and learning of PS in Grade 10 class as well as gaining an insight on participants (i.e. teachers, parents and learners) views and perceptions towards the use of the TPSSR.

5.2. The route of the development of TPSSR

This section presents and discussed data collected through diary and the finding of the study. Hence, this section will focus on the research question that follows:

- What are the challenges and opportunities in the development of TPSSR for teaching and learning of PS?

However, this section will present and discussed data of first theme, which is the development of TPSSR.

5.2.1. Theme one: Development of TPSSR

The aim of the first theme was to report some of the challenges and opportunities the researcher diagnosed in the process of the developed TPSSR (Appendix S, page 251). Table 6 shows first theme which consist of its category and characteristics.

Table 6: Development of TPSSR

Theme	**Category**	**Characteristics**
Development of TPSSR	**Development**	Challenges
		opportunities

5.2.2. Data presentation and discussion of results applicable to theme one

Tshivenḓa language is one of the official languages that is learnt in some schools in the Limpopo Province and other provinces of South Africa. As the researcher stipulated in the previous chapter, during the process of developing TPSSR (Appendix S), she experienced some challenges of deciding which resources to use as the reference. The researcher had a meeting with PS teacher whom she thought could be of assistant regarding the issue, as reported next by the researcher:

> *"Before the researcher begun with the process of developing Tshivenḓa physical sciences scientific register, she had a meeting with physical sciences teacher. During the meeting the researcher informed the teacher about her research of developing and using Tshivenḓa physical sciences scientific register for physical sciences. Hence, the researcher needs to be*

assisted with the selection of resources to use as reference in the process of developing Tshivenḓa physical sciences scientific register. The physical sciences teacher indicated that the topic would come with some challenges as science is broad and some of the terms or words used in science are difficult to find in Tshivenḓa. The teacher also reported that some words seem to not exist in Tshivenḓa or have different meaning. Lastly, the teacher suggested the resources, for example textbooks the researcher should consult while developing the register which were self-explanatory."

From what was pointed out from the preceding description mentioned, it shows that Tshivenḓa is still underdeveloped in education system. Madiba (1994) reports that science is full of concepts which have no equivalents in Tshivenḓa. Madiba (1994) further maintains that words from foreign languages which have no equivalents in Tshivenḓa are very often adopted into the language, for example saintsi (science), pharafeni (paraffin), fanele (funnel) etc.

The researcher approached a student from anonymous university who came at researcher workstation to do her Tshivenḓa teaching practice. The student approached was not only a student from a university which cannot be mentioned for confidentiality purposes but also work at the same university to compile dictionaries. By the time the researcher was experiencing challenges in finding some scientific words in Tshivenḓa, researcher explained the challenge she was experiencing, and the student from anonymous university offered to help as reported by the researcher in the following statement:

"When the researcher was in the process of developing Tshivenḓa physical sciences scientific register she met a student from anonymous university who also work at the same university to compile dictionaries. The researcher explained her study and the challenge she was experiencing of not able to find some equivalent scientific words in Tshivenḓa such as microscope, syringe, ice, crystal, freezing point, oxygen, volume, diffusion, thermometer, carbon dioxide, vapour, temperature, copper, nitrogen, sublimation, energy, latent, transition,

evaporation, condensation, petrol, beaker, vertical axis, horizontal axis. The student said she will give the researcher Tshivenḓa-English dictionary and some term list documents she thought could be of assistant to the researcher in her development of Tshivenḓa physical sciences scientific register."

The researcher was given Tshivenḓa-English dictionary and the term list documents written in different languages which was sent to the researcher through email. The documents sent to researcher through email includes terminologies written in Tshivenḓa, Afrikaans, Xitsonga and English which researcher was advised to consult while developing TPSSR. The provided Tshivenḓa-English dictionary did assist the researcher since there were few words relevant to what the researcher needs in her development of TPSSR. Hence, the terminology list document did also assist as some of the information related to researcher appeared in the document (See the following researcher reporting statement):

"Beside the researcher being provided with Tshivenḓa-English dictionary by the student who works at anonymous university, the documents with list of terminology was sent to the researcher through email. The dictionary did assist with few words which were relevant to the research. The researcher also went through the sent document and it was useful as some of the information appeared in the document was related to what the researcher was doing."

As the researcher was busy developing TPSSR, she experiences difficulties in developing words like diffusion, thermometer, carbon dioxide in Tshivenḓa. Hence, there was a there was a three days workshops which was conducted with PS teachers from different circuits that cannot be mentioned for confidentiality purposes. The researcher saw the workshop as an opportunity for her to be assisted by other PS teachers to develop Tshivenḓa scientific words or assisted with equivalent scientific words or terms in Tshivenḓa. The researcher then approached different PS teachers from anonymous circuits whom she knew. See researcher reporting on the following statement:

> *"While the researcher was currently busy with the process of developing the Tshivenḓa physical sciences scientific register there were scientific words which she was failing to come up with their meaning in Tshivenḓa. There was a three days' physical sciences workshops which was conducted with physical sciences teachers and the researcher sees such workshop as an opportunity for her to ask for assisted with the development or equivalent scientific terms in Tshivenḓa. However, almost all the teachers approached gave similar response of not knowing the words the researcher wanted assistant with. Only two teachers gave some suggestions on other terms, and they advise the researcher to consult Tshivenḓa teachers whom she knew about the words they suggested if they were true or equivalent."*

While the researcher was still having some difficulties in finding some scientific words in Tshivenḓa, one of my family members gave me contact of someone who works at anonymous science foundation. The researcher did phone the person and explained the kind of work she needs to be assisted with and a document with words that the researcher need to be assisted with was sent to the person after she offered to assist. The researcher phoned the person few days later and the person admitted that she will no longer assist as it indicated next by the report from the researcher:

> *"After all the efforts the researcher made in contacting the person suggested by one member of her family who was thought could be of assistance. The person was contacted by the researcher and the document with words that the researcher needs to be assisted with was sent to the person as she promises to assist. However, few day later the researcher contacted the person to find out about the progress made on the document sent and the person admit that she could no longer assist due to personal challenges."*

Since the researcher was still experiencing challenges of not being assisted with some scientific terms in Tshivenḓa in such a way that she was satisfied, she then approached senior citizens or pensioners who resides in her village. The researcher explained her study to them and the assistance she required from them. The researcher needs to be assisted with the development of some Tshivenḓa scientific words or those which could be relevant (See researcher reporting on the following statement):

> *"The researcher visited some senior citizens or pensioners in her village who were Tshivenḓa speaking people. They were asked about words they could use to explain the words such as oxygen, energy and other words. Their responses were that oxygen is the air that we inhale. Hence, oxygen is equivalent to muya mufhe. Energy can be called Fulufulu in Tshivenḓa. Additionally, some of the scientific words meaning can be constructed depending on the statements the researcher wants to employ such words. All the terms suggested by senior citizens were verified with Tshivenḓa teachers and supervisor."*

Beside all the predicament the researcher experienced in her route of developing TPSSR, there were some opportunities which supported and encouraged the researcher to proceed with the study. The researcher was given Tshivenḓa-English dictionary as well as multilingual natural sciences and technology term list written in English, Afrikaans, Tshivenḓa and Xitsonga. Hence, this revealed the efforts made in terms of developing scientific terms in indigenous languages. The documents provided assisted the researcher even though there were few scientific words available in Tshivenḓa. However, most of the developed words were borrowed from English and Afrikaans and adapted to Tshivenḓa (Mafela, 2012). The researcher was able to develop some scientific words in Tshivenḓa based on the statement used as advised by senior citizens.

After the development of TPSSR (Appendix S), the researcher had a meeting with her supervisor for a discussion, as reported next by the researcher:

> *"After the researcher finalised the developed TPSSR she had a meeting with her promoter which was held through teams. During the meeting the promoter noted some words like esidi, lathenthi, haiphothesisi,*

thiransishini presented in the register which he thought were not appropriate and suggested that such words need to be revised and reformed. In conclusion of the register discussion few words were developed and modified. The following words were modified: esidi – dungi; lathenthi- Dzumbama; haiphothesisi-khumbulelo; thiransishini-Tshanduko."

Even though there were limited scientific terms in Tshivenḓa, the preceding statement demonstrates that it is possible to develop equivalent scientific terms in Tshivenḓa. Additionally, direct translations and, borrowings terms from other language can also assist in developing scientific terms for Tshivenḓa language. Hence, some Tshivenḓa scientific terms were borrowed from English and Afrikaans. Though the progress of development of Tshivenḓa is slow, there is availability of some of published literatures in Tshivenḓa language which are in the form of folklores, dramas, novels, poems and short stories which are taught in both primary and secondary schools. However, when it comes to availability of material, they are not available and that affects the use of Tshivenḓa negatively as people are replacing it with other languages which have what they need (Luvhengo, 2012).

5.2.3. Theme one Findings

The study findings reveal that developing TPSSR (Appendix S, page 259) for teaching and learning is not easy as Tshivenḓa is an indigenous language which is still in the process of developing. Hence, Tshivenḓa has limited scientific terms. Most of the scientific terms available in Tshivenḓa are translated and borrowed from English and Afrikaans. Therefore, teamwork is required to develop sufficient terms for this language (Tshivenḓa) to be developed and not only be recognised as an official language but also as a language of teaching and learning at schools and in institutions offering higher education. Additionally, availability of literature books and multilingual natural sciences and technology term list does promise that eventually Tshivenḓa will be well developed like Afrikaans and English.

5.3. Theme two: Perceptions of participants toward the application of TPSSR

This section presented views and perceptions of a teacher, learners and parents obtained through interviews. This section focused on two research questions which are:

- ❖ What are the challenges and opportunities in the use of TPSSR for the teaching and learning of PS?
- ❖ What are the views and perceptions of PS teachers, parents, and learners towards the use of TPSSR?

The application of register consists of the following categories, namely, areas of difficulties and the opportunities. The aforementioned categories comprise of variety of characteristics as presented in the Table 7.

Table 7: Participants perceptions on the application of TPSSR

Theme	**Category**	**Characteristics**
Perceptions of participants toward the application of TPSSR	**Areas of difficulties**	Teacher perception
		Learner perception
		Parent perception
	Opportunities	Teacher perception
		Learner perception
		Parent perception

5.3.1. Case one: Dominance secondary school

5.3.1.1. Data presentation and discussion

The Department of Basic Education (DBE) (2010) and SASA (1996) stipulated that the decision about the language policy of the schools is upon the shoulders of the SGB and such language policy should be constructed as reported in SASA and the Constitution of South Africa (1996). However, Brock-Utne (2014) asserts that in South Africa learners are receiving their education through English as the medium of instruction and that indicates that African language policy is not implemented. While the researcher was producing the TPSSR (Appendix S, page

251), she desired to know the views and perceptions of participants i.e. teachers, learners, and parents on the use of TPSSR to teach PS. Thakhani indicated that:

> *"Ndi vhona u shumisiwa ha TPSSR yo nwalwaho nga luambo lwa vhana lwa damuni zwi tshi do lelutshela vhagudiswa uri vha fare zwine vha dovha vha khou funziwa (I think the use of use of Tshivenḓa physical sciences scientific register mother tongue will enable learners to grasp what they will be taught much easier). Zwi ḓo ri lelutshela na rine sa vhadededzi ngauri vhana musi ri tshi khou funza nga luambo lwa luisimane avha khou tou zwipfesesa zwavhuḓi sa musi husi luambo lwavho lwa ḓamuni (It will also be easier for us teachers because when learners are taught in English language they don't understand well since the language used is not their own)." School 1 Teacher Thakhani*

According to the aboved-mentioned statement, the teacher articulates his views which is supporting the use of TPSSR to teach PS. This proves that English is still used as language of teaching and learning in some South African schools for African learners, which can cause poor performance to learners whose home language is not English. The language of instruction which is English is a barrier to effective learning and teaching, especially to the conceptualisation of the intricate science concepts that calls for the mastery of the LoTL (Koti, 2016). From the teacher's perspective, learners learn and understand what they are being taught better when their mother tongue is employed. Furthermore, Botha (2022) asserts that the application of mother tongue as LoTL will assist learners to be active participants of their learning experiences in their classroom. Koti's (2016) findings resonate with the findings of this study as reported by Thakhani during his interview with the researcher:

> *"Ndi a tangana ha thaidzo musi ndi khou funza vhana nga Luisimane ngauri Vhunzhi ha vhana avha pfesesi zwine zwa vha zwi tshi khou funziwa (I experience a problem while teaching learners through English instruction because most learners do not understand what they are taught.)'' school 1 Teacher Thakhani*

The teacher also revealed the influence of English language used in the teaching and learning of PS in learner performance. The following verbatim quotation confirms this analysis:

> *"Ndi vhona unga luambo lune lwa khou shumisiwa lu khou shela mulenzhe kha zwine vhana vha khou shumisa zwone ngauri arali vhana vha si khou kona u pfesesa fhungo nga luisimane naho zwo talutshedziwa nga ndila dzo fhambananaho a si divhe uri zwiamba mini ndi mafhungo ano tatisa ngauri zwido ita uri asi kone tshithu (I think the language used did play a role in how learners are performing because if learners are failing to understand something in English even though various explanation was done and not understand what it means it is scary which will resulted in her/him knowing nothing). Mara musi huna Tshivenḓa naho a zwi vhala na nga tshikhuwa a zwinga tuwi ngauri udo zwidivha nga nyambo dzothe hedzi mbili (But if Tshivenḓa is also there, even though he or she read in English he or she will never forget as he or she will be understanding in both languages)." School 1 Teacher Thakhani*

According to Madima and Makananise (2020), some learners experience challenges of understanding and using English instruction in communication and discourses. According to Setati and Adler (2000), code-switching and transliteration practices are common in some of South African classrooms setting as both learners and teachers employ code switching to facilitate communication and interaction among themselves. Thakhani also reported on the languages he used while he taught his learners PS as indicated in the following statement:

> *"Ndi shumisa tshikhuwa nda dovha nda shumisa na Tshivenḓa hu u iteala uri vhana vhakone uzwi pfesesa zwavhuḓi(I use English and again employ Tshivenḓa so that the learners will understand). kha maipfi a tshikhuwa ane nwana ha khou a divha ndi toda la Tshivenḓa uri nwana a kone u pfesesa (The English words that a learner doesn't know I use Tshivenḓa words which are similar to those English words.)'' school 1 Teacher Thakhani*

According to Botha (2022), learners who use the language they use at their home in their educational settings do enjoy positive learning experiences, especially if they use the language as a LoTL. Additionally, researchers like Rollnick and Rutherford (1996) and Setati (1998) revealed that some of non-English learners who appear to be experiencing difficulties with science concepts manage to do well if provided with an opportunity to engage in their home language. This is confirmed by learners' responses to their perceptions:

> *"Ndi vhona u guda nga luambo lwa hayani zwi zwavhuḓi samusi ri tshi pfesesa vhukhwine u gudisiwa nga luambo lune ndi lwa damuni ufhirisa u funziwa nga luambo lune ari lu pfesesi zwavhuḓi (I think through home language is a good thing since we understand better when taught in language which is our mother tongue than being taught with a language that we don't understand well.)" school 1 group 1 L1*

> *"Ndi vhona u guda nga luambo lwa hayani zwi zwavhuḓi uri ri kone u pfesesa husina vhuleme (I think learning through mother tongue is a good thing so that we can understand without difficulties.)" school 1 group 1 L2*

Baker (2011) and Van Laere, Aesaert and van Braak (2014) assert that the language used at home which is different from the language used as medium of instruction (English) at schools is one of the key factors which is associated with learners' achievement gap in their school subjects. This is confirmed by learners' responses to their perceptions on their difficulties in learning through English instruction. They responded as follows:

> *"U sa pfesesa ha manwe maipfi na u salela murahu. Zwo vhangiwa ngauri a thi dzuleli u amba ngalo (not understanding other words and being behind on the content. Which resulted because I don't always use the language when I speak.)''school 1 group 2 L1*

> *"u sa divha zwinwe zwa zwithu zwine zwa khou ambiwa na u balelwa u talutshedza zwi tshi khou vhangiwa ngauri huna manwe maipfi a Luisimane ane a shumisiwa a songo doweleaho (I don't know some of the*

things that is being talked about and fail to explain which is caused because there are other words used in English that I am not familiar with.)'' school 1 group 2 L2

The learners further noted the language they would prefer to learn PS. Their responses are captured as follows:

"Tshivenḓa ngauri ria tavhanya u pfesesa musi vha tshi ri funza (Tshivenḓa, because we understand fast when taught with it)". school 1 group 2 L2
"Tshivenḓa ngauri ndia kona u pfesesa zwine ndisi zwi pfesese nga tshikhuwa (Tshivenḓa because I can understand what I am failing to understand in English.)" school 1 group 2 L3

From the aforementioned statement, it is clear that these learners are more comfortable with Tshivenḓa being used to teach PS based on the fact that it is the language they mostly used at their homes, and they understand it better than English.

Despite the difficulties and disadvantages medium of instruction poses in learners receiving better education, there are some learners who prefer to use English in receiving their school education. Some of the learners prefer English as a medium of instruction to be able to understand curriculum subjects concepts and they think English can benefit them since English is a language that is mainly used in higher education and also being of necessary for most types of future employment. The following responses summarise the learners' responses:

"Luisimane ngauri maipfi a hone manzhi a khwine kha a Tshivenḓa (English because many English words are better than Venda words.)"
"Luisimane, ngauri ndi a lu takalela lwadovha hafhu lwa vha luambo lune lu shumisiwa fhethu hunzhi (English, because is the language I like and is the language used in many places.)" school 1 group 3 L1

"Luisimane ngauri ndi luambo lune ndia kona u pfesesa maipfi a santsi vhu khwine (English because is a language that I am able to understand science words better.)" school 1 group 3 L2

Most parents prefer English as LoTL because they see it as a gateway to better education and empowerment (De Wet, 2002). Regardless of the impact, African parents still encourage the use of English language in the teaching and learning in schools. This is how parents responded when asked which language they would like their children to learn:

"Ndi ngauri heyo ndiyone amba dzifhele kha luambo ri tshida kha ha mishumo ngauri fhethu hunzhi huvha hu khou shumisiwa Luisimane (It is because that is the best language when it comes to employment because English, it is used in many places.)" school 1 parent 1

"Ndi English ngauri nne zwavhuḓi vhudi ndi toda uri avhe nau konana na vhanwe vhasi vha tshakha dzawe vhakone u andana (It is English because I want a child to interact with others different to the language the child is using). ndi ngauri huna manwe maipfi ane avha a khou ambiwa nga tshikhuwa ngeno vha tshi vho a isa kha Tshivenḓa vha wana maipfi ahone a si tsha tou dzudzana zwavhuḓi, vhana vhasitsha kona uzwi talukanya (It is because there are other words that are being talked about in English when you translate it to Tshivenḓa you find that are not appropriate.)" school parent 2

From the preceding assertions, there are parents who do not promote the use of indigenous languages to teach PS. Therefore, it is a reality that the preference of English as LoTL demoralises the policy of government to endorse equal opportunities of all languages granted official status in South Africa (Chaka, 1997).

"Eish hai I ngasi tende, I ngasi tende ngauri mini na khaedu u dovha ya mini na u tshiya kha dzinwe dzi tshakha u fan ana nnda ha south Africa ngauri luambo lune lwa khou shumisiwa nga maanda ndi English (Eish no,

it will not work, it will not work because of what, there would be a challenge when you will be visiting out of south Africa because the language mostly use is English.)" school 1 parent 3

The parent indicated that he would prefer his child to learn PS in English. Irrespective of the status and benefits that come with using English as a medium of instruction, some parents still feel it is not the preferred medium of instruction as indicated next:

"Tshivenḓa.Ngauri zwi lelutshela vhabebi uri vha kone u thusa vhana vha vho nga dzi tshunwahaya(Tshivenḓa because it will be easier for parents to be able to assist their learners with homework.)" school 1 parent 4

The above responses shed light that they are people who do acknowledge the benefits that come with English as a medium of instruction. But the use of indigenous language as a medium of instruction could bear much success as these learners will be learning in the language which they understand better and they could perform better. Moreover, preferences of mother tongue will also enable to understand concepts of other subjects more easily, but also enables parents to help with homework, take part in parent meetings, and communicate with teachers in a language in which they are comfortable (Nikki, 2017).

5.3.1.2. Findings of participants perceptions of Dominance secondary school

Teacher's perceptions

This study reveals that Thakhani has a positive perception of the application of TPSSR in the learning and teaching of PS. He had diagnosed the benefits resulted with the use of TPSSR in the learning and teaching of PS. Thakhani also reported that English as medium of instruction causes hindrance in learners' performance. Thakhani also discovered that the use of register that was written in learners home language assisted learners in learning the ideas of science easier compared to when English is used as LoLT. Consequently, Thakhani also used of code switching though it is not in the language policy of education but as a teacher he felt compelled to switch to home language (i.e. Tshivenḓa) to explain concepts in PS because some learners will just sit and look at him as an indication that they do not understand.

Learners' perceptions

This study also reported different perceptions apprehended by learners. Learners in this case shared different perceptions about the usage of TPSSR in the learning and teaching of physical Sciences. Some pupils reveal that using Tshivenḓa will disadvantage them as they are words, they are not good at in their mother tongue and, further to that, it is their parents' wishes for them to receive their education through English instruction. These learners also outline that they do not clearly understand when they are being taught in English and that was delaying their progress, but still prefer it. This reflected the influence and pressure they got from people around them. Contrary to what they claimed, some saw the use of Tshivenḓa in the learning and teaching of physical Sciences as a better route for them to understand the subject physical science better compare when learn it through English instruction. They also indicated how the use of English is hindering their learning in terms of their performance.

Parents perceptions

Not all parents' perceptions on the use of Tshivenḓa to teach and learn PS similar from those of learners. This study reveals that parents have different perceptions on how their learners should use which language to receive their education. Hence, there are parent who prefer the use of English as a language of teaching and learning whereas other are against that as they prefer the use of mother tongue instruction. Some think the use of mother tongue will disadvantage their learners as they won't be able to communicate well with people who their home language is different to theirs whereas other parents think the use of mother tongue will enable their learners to understand what their taught without difficulties. However, this point the pictures that parents know what best to their children even though they know how their learners are struggling in learning through language which is not of their own. Hence, this was diagnosed during parents-researcher interviews. There are parents who are in support of the use of mother tongue in the teaching and learning. Their views and perceptions were strongly based on the fact that their children are good in Tshivenḓa since it is the language of their own and they will perform to the best of their ability as they understand Tshivenḓa. These parents further noted that the use of Tshivenḓa will give them the opportunity to support their children with their school activities as the use of English is limiting them to be involve in their children education.

5.3.2. Case Two: Obtainable secondary school

5.3.2.1. Data presentation and discussion

Constitution of the RSA (1996) stipulated that every learner has a right to receive education in any of the official languages in public schools. However, Botha (2022) reported that even though the choice to learn through mother tongue is being offered, there are still multiple cases where learners are not being educated in their mother tongue. According to the Constitution of RSA (1996), SASA (1996); and Nikki (2007) the SGBs are expected to encourage the best interests of the community in which the school is located, and it has the power to determine language policy but such school policy must therefore limited by what was stipulated in the Constitution of South Africa and SASA. Nevertheless, this is still a paper policy in primary and secondary schools of South African as Tshotsho (2013) reported that the government of South African has not delivered the human resources and physical resources required to promote mother tongue education and English still has a greater status when compared to other indigenous languages in South Africa. In this study, the researcher desired to know the views and perceptions of participants on the use of TPSSR in the teaching and learning of PS. Teacher Takalani indicated that:

> *"Ndi vhona u funza nga TPSSR yo nwalwaho nga luambo lwa damuni (Tshivenḓa) i tshi ngavha inwe thandululo ya kha u divha science nga luambo lwa hayani (I think teaching using TPSSR written in mother tongue can be a solution of knowing science in home language.)" school 2 Teacher Takalani*

According to the aboved-mentioned statement, the teacher articulates is in support of the use of Tshivenḓa to teach PS. This proves that English is used as instruction in south African schools for African learners, which can disadvantage learners who their own language is not English. Taylor and Prinsloo (2005) identified language of instruction as the main factor affecting learners' performance at school. From the teacher's perspective, learners learn and understand what they are being taught better when their mother tongue is used. Furthermore, According to Nyaungwa (2013), children have more vocabulary in their home languages than English. Oyoo (2012) asserts that language is important in all the activities which have to do with the effective teaching and learning of science. Goldenberg (2008) on science achievement point out that learners whose their mother tongue is not the same with the language used as medium of instruction are facing double challenge, that of acquiring academic knowledge and skills through a decontextualized school language and they must do this through a language that they have often not yet fully mastered. What reported by Goldenberg (2008) supported by what Takalani reported during his interview with the researcher:

> *"Khaedu ndi ya uri vhana vhanzhi avha divhi Luisimane zwine zwa ita uri vhavhe na vhukondi zwitshida khau divha language ya science (The challenge is that majority of learners know English, but they don't know the language of science)'' school 2 Teacher Takalani*

The teacher also revealed that the language used in the learning and teaching PS does has an influence in learner performance (see the following interview transcript).

> "*ndi khou tikedza u shumisiwa ha rigisitara heyi ya Tshivenda ya saintsi nga nthani hauri ndo ri ndo vhafha mushumo wau nwala hafhala kha classwork ye vha nwala ya Tshivenḓa ndi tshi khou compare na ya English, Kha Tshivenḓa vho performer lwe vhanzhi vho wana dzothe mara kha English zwovha zwikhou konda (I am supporting the use of Tshivenḓa scientific register because I gave then classwork in Tshivenḓa and they perform better when I compare to the English classwork, most of the learners obtained total in PS when Tshivenḓa was used, but it was difficult in English classwork)" school 2 Teacher Takalani*

Msimanga and Lelliott (2014) report that ESL learners experience a dual task in the learning environment, which is that of learning English as a medium of instruction while simultaneously having to employ the same language which they are still not proficient in to learn science concepts. Hence, it is not surprising that ESL learners run a greater risk of under achievement in their school education (Sierens & Van Avermaet, 2010). This is how the one learner from one group responded when asked about their experience in learning through language which is not their own:

> *“English ina manwe maipfi ane a khou buliwa avha a tshi khou konda a tshi khou kundela na vhanwe, avha a vhuleme kha vhanwe. zwino musi ri tshi khou funziwa nga luambo lwa damuni na hetshila tshifhinga vha tshi khou ri funza nga Tshivenḓa ho vha hu na zwithu zwine ra khou kona uzwipfesesa zwine nga tshikhuwa ro vha ri sa khou zwipfesesa (English had some words which are difficult to pronounce to me and other learners. But when we are being taught in our mother tongue, even that time when our teacher was teaching us using Tshivenḓa there was something that we were understanding that we were not understanding in English)” school 2 group 1 L1*

Hlabane (2014) indicated that the lack of English proficiency results to poor learners’ academic performance. Hlabane (2014) further reported that learners need to comprehend the concepts of the subject so that they can use them when solving problems. Rollnick and Rutherford (1996) point out that the usage of learners’ home language during classroom practice is a powerful means of getting learners to express their thought on the content taught. Furthermore, without the use of code-switching during teacher classroom practices will results in some learners developing alternative conceptions that could remain unexposed (Rollnick & Rutherford, 1996). Takalani also reported the language he used while he teaches his learners PS as indicated in the statement below:

> *“Ndi ngauri ndi fanela u explainer nga English ndi dovhe ndi talutshedze nga Tshivenḓa, ndi nekedze vhana na dzi tsumbo dza uri ri khou amba ngaha mini (Because I have to explain in English and again in Tshivenḓa, I also give learners examples that shows what we are talking about).” school 2 Teacher Takalani*

According to Botha (2022), it would be ideal if learners were to be educated in their home language since the processing of knowledge is easier in the home language. Moreover, Nyaungwa (2013) asserts that it is the right of learners to be taught in a language they are fluent in, familiar with, effectively endowed in and fully understand. Hence, scientific evidence advocated that teaching learners through their mother tongue affirms their identity and is a good foundation for their intellectual development and economic development (Chirinda, 2011). This is confirmed by learners' responses to their perceptions as follows:

> *Ndi vhona u guda nga luambo lwa hayani zwi zwavhuḓi samusi ri tshi pfesesa vhukhwine u gudisiwa nga luambo lune ndi lwa damuni ufhirisa u funziwa nga luambo lune ari lu pfesesi zwavhuḓi.(To be taught in our home language is a good thing because we understand better unlike being taught in a language that we don't understand well.) school 2 group 2 L1*

> *Ndi vhona u guda nga luambo lwa hayani zwi zwavhuḓi uri ri kone u pfesesa husina vhuleme(I think being taught in our home language is a good thing so that we can understand without difficulties). school 2 group L2*

Smith (2010) posits that learners who are not using the language they are familiar with while learning, basically their home language, are disadvantaged and unlikely to perform to their best of their abilities.

> *"ndi ngauri tshikhuwa a si luambo lwa damuni maipfi a tshikhuwa manzhi ana vhuleme namusi a tshi buliwa uri ana vhuleme namusi vha tshi khou amba huna maipfi ane avha olapfa manwe avha e mapfufhi mara uri ri kone u a bula zwivha zwi tshi khou konda uya nga mupeleto wao (English is not our mother tongue. Many English words are difficult to pronounce, there are long and short words in English but for us to speak those words is not easy)." school 2 group 3 L1*

The learners further noted the language they would prefer to learn physical Sciences. Their responses are captured as follows:

> *"ndi ngauri Tshivenḓa ndi tshone tshine ra tshi pfesa ufhira luambo lwa tshiisimane (Tshivenḓa is a language that we understand than English language)" school 2 group 3 L2*

> *"ngauri Tshivenḓa ndi luambo lwa damuni ndi lone lune lune ra luamba duvha na duvha ufhirisa English (Tshivenḓa is our mother tongue and is a language that we use daily than English)." school 2 group 1 L2*

From the above, these learners are more comfortable with Tshivenḓa being used to teach PS based on the fact that it is their mother tongue, and they understand it better than English.

Despite the challenges and difficulties that the English medium of instruction poses for African learners, it remains the preferred language of teaching and learning at south African schools. A study conducted by Tshotsho (2013) reported that some of black South African have chosen English as language of instruction at school and by so doing they demoralizes the survival of African indigenous languages and reduces chances of African indigenous language like Tshivenḓa as an alternative language of instruction at schools. Therefore, it is a reality that the preferred of English demoralizes the policy of government to indorse equal opportunities of all languages granted official status in South Africa (Chaka, 1997). See the following comments:

> *"Luisimane, ngauri nga Luisimane zwine ravha ri khou funziwa zwivha zwi songo lapfesa nauri ria kona uzwi pfesesa (English because what we are taught in English is not that long and we are able to understand)." school 2 group 4 L1*

> *"Luisimane, ngauri ndi lone rolu dowelesa kha u funziwa na u guda physical science (English, because is the language we are used to be taught and learnt PS)." school 2 group 4 L2*

The shift from home language to English instruction seems to be a problem to majority of learners. Fleisch (2008) accentuates that in most schools where learners in their early schooling employed mother tongue and in making the transition to English instruction, they seem to experience difficulties connected with the change of language medium. Regardless of the impact, African parents still promote the use of English as a medium of instruction in schools. They responded as follows:

> *"ndinga nthani hauri manwe maipfi tshinwe tshifhinga ri tshi a isa kha Tshivenḓa aya konda u a pfesesa nauri ndi luambo lune lwa shumisiwa hothe hothe Luisimane (Some of English words when we translate them to Tshivenḓa are difficult to understand and English is the language that is used everywhere)." school 2 parent 1*

> *"ndi ngauri hune nwana u tea ubva kana uya hunwe madaloni, wa wana hunwe a tshikhou tangana na vhanwe vhane avha shumisi luambo lwawe lwa damuni (It is because a child sometimes must visit other places and you will find that the child will meet other people that do not use the same language like hers)." school 2 parent 2*

From the above, parents do not promote the use of indigenous languages to teach PS because English has a greater status in further education and in the job market, learners whose medium of instruction is not English their parents will often select English as their first additional language (Nikki, 2017). A study conducted by Tshotsho (2013) reported that some of black South African have chosen English as language of instruction at school and by so doing they demoralizes the survival of African indigenous languages and reduces chances of African indigenous language like Tshivenḓa as an alternative language of instruction at schools. This is how the parent responded when asked if they will support the use of Tshivenḓa in the teaching and learning of another curriculum subject:

“Tshivenḓa utou guda Tshivenḓa sa luambo lwa damuni fhedzi, hedzi dzinwe a funziwe nga Luisimane (A child can learn Tshivenḓa as home language, but other subjects she must use English).” school 2 parent 3

The foregoing statement indicates that the participant is aware of the benefit of learning home language at schools. Hence, De Wet (2002) reported that most of the parents choose English as the LoTL because they see it as a gateway for better education and empowerment. This is confirmed by Maluleke (2019) when asserting that some of the parents consider English as a language which is superior to any other languages because it allows people with opportunities that they would not have otherwise. The President of the Republic of South Africa Mr Cyril Ramaphosa dispelled such a perception Tuesday, 24 September 2019 at the national Heritage Day celebrations that was held at the Mxolisi Jacobs Stadium in Upington, Northern Cape, the President of the Republic of South Africa Mr Cyril Ramaphosa stipulated that South Africans should embrace their indigenous languages. He further indicated that South Africans should learn their languages in order to understand their identities. ‘’No language in South Africa is superior to another and every single language spoken in this country has equal value and equal worth’’, said the president Cyril Ramaphosa. This means that all languages are equally good and effective in communication, none is superior, and none is inferior.

Irrespective of the status and benefits that come with using English as a medium of instruction, some parents still feel it is not the preferred medium of instruction. See the following quotation:

“Na zwezwo zwau shumisa Tshivenḓa zwiavha zwi zwavhudi uri nwana a kone u pfesesa tshothe zwine a khou funziwa na u guda zwavhuḓi. ndi lone lune alu pfesesa ufhira nyambo dzothe (I think the use of Tshivenḓa is a good thing so that a child can understand everything that the teacher will be teaching. Tshivenda is the language that the child understands than other languages).” school 2 parent 4

“ndi ngauri tshikhuwa tshi khou ri bala u talukanya manwe a maipfi. ndi ngauri tshikhuwa tshi khou ri balela u tshi pfesesa (We are failing to understand other English words. We are failing to understand English). school 2 parent 5

They further alluded to the impact that English has as compared to Tshivenḓa in the teaching of PS. They expressed themselves as follows:

“hai, nwana ha lupfesesi nga maanda luisimane.ndi ngauri asi lwa damuni. u khou shuma mara hatu shuma zwavhuḓi. ndi ngauri zwi khou bala kha vhana u pfesesa luambo lwa Luisimane (No, a child doesn’t understand English very well because is not the child mother tongue. The child is not performing well through English medium of instruction. Because it is difficult for learners to understand English language).” school 2 parent 4

Parents were also asked in which language they would like their children to be taught PS, one parent stated:

“English, ngauri vha ya lu pfesesa ndi khou vhona vha khou performer zwavhuḓi nau kona u pfesesa (English because they understand it and they are performing well).” school 2 parent 1

The foregoing responses shed light that they do acknowledge the benefits that come with English as a medium of instruction. But the use of indigenous language as a medium of instruction could bear much success as these learners will be learning in the language which they understand better, and they could perform better, as alluded to by researchers such as (Adedemowo, 2017). These parents share the same sentiment with political commentators such as Dr Somadoda Fikeni, traditionalists such as Zolani Mkiva, and Historian and Cultural Analyst Professor Pitika Ntuli, who affirms that learning in the mother tongue improves a learner’s performance. Traditionalist Zolani Mkiva, the General Secretary of the Congress of Traditional Leaders of South Africa (CONTRALESA), is also in support of the use of indigenous languages as a medium of instruction. He believes that indigenous wisdom should be incorporated into the curriculum so that it is not lost over time (Ngobeni, 2020). He maintains that the intellect of people is better tested when they use their mother tongue because it takes longer for one to learn a foreign language, and he noted that better results will be achieved across the board if learners are taught in their home languages.

5.3.2.2. Findings of participants perceptions of Obtainable secondary school

Teachers perceptions

The findings of this study reveal that Takalani has a positive perception of the use of TPSSR in the teaching and learning of PS. However, she acknowledges that learners do not understand the English instruction of science and he supports the use of TPSSR. Takalani also highlighted that English is a barrier to African learners as they do not know English. He reported that to minimise learners' difficulties in learning PS through English instruction he uses both English and Tshivenḓa in his teaching chich this referred to as code switching. The teacher felt he is compelled to so that learners could understand the ideas of the lessons.

Learners perceptions

Learners perceived the use of TPSSR as a great opportunity to learn the ideas of science. Their perceptions were positive because they reported the difficulties they experienced in learning through English instruction. They indicated that there are words which are difficult to read, write and understand. Furthermore, they also mentioned the difficulties of failing to ask questions. From the challenges they reported about the use of English instruction, they are in support of Tshivenḓa language as they think it will be easier to them to understand science better compared to English instruction.

Parents perceptions

The findings of this study reveal that not all parents are in support of using TPSSR. Some parents prefer English instruction because not all words can be found in Tshivenḓa. Whereas some parents think learning through language learners, mostly use at home will be an opportunity for learners to receive better education. Hence, learners understand Tshivenḓa, and it will be easier for them to know and understand the idea of science. Furthermore, other parents are in support of Tshivenḓa indigenous language because they reported that they are not good in English.

5.3.3. Case Three: Remarkable secondary school

5.3.3.1. Data presentation and discussion

In South African schools' learners are expected to learn through English instruction. However, there are some teachers and learners who are not comfortable, competent, and proficient in English (Nel & Muller, 2010). Physical science is taught and learned using English as medium of instruction, however for this study purpose PS was taught using TPSSR. However, beside learners being taught with TPSSR, they were also taught in English register. The researcher gave developed TPSSR to the teacher to use in his preparation for his PS classroom practices. Due to the fact that it was his first time doing PS lesson preparation using TPSSR, during his pre-lesson interview with the researcher he reported some of the challenges he came across during his lesson preparation using developed TPSSR which was obtained from the researcher. See statement below:

> "*Khaedu khulwane ye nda tangana nayo musi ndi khou ita ndugiselo dza PS ndi ya uri luambo lune lwo shumisiwaho kha register ya physical science a si luambo lune ra vha ri khou lushumisa duvha na duvha (The biggest challenge I had come across during Physical Sciences lessons preparations is of the language that was used in the Physical Sciences register). Hafha duvha na duvha ri khou tshila maipfi manzhi a physical science naho a hone nga Tshivenḓa ri wana uri ri vho a shumisa kha luambo lwa duvha na duvha lwo novha nga tshikhuwa ra wana ri sa tsha divha uri aya maipfi a amba mini nga Tshivenḓa (In our daily lives, even though there are Physical Sciences words available in Tshivenḓa we normally use them in English and forget what they mean in Tshivenḓa). Mara nga murahu ha musi u tshi khou di ita ndungiselo u ya kona u zwi vhona zwauri zwoleluwa mathada a tou vha uri holu luambo lune ra khou lushumisa duvha na duvha a lu tshavha luambo lwa Tshivenḓa tsho kunaho (But after doing some preparations, you then realized that it is easy, but the problem is that the language we use every day is no longer*

a pure Tshivenḓa). Lune zwaita uri na iwe u vhe na vhuleme musi u tshilugisela ngudo hedzo nga register ya PS ya Tshivenḓa (Hence, resulted in me having difficulties in the preparation of those lessons using Tshivenḓa Physical Sciences scientific register)." school 3 Teacher Leon

However, though there was a challenge experienced by Leon during his lesson preparation using developed TPSSR (Appendix S), Leon also indicated in his interview that he tried to reach out on colleague whom he thought could be of assistance in explaining some of the Venda words he could not understand and those that were new to him. See the following statement reported:

"Zwe nda ita zwone ndi zwauri ndoya kha munwe wa mudededzi ano funza Tshivenḓa nda humbela talutshedzo ya manwe maipfi sa ezwi nan ne mune ndo vha ndi sa tshi tou madivha zwavhudi nga Tshivenḓa manwe ndovha ndi khou di wana e maswa kha nne (For me to minimize or to resolve the problem of some of the words presented in the Tshivenḓa Physical Sciences scientific register I reach out to my colleague who taught Tshivenḓa in my school to explain some of the words that I forget their meaning and those that were knew to me). so mudededzi wa Tshivenḓa hafha tshikoloni tshine nda shuma khatsho ndiene othusaho uri ndi kone u pfesesa luambo ulu u ita nau thusedza (So, Tshivenḓa teacher in my school is the one who assisted me a lot during my lessons preparations using the proposed register in the teaching and learning of Physical Sciences)" school 3 Teacher Leon

During Leon PS classroom practices, he identified areas of difficulties or challenges that his learners were experiencing while he was teaching them with the developed TPSSR. Leon indicated some of the difficulties or challenges he saw his learners experiencing when he was teaching PS using developed TPSSR as reported in the following statement:

"Khaedu khulwanesa ye vhana vha tangana nayo idinga yeneyi nthihi ye na nne nda tangana nayo musi ndi khou ita ndugiselo ya usa divha na u pfesesa manwe maipfi a santsi kha register ya Tshivenḓa (The biggest

challenge that learners' experiences is the same challenge I as a teacher experience when I was doing lessons preparations which is of not knowing and understanding some of science words used in Tshivenḓa register). Maipfi manzhi a luvenda ono xela vhathu ri tshi katela na vhana. Vhana luambo lwa Tshivenḓa na vhone lo no vha shavha a vha tsha divha maipfi manzhi a Tshivenḓa Many Tshivenḓa words has disappeared to People including learners. Tshivenḓa language has disappeared or lost in learners as they no longer know many words in Tshivenḓa. Ndi ngazwo nangwe maipfi a santsi kha register o nwaliwa nga Tshivenḓa, vhana vhovha vha si khou divha uri elo ipfi ndi lifhio That is why even though science words in the register were written in Tshivenḓa, children were no longer knowing which word is it.. Udo wana uri nwana u divha helo ipfi nga tshikhuwa fhedzi nga Tshivenḓa ha li divhi You will find that a child knows that word in English but not knowing the word in Tshivenḓa.. kha tshikhuwa ndi luambo lwawe lwa duvha na duvha fhedzi kha Tshivenḓa ndi manwe maipfi ane avha atshi vhonala sa maswa sa tsumbo ahuna nwana asa divhi firidzhi, nwana munwe na munwe udivha uri huna firidzhi ende udivha uri firidzi ashela madi haala madi ashanduka avha aisi zwino utshi vho amba nga ha tshixwatudzi nwana uvha asitsha divha uri tshixwatudzi ndi mini mara tshixwatudzi utshi vhona duvha na duvha , utshi amba nga ha muxwatu , nwana hadivhi uri muxwatu ndi mini fhedzi ice udzi vhona duvha na duvha In English it is his or her everyday language but in Tshivenḓa it seem to be new words, for example there is no child that doesn't know fridge, each and every learner knew fridge and he or she know that if he or she put water inside the fridge, the water will change and become ice but when you talk about tshixwatudzi (fridge) a child no longer know what tshixwatudzi (fridge) is, but he or she sees tshixwatudzi (fridge) every day. When you talk about muxwatu (ice) a child doesn't know what muxwatu (ice) is even though ice he or she sees it every day. heyo ndi khaedu ye nda vhona vhana vha khou tangana nayo musi ndi khou vha funza. Vhana vhono xelelwa nga luambo lwa Tshivenḓa, maipfi manwe avha tsha a divha That the challenge I saw learners experiencing when I was teaching them. Tshivenḓa language has disappear to children, some of the words they no longer know them)." school 3 Teacher Leon

Teaching and learning of PS using developed TPSSR was new to learners. Hence, learners had challenges since they were used to PS being taught and learned through English language register. They expressed themselves as follows:

> *“Manwe maipfi kha Tshivenḓa Physical Sciences scientific register o vha a songo ḓowelea nga sa mutsiḓi, muxwatu, tshixwatudzi, magwada a muxwatu, Muḓimuwo, Muluḓeo, Mutaladzi wa murambaladzo, Mutaladzi wa tswititi (Some of the words used in the Tshivenḓa Physical Sciences scientific register we are not used to them in Tshivenḓa, words like steam, ice, fridge, crystal, evaporation, condensation, horizontal axis, vertical axis).” school 3 group 1 L1*

> *“Hovha na manwe maipfi o shumisiwaho kha TPSSR angaho tshixwatudzi, muxwatu, mutsiḓi, muxwatudzo, Muyamufhe, zwilavhi, Phaḓalala ovha a maswa ndi tshi khou balelwa u a talukanya (There were words that were used in the Tshivenḓa Physical Sciences scientific register that were new to me and I fail to understand them , words like fridge, ice, steam, freezing point, oxygen, particles, diffusion).” school 3 group 2 L1*

> *“Manwe maipfi kha Tshivenḓa Physical Sciences scientific register ovha a songo leluwa u a pfesesea ngauri rovha ri sathu apfa sa tshixwatudzi, Gesedungi, gesehambe, fulufulu (Some of the words in Tshivenḓa Physical Sciences scientific register were not easy to understand because we never heard them before, for example fridge, carbon dioxide, nitrogen, energy).” school 3 group 3 L1*

> *“Manwe maipfi kha Tshivenḓa Physical Sciences scientific register e avha a khou ambiwa ndo vha ndi sa a divhi, sa ipfi mutsiḓi, tshifaredzi, Tshiedzwa, tshikhala, tshipeiti, u xwatudza, vhungomu (Some of the words in Tshivenḓa Physical Sciences scientific register the teacher was talking*

about I was not knowing them, like the word steam, beaker, sample, interval, syringe, freezing point, volume)." school 3 group 4 L1

During interviews with learners of different groups, they reported problems they encountered when their teacher was teaching them PS with the TPSSR. However, almost all learners in PS experiences similar problems. The following are some of the problems learners from different groups experienced during their learning with TPSSR:

> *"Ndo vha na thaidzo kha manwe maipfi a tshivenḓa are kha Tshivenḓa Physical Sciences scientific register u fana na muxwatu (I had a problem with some of Tshivenḓa words in Tshivenḓa Physical Sciences scientific register like ice)." school 3 group 1 L2*

> *"Ndo vha na thaidzo ya maipfi o shumisiwaho kha Tshivenḓa Physical Sciences scientific register a nonga Tshiomate, ndo vha ndi sa divhi uri zwi amba mini (I had a problem of some of the words used in Tshivenḓa Physical Sciences scientific register like solid, I didn't know what it mean)." school 3 group 2 L2*

> *"Ndi thaidzo ya maipfi maswa kha Tshivenḓa Physical Sciences scientific register e nda vha ndi sa a divhi sa muxwatu (I had a problem of new words in Tshivenḓa Physical Sciences scientific register that I didn't know like ice)." school 3 group 3 L2*

Language is essential for identifying the concepts and relating the concepts with one another and for building up a whole new domain in cognitive and communicative terms (Anthony, 2015). Even though some learners were experiencing challenges while learning PS with TPSSR which is not the language register they were not used to, their teacher tried to assist the learners to learn the content he was delivering. The following statement reported how teacher Leon assisted his learners to learn the content taught with TPSSR:

“Ndo kombetshedzea uri kha dzinwe dza dzi nyimele ndi ite ndi tshi talutshedza maipfi a Tshivenḓa ndi tshi maisa kha tshikhuwa hu u itela uri vhana vha kone u zwi tumanyisa na vhutshilo hashu ha duvha na duvha (*In some of the situation I was compelled to sometimes translate some of Tshivenḓa words to English so that learners can connect them with our lives of everyday).” School c Teacher Leon*

Department of Education (DoE) (2000c) accentuates that teachers’ roles include being mediators of learning, interpreters and designers of learning programmes and materials, researchers, lifelong learners and learning area specialists. Therefore, Leon was able to assist his learners with resolving variety of issues or challenges the learners came across in the learning of PS through TPSSR. During the groups interviews with the researcher, learners reveal how their teacher assisted them to understand the lessons taught with TPSSR (Appendix S).

“Mudededzi vho mboḓi talutshedza maipfi a saintsi are kha register ya PS ya Tshivenḓa na nga dzi tsumbo (The teacher explained the meaning of the sciences words in Tshivenḓa Physical Sciences register scientific words with examples).” school 3 group 1 L3

“Mudededzi vhovha vha tshi ita vha tshi talutshedza maipfi a santsi a Tshivenḓa kha TPSSR nga tshiisimane (the teacher sometimes explains Tshivenḓa science words in Tshivenḓa Physical Sciences scientific register in English).” school 3 group 2 L3

“Mudededzi vho funza vhatshi dovholola uri ri pfesese (The teacher did a lot of repetitions when he was teaching us so that we could understand).” school 3 group 3 L3

“Medededzi vho talutshedza maipfi e a vha a khou ri kondela vhadovha vha ri ri fanela u di nea tshifhinga tsha u guda manwe maipfi a Tshivenḓa a saintsi (The teacher explained words that were difficult to class and

advise us to give ourselves time to learn some of Tshivenḓa science words)." school 3 group 4 L3

Botha (2022) reports that it is imperative for children to be given the opportunity to become expert in their home language. In this study, learners were given an opportunity to learn PS with TPSSR (Appendix S) and such language used in the register was their home language (Tshivenḓa). Sanchez (2013) states that children feel most comfortable and can learn best through their home language because they understand it. This means that learners can receive better education through language which is familiar to them. Additionally, United Nations Educational, Scientific, and Cultural Organisation (UNESCO,2008) indicates that home language teaching is vital for effective learning.

"Ndi vhona zwi zwavhuḓi u guda PS nga Tshivenḓa scientific register ngauri ndi do vha ndi khou pfesesa zwine nda khou funziwa nga Tshivenḓa sa luambo lwanga ufhira nga lunwe luambo (I think learning Physical Sciences with Tshivenḓa scientific register will be a good thing because I will be understanding what is being taught because Tshivenḓa is my home language unlike with other language register)." school 3 group 1 L4

"Ndi vhona u shumisiwa ha Tshivenḓa Physical Sciences scientific register kha u guda physical science zwi zwavhuḓi samusi ri tshi do kona u amba na u wanulusa zwinwe zwa saints inga luambo lwashu husina vhuleme ha u pfesesa luambo lo shumisiwaho (I think the use of Tshivenḓa Physical Sciences scientific register in the learning of Physical Sciences. It is a good thing as we will be able to talk and explore the ideas of science through our own language without difficulties of understanding the language used)". school 3 group 3 L4

In this study, Tshivenḓa speaking teachers and learners were given opportunity to teach and learn PS with the developed TPSSR. Therefore, participants views and perceptions concerning the use of TPSSR in the teaching and learning of PS was crucial to meet the objective of the study, which is "to explore the views and perceptions of physical science teachers, parents and learners towards the use of the Tshivenḓa scientific register for physical science ‘’. Therefore, the participants were given an opportunity to express their thought about the use of TPSSR for PS teaching and learning. The statements that follows reported the views and perceptions from Leon (teacher), learners and parents:

> *“ndi vhona unga zwovha zwitshi tea unga konadzea uri nwana a kone u guda PS nga Tshivenḓa scientific register (I wish it can happen that Physical Sciences could be learnt with Tshivenḓa scientific register).” school 1 Teacher Leon*

Researchers (Afolayan, 1976; Bamgbose 1976; Adegbija, 1994; Mutasa, 2004) emphasised that mother tongue education ensures learners’ performance at the maximal ability and psychological support. This is confirmed by learners’ responses to their perceptions:

> *“Ndi vhona u shumisiwa ha TPSSR zwi zwavhuḓi ngauri ndi nga kona u pfesesa luambo lwa santsi nau kona u amba na mudededzi (I think the use of TPSSR will be a good thing as I will be able to understand language of science and being able to talk to the teacher).” school 3 group 3 L4*

> *“Ndi vhona u shumisiwa ha TPSSR zwi zwavhudi ngauri ri vha ri tshi khou kona u pfesesa zwine ravha ri tshi khou funziwa (I see the use of Tshivenḓa scientific register for PS as a good thing because we are able to understand what the teacher is teaching).” school 3 group 4 L4*

In general, learners study and learn best through their mother tongue (Murwamphida, 2008) and when mother tongue is used, learners are psychologically at ease and learning is therefore facilitated (De Wet, Nieman & Matsela, 1999). In addition, using of African indigenous language as a language of instruction at education is an advantage (Murwamphida, 2008).

> *“u shumisiwa ha TPSSR ndi zwavhudi ngauri ri a tavhanya u pfesesa zwine ra khou funziwa (the use Tshivenḓa scientific register in the teaching*

and learning of Physical Sciences is a good thing as we find it easier to understand what we are taught)." school 3 group 2 L1

"Ndi vhona zwi zwavhudi ngauri Tshivenḓa Physical Sciences scientific register yo shumisa luambo ro no lupfesesa khwine (I think it is a good thing because Tshivenḓa scientific register used the language that we understand better)." school 3 group 1 L3

"Ndi vhona u shumisiwa ha TPSSR kha u funza na u guda physical science zwi zwavhudi ngauri muthu ndi do kona u pfesesa zwine zwa khou funziwa (I think to use Tshivenḓa scientific register in the teaching and learning of Physical Sciences will be a good thing because one will be able to understand what is being taught)." school 3 group 2 L2

"Ndi vhona u guda santsi nga u shumisa Tshivenḓa Physical Sciences scientific register zwi zwavhudi ngauri ri do kona u pfesesa ngauri luambo lo shumisiwaho kha register ndi luambo lwashu lwa damuni lune lwa vha luambo lune ra lu pfesesa u fhira dzinwe nyambo. (I think to learn the ideas sciences through the use of Tshivenḓa Physical Sciences scientific register will be nice as we will be able to understand because the language used in the register is our mother tongue which is the language we understood better compared to other languages)." school 3 group 3 L1

Irrespective of the status and benefits that come with using English as a medium of instruction, some parents still feel it is not the preferred medium of instruction. See the following responses:

"u shumisiwa ha TPSSR kha u funza PS zwi do thusa vhana vhane ndi luambo lwa vho lwa damuni. Vhunzhi ha vhana a si vhanzhi vhono pfesesa English mara arali vhanga shumisa register ya Tshivenḓa vha ḓo kona u nga pfesesa zwe zwa funziwa (the use of TPSSR in the teaching PS will assist children who their mother tongue is Tshivenḓa. Most of children don't understand English but if you can use Tshivenḓa register learners will be able to understand what they are taught)." School 3 parent 1

“mmmh, hai ndi nga dipfa zwavhuḓi arali ha nga shumisiwa TPSSR kha u funza na u guda PS ngauri zwi do nea vhana Tshikhala tshau guda zwinzi nga science nga kha luambo lwo shumisiwaho kha register lune ndi luambo lwavho lwa hayani (mmmh, I will feel happy if TPSSR is employed in the teaching and learning of PS because it will give learners opportunities to explore the ideas of sciences through language used In the register which is their home language).” school 3 parent 2

From the preceding responses, these parents are in support of the use of Tshivenḓa to teach PS. Furthermore, they noted that teaching these learners in their home language will benefit them as they will have a better understanding of the subject. In South Africa, language barriers could account for the poor performance in PS (Prinsloo & Rogers, 2013). Hlabane (2014) argues that lack of English proficiency also results in poor learners’ academic performance since learners need to comprehend the concepts to apply them in solving problems. Ouane and Glanz (2010: 30) note that the mother tongue is a recognisable language that children can relate to. According to Botha (2022), mother tongue language will assist with child-centred teaching practices that are effective in inspiring learners to be active participants of their learning experiences in the classroom.

“ndi ngapfa zwi zwavhudi arali Tshivenḓa physical sciences scientific register ya nga shumisiwa kha u funza physical sciences sa musi luambo lo shumisiwaho lu luambo lune vhana vhashu vha lu shumisa duvha na duvha nauri vha do kona u pfesesa na zwine vha do funziwa (I will feel good if Tshivenḓa physical sciences scientific register is being used for physical sciences teaching as the language used in the register is the language our children use daily and they will understand the lessons they will be taught).” school 3 parent 3

“ndi vhona unga u shumisiwa ha TPSSR zwi nga vha zwavhuḓi ngauri register yo shumisa luambo lwa Tshivenḓa lune vhana vha lupfesesa fhira lwa tshikhuwa (I think the use of TPSSR will be a good thing because the

register is presented in a language (Tshivenḓa) that learners understand better compared to English)." school 3 parent 4

"u shumisiwa ha TPSSR zwi nga ntakadza sa musi vhagudiswa vha tshi do kona u pfesesa vha do pfesesa zwithu zwa saintsi khwine (the use of TPSSR will make me happy as learners will be able to understand the ideas of science better)." school 3 parent 5

From the foregoing parents' responses, these parents prefer indigenous languages because their kids will have a better understanding of the subject and they will perform better. Chavez (2016) accentuates that learners should be educated in the language they know best as this will develop their capabilities and enable them to fully understand expressions and to express themselves competently and confidently. According to Botha (2022), mother tongue can assist with learner-centred approach which is effective and encourage learners to be active participants during their classroom learning experiences. Furthermore, Ozfidan (2017) argues that home language education increases social skills and provides individuals with the confidence they need to feel secure in their identity, because language is etched in who people are. The study revealed that the use of TPSSR was useful to both teacher and learners. See the following teacher and learners interview transcripts:

"heyi Tshivenḓa Physical Sciences scientific register ndi yavhudi, ya dovha hafhu ya shumisea iya tutuwedza na muthu kha kuhumbulele kune ngavhe physical science yovha I tshi kona u funziwa duvha na duvha na nga register ya Tshivenḓa. Heyi register ina luambo lwo kunaho ende ndi tshi sedza, nda wana uri iya talutshedza nga ndila ino pfesesea (This Tshivenḓa Physical Sciences scientific register is nice, it is usable, and it encourages a person in a perception that I wish it can be possible for Physical Sciences to be taught and learn with Tshivenḓa register. The language used in the register is pure and when I look at it, I find that it explained in a way that is understandable)." School 3 Teacher Leon

Research by Awopetu (2016:60) focused on the effectiveness of the mother tongue as a language of instruction on learning abilities of pre-school age children. The results of these findings reveal that these learners who were communicated to and instructed in their mother tongue achieved better results than their fellow participants who were communicated to and instructed in English. Learners made it clear that the initiative of using Tshivenḓa to teach PS can improve their understanding because they will be learning in their home language. They were then interviewed about their performance on the subject and how the language they used affected their performance. Here are the following responses:

> *"Ndo pfa ndo takala musi TPSSR yo shumisiwa musi ri khou funziwa na u guda PS ngauri ndo vha ndi tshi khou ḓivha zwe mudededzi ovha a khou amba nga hazwo (I felt happy when Tshivenḓa Physical Sciences scientific register was used in Physical Sciences teaching and learning because I knew what the teacher was talking about)."school 3 group 1 L2*

> *"Ndo ḓipfa zwavhuḓi musi mudededzi a khou funza nga Tshivenḓa Physical Sciences scientific register ngauri register yo vha yo nwaliwa nga luambo lwanga lwa damuni zwe zwaita uri zwi vhe zwoleluwaho uri ndi pfesese (I felt good when the teacher was using Tshivenḓa Physical Sciences scientific register when teaching because the register written in my mother tongue which makes it easier for me to understand)." school 3 group 2 L2*

> *"Ndo farea zwavhudi kha u guda zwithu zwa saintsi nga Tshivenḓa Physical Sciences scientific register zwe zwa ita uri ndi sa tou vhesa na vhuleme kha pfunzo dze nda funziwa (I felt okay learning the ideas of sciences with Tshivenḓa Physical Sciences scientific register which resulted in me not facing a lot of challenges during the lessons taught)." school 3 group 3 L2*

From the foregoing parents' responses, these parents prefer indigenous languages for the fact that their kids will have a better understanding of the subject and they will perform better.

> *“u shumisiwa ha Tshivenḓa Physical Sciences scientific register kha u funza PS zwo ntakadza, zwoita uri zwi ndelutshele kha u pfesesa zwo funziwaho* (*The use of Tshivenḓa Physical Sciences scientific register in the teaching of Physical Sciences makes me happy as I find it easier to understand what was taught).” school 3 group 1 L1*

> *“Ndo farea zwavhudisa kha pfunzo dzothe dze ha shumisiwa TPSSR, pfunzo dzovha dzi khou takadza ngauri dzo vha dzi khou funziwa nga luambo lwanga lwa damuni (All lessons taught with Tshivenḓa Physical Sciences scientific register makes me happy, the lessons were exciting because the register was in a language which is my mother tongue).” school 3 group 2 L1*

> *“Ndo dipfa ndo takala musi ndi khou funziwa na u guda Physical Sciences nga Tshivenḓa Physical Sciences scientific register ngauri ro vha ri khou kona u fhindula zwe mudededzi ovha a khou vhudzisa (I was happy when Tshivenḓa Physical Sciences scientific register was used in the teaching and learning of Physical Sciences because we were able to answer what the teacher ask).” school 3 group 3 L1*

> *“Ndo dipfa zwavhudisa u funziwa Physical Sciences nga Tshivenḓa Physical Sciences scientific register ngauri luambo lwo shumisiwaho kha register ndi lwone luambo lune nda lupfesesesa u fhira Luisimane (I was happy being taught Physical Sciences with Tshivenḓa Physical Sciences scientific register because the language used in the register is the language I understand most comparing to English).” school 3 group 4 L1*

Botha (2022) indicates that learning through home language offers one an advantage to understand what has been said instead of having to translate the LoTL into the mother tongue and then make sense of it. Additionally, Ouane and

Glanz (2010) posit mother tongue as a recognisable language that children can relate to. Leon indicated in his post interview lesson with the researcher that the use of TPSSR in the teaching and learning of Physical Sciences was successful as it assisted learners to learn and understand the content taught. The following statements present aspects noted during interviews with the participants on the application of developed TPSSR in the teaching and learning of PS:

> *"musi ndi tshi zwi sedza pfunzo dzothe dze nda shumisa TPSSR ndi vhona uri vhana vho guda nga maanda nahone vho kona u pfesesa zwinzhi zwa physical science ngauri register yo talutshedza saintsi nga Tshivenḓa ende ndi luambo lwavho lwa hayani. So ngudo dzothe dzo tshimbila zwavhuḓi (when I look at all PS lessons taught with TPSSR I think children learnt a lot and they understood a lot about PS because register explained science in Tshivenḓa which was their home language. So, all lessons went well)." school 3 Teacher Leon*

From the preceding teacher's response, the teacher is in support of the application of TPSSR in the teaching and learning of PS. The teacher view teaching and learning through TPSSR as imperative for the fact that learners understood many concepts on the subject PS as the language used on the register was their own.

5.3.3.2. Findings of participants perceptions of Remarkable secondary school

Teachers perceptions

This study reveals that Leon has a positive perception about the use of TPSSR in the teaching and learning of PS. His perceptions are based on the fact that learners will be able to learn the ideas of science easier through language (i.e. Tshivenḓa) used in the register which was the language learners mostly use at their home. He further noted that using Tshivenḓa will advantage learners as they will learn to the best of their ability which could results in good performance on the subject. Leon also reported code switching as vital since it can make it possible for learners who are experiencing difficulties to understand the ideas of the lesson.

Learners' perceptions

The findings of this study reveal that the use of TPSSR inspire some learners to express their thought and take control on their education. However, other learners perceptions about the use of TPSSR in the teaching and learning of PS were not optimistic. Some learners are in favour of the language (Tshivenḓa) used in the register as they see it as an opportunity to achieve better in the subject under exploration. They further indicated that learning through Tshivenḓa which is the language use in the register will assist them in learning words they found difficult and not understand in English instruction. However, some learners' perceptions about the use of TPSSR in the teaching and learning of PS were not optimistic. Some learners reported that they prefer to learn through English because they are used to PS learning through English medium of instruction, and it is easier to learn the subject concepts. They further indicated that some words are difficult to understand in Tshivenḓa.

Parents' perceptions

The outcomes from parents' views and perceptions in this case on the use of TPSSR were optimistic. Consequently, the parents did endorse the language (Tshivenḓa) used in the register for teaching and learning PS. Their perceptions were based in Tshivenḓa being their mother tongue and is the language they mostly use in their day to day and there are good at it. Furthermore, these parents reported that the use of mother tongue in the teaching and learning of PS will enable learners to understand PS better when compared to English medium of instruction.

5.4. Summary

In this chapter, opportunities and challenges in the development of the TPSSR and the participants (teachers, learners, parents) perceptions on the use of TPSSR in the teaching and learning of physical sciences were analysed, and the findings of the cases of this study were presented and discussed separately. In the next chapter, the researcher presents and analyse the findings obtained from the use of TPSSR.

CHAPTER 6:

APPLICATION OF TSHIVENḒA PHYSICAL SCIENCE SCIENTIFIC REGISTER

6.1. Introduction

The data gathered will be presented in this chapter. Additionally, the data obtained from the participants will be discussed in this chapter and the findings will be conveyed. This study was guided by the following research questions:

- ❖ What are the challenges and opportunities in the development of TPSSR for teaching and learning of PS?
- ❖ What are the challenges and opportunities in the use of TPSSR for the teaching and learning of PS?
- ❖ How does the use of TPSSR in the teaching and learning of PS influence interaction and discourse?
- ❖ What are the views and perceptions of PS teachers, parents, and learners towards the use of TPSSR?

However, this chapter will present the data collected from three cases separately. Hence, the findings from each case will be reported.

6.2. Theme three: Classroom interaction and discourse

This section presented interactions and discourses diagnosed in the teaching and learning of PS lessons presented with TPSSR and ESR. In this section, the researcher revealed how PS lessons were facilitated by the teachers in terms of interaction and discourse. This section focused on two of the research questions which are as follows:

- ❖ How does the use of TPSSR in the teaching and learning of physical science influence interaction and discourse?
- ❖ What are the challenges and opportunities in the use of TPSSR for the teaching and learning of PS?

Here, the researcher wanted to explore how the application of TPSSR (Appendix S) shape classroom interactions and discourses? Additionally, the researcher also took note of the challenges and opportunities in the application of TPSSR during PS classroom practices.

Nystrand, Wu, Gamoran, Zeiser and Long (2001) explain classroom discourse as a way in which teachers talk soliciting teacher-learner interaction in the classroom. Green and Rex (2018) report that classroom discourses unloads how day-to-day language employed shapes practices, developments and content demands of the syllabus. Furthermore, Green and Rex (2018) indicate that academics employed classroom interactions to explore activities and learning and teaching approaches associated with the learner learning indices. In this chapter, the researcher inspected how the use of developed TPSSR influences teacher-learner interaction and discourse during PS lessons. The interactions and discourses in a classroom of science among learners and their teacher is essential during the process of learning and teaching.

6.2.1. Case one: Thakhani from Dominance secondary school

6.2.1.1. Data presentation and discussion

Before the researcher observed teacher classroom practice, she wanted to know teacher views and perceptions on the use of TPSSR during his lessons preparations. Hence, by so doing, the researcher wanted to gain an insight on teacher experiences on the use of TPSSR during his lesson's preparations. Thakhani reported the challenges he experiences, and the causes as indicated next:

> *"Ovha mafhungo a u shandukusa maipfi a tshikhuwa a tshiya kha Tshivenḓa. Maṅwe a maipfi ha tou wanala zwavhuḓi kha Tshivenḓa lune zwa kombetshedza uri huvhe na u pambiwa hunzhi ha maipfi. Ndi thaidzo ya maipfi ane a ri nao kha Tshivenḓa (I had a challenge of changing of English words to Tshivenḓa. Other words are not found in Tshivenḓa which resulted in using English words. So, it is a problem of words which we don't have in Tshivenḓa)"school 1 teacher Thakhani*

The foregoing response indicated the problems or challenges he experienced while doing his lesson preparation using the developed register. Additionally, the teacher also revealed the cause of the problems. Most of the developed Tshivenḓa words were borrowed from English and Afrikaans and adapted to Tshivenḓa (Mafela, 2012).

The researcher also had interviews with the learners after teacher classroom practices as she wanted to know learners' views and perceptions on the learning of PS using the TPSSR. Some learners responded to the problems they experience, and the possible causes as follows:

> *"Thaidzo yanga yo vha ya u sa pfesesa manwe a maipfi o shumisiwaho a nonga sa mutsiḓi, muxwatu na tshixwatudzi.* Zwo vhangiwa *nga u sa ḓowela u funziwa thero ya physical science nga tshivenḓa (I had a problem of not understanding other words used like steam, ice and fridge. This was caused by not used of being taught physical sciences in Tshivenḓa)" school 1 group 3 L1*

These learners' responses indicated the problems or challenges they experienced while learning PS through developed register. Additionally, learners also reveal what causes the problems they reported. However, the learners' problems or challenges they experienced were minimised or resolved as learners indicated that:

> *"Ndo vhudzisa mudededzi wanga nga zwe nda sa zwipfe zwavhudi, Mudededzi wanga vho mboḓi talutshedza uri zwi amba mini. (I asked my teacher what I did not understand and my teacher explained what I did not understand)" school 1 group 1 L1*

After the researcher observed teacher classroom practice using the TPSSR, she wanted to know teacher views and perceptions on the use of TPSSR during his PS classroom practices. Hence, by so doing, the researcher wanted to know teacher experiences on the use of TPSSR during his PS lessons. Thakhani reported what he noted while he was using TPSSR in his classroom as indicated next:

> *"Ndo vhona i khou thusa nga maanda kha vhana ngauri zwi dovha zwa thusa khau vuseledzaTshivenḓa vha kona u guda Tshivenḓa ngauri Tshivenḓa tsha maduvhano tsho tanganesana na tshikhuwa zwino heilani rigisitara yo thusa nga maanda uri hetshilani Tshivenḓa tshikone u dzudzanea. Nahone ndovha ndi tshi nga tama uri ngavhe I tshinga dovha hafhu ya hula ya andadziwa habva maipfi manzhi.(I have seen the register helping learners a lot because learners were also learning Tshivenḓa as Tshivenḓa of these days learners mixed it with English but the register assisted a lot as the Tshivenḓa used was pure. I wish the register could expand and produce many words)." school 1 teacher Thakhani*

> *"Ndo vhona zwi khou leludza ngauri na vhanwe vhe vhavha vhasa koni u fhindula vhanwe vha tshi tou shona na u shavha vhovha vha tshi kona u takuwa vha sumbedzisana zwine vhone vhadivha zwone ende ngauralo dzangalelo lavho lovha lihulu lau guda saintsi na nyofho dzisiho (I have noted that the use of register makes things easier for learners because I have seen that other learners who don't respond and others who are shy I have seen them expressing what they know and they were very excited when learning science without fear)" school 1 teacher Thakhani*

However, beside the challenges learners experienced, learners' views and perception regarding what they felt on the use of register to learn PS were optimistic as they stated that:

> *"Ndo dipfa ndo takala sa izwi ndo kona u pfa zwine mudededzi avha a khou funza zwavhuḓi nga luambo lwelwa shumisiwa TPSSR lune lovha lu luambo lwanga lwa hayani (I felt good as I was understanding what the teacher was teaching using TPSSR which was written in my home language)" school 1 group 2 L1*

“Ndo pfa ndo farea zwavhuḓi ngauri ndovha ndi khou funziwa nga luambo lwa Tshivenḓa zwe zwa ita uri ndi gude zwinzhi (I felt good because I was educated in Tshivenḓa language, and I have learnt a lot)” school 1 group 4 L1

The preceding learners’ responses are supported by Chavez (2016) when arguing that learners should be taught in the language they know best to develop their competences and allow them to comprehend terminologies and to express themselves knowledgeably and positively. Parents views and perception in the TPSSR were also important.

Some parents' responses on how the developed TPSSR for teaching and learning PS shape classroom interactions and discourses were positive. Their responses are consistent because learners will learn better as they will be using the language that they understand and speak (Msila, 2013). However, some of the responses above contradict the parent’s perception of the use of Tshivenḓa to teach PS. Their contradictory responses may be a result of their failure to understand the relationship between using Tshivenḓa to teach PS and the developed TPSSR.

“Ndi ngapfa ndo takala ngauri nwana u dovha a khou topfa zwothe na manwe maipfi a physical ane a si a divhe nga tshikhuwa, nga Tshivenḓa u dovha a khou zwipfa zwavhuḓi a khou talutshedziwa ngauri ndi luambo lwa hawe (I will be happy because the learner will be hearing everything and science words that he/she don’t know he/she will be knowing them as they will be explained in Tshivenḓa which is his/her home language).” school 1 parent 1

From the foregoing responses, stakeholders agreed that the developed TPSSR shape classroom interactions and discourses. Their responses were strongly based on the benefits and advantages of using the mother tongue, which results in meaningful learning and further yields to better performance Adesemowo (2017). Political commentators such as Dr Somadoda Fikeni, traditionalists such as Zolani Mkiva, and Historian and Cultural Analyst Professor Pitika Ntuli, also buttress that learning in the mother tongue improves the learner’s performance. These stakeholders' responses are further supported by scholars (i.e. Reis and Ng-A-Fook, 2010), who also highlighted how the use of indigenous language can enhance meaningful learning and better results

The researcher observed participants, i.e. learners and teachers during PS lessons in their classroom setting. By so doing, the researcher wanted to substantiate, and triangulate collected data attained from the interviews and that detected during teacher classroom practice (Netshivhumbe, 2018). Hence, classroom observation considered as the only technique possible to capture classroom interactions and discourse. During the interviews, Thakhani revealed that the use of developed TPSSR does shape classroom interactions and discourses. Hence, he was observed during his classroom practice while employing TPSSR (Appendix S) to teach PS in his Grade 10 learners. Thakhani started his lesson by introducing the lesson topic and thereafter asked learners’ questions. By so doing, he wanted to check learners’ experiences or their prior knowledge of the topic he introduced to them, which is imperative for meaningful learning as alluded to by Keeley (2012). He stated that:

Thakhani: *Zwino namusi kha thero ya namusi ri khoyo funzana nga zwivhumbeo zwa zwithu (now today on topic of today we are going to teach about forms of matter). Zwivhumbeo kana zwiimo zwa zwithu, ri na zwivhumbeo zwono swika zwiraru (forms or phases of matter, we have atleast three forms of matter). Hezwi zwivhumbeo zwa vho rine ndi zwiraru ende zwi zwiraru rothe ri ngavha ri tshi zwihumbulela uri hungavha hu zwifhio? (These forms of ours are three and when they are three all of us we maybe be thinking of these phases, which could be these phases) tsha u thoma tshi ngavha tshifhio? (which one can be the first one?)*
Learners: *zwiludi (liquids).*
Thakhani: *zwiludi (liquid), kha zwiludi ni divha zwingana zwine ra nga zwiamba, tshakha dza zwiludi tsha u thoma ndi mini (the teacher proceeds and said, examples of liquids that you know, which 1 is the first one)?*
learners: *madi (water).*
Learner 1: *nyamuanaithi (cooldrink).*

Learner 2: *tie (tea)*

The above statements indicated that Thakhani employed authoritative discourse during the lesson as he convey information to learners through questioning techniques as alluded to by Mudau (2013), as learners were given a chance to engage and discuss the content presented to them. However, Thakhani also used interactive-authoritative approach during the lesson which is indicated by the statement captured dung the lesson:

Thakhani: *hu na tshiimo tsha vhuraru, tsha u fhedzisela tshipfi mini? There is a third state, what do you call the last one?*
Learner 1*: ndi muya? (is air)*
Learner 2: *Vhutsi (gas).*
Thakhani: *ndi Vhutsi (it is gas)*

Thakhani also used dialogic discourse during his classroom practice as learners were given class activity which they were supposed to write as groups. By so doing the teacher enable learners to learn from each other. Below is the statement indicating the activity given to learners:

> *"Zwino vhone kha mushumo wazwino wa kilasini vha khou nwalela zwitalusi zwa Vhutsi zwina (now you are going to write a classwork and write four properties of gas), vhadovha vha nwala zwitalusi zwazwiludi zwina (and also write properties of liquids). Vhone vha khou nwala zwino ndi dovha ndi khou tshimbila tshimbila ndi tshisedza tshigwada tshinwe na tshinwe tshi tshi khou nwala (you will be writing now, and I will be moving around checking every group). Hu a divha na muthu muthihi ane a khou nwala kha tshigwada vheiwe vhanwe ndi tshi khou tou amba uri zwinwale ngau tavhanya ri do fhedza (one learner can write in a group and others we just do the talking so that we can quickly finish)" Thakhani*

The following pictures display learners discussing the activity as a groups. All these happened using TPSSR.

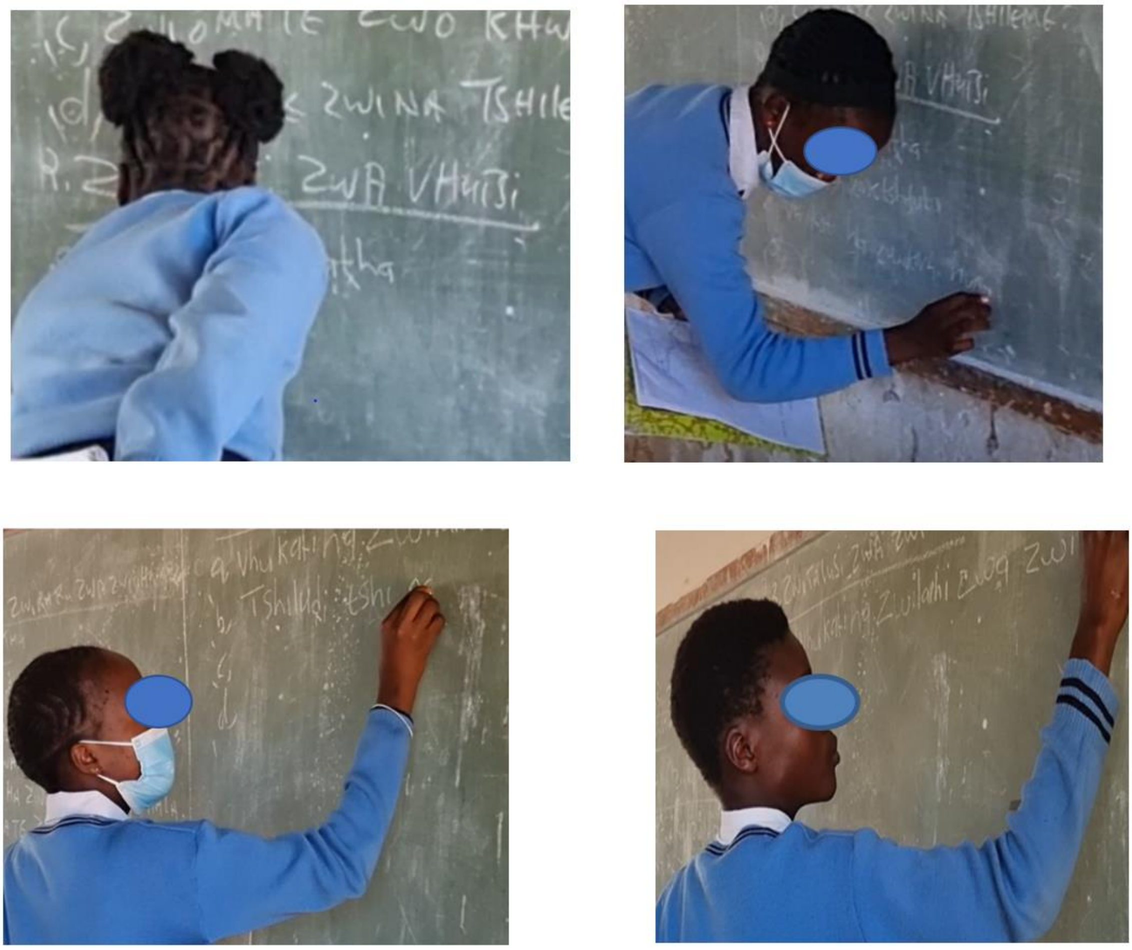
Examples of learners discussing activity among themselves

From the preceding assertions, Thakhani did not only use dialogic-discourse but an interactive-dialogic approach as well. As his learners were observed, writing their groups responses on the chalkboard. However, the teacher allowed learners to write answers without him interfering until all answers were on the chalkboard. Thereafter, he did corrections with his learners. The following statement showed how learners gave responses and how the corrections was done thereafter.

> *"Ndi khou humbela munwe na munwe ane a khou tea u nwala yawe ade a nwale thi, muthu munwe na munwe o tendelwa u nwala nthihi fhedzi (Anyone who is supposed to write can come and write, you are allowed to write one response). Ri khou amba zwitalusi zwa Vhutsi muthihi khade a nwale yau thoma (We are talking about properties of gas; one learner must come and write the first one). O nwala zwitalusi zwivhili (he wrote two properties). Munwe ade a nwale (Another one must come and write). munwe mugudiswa u khou nwala kha bodo (another learner go and write). Ivhani no ima atshifhedza nidoya (wait, you will go and write when he is*

done). Munwe ane a khou tevhela asokou ima(the next person should stand), ane a khou ima ridivha atshikona u nwala (a person who is standing we know can write). A hutevhele munwe (another person can come). Vheiwe nine na khou tobva uswika no wana ri khou amba nga zwitalusi zwa zwivhumbeo zwo fhambananaho athiri (those who just arrive you found us talking about properties of different state of matter), rina zwivhumbeo zwiraru nia zwidivha ndi zwiomate, zwiludi na Vhutsi (we have three state of matter that you know, which is solids, liquids and gas). Ravha ri khou nwala zwitalusi zwahone (we were writing their properties). Ane a khou tevhela. Ane a khou fhedzisela (the last person who must come and write). Ni songo hangwa na kha Vhutsi hafhala ni fhedzise (don't forget to finish on the gas)". Thakhani

"Yau fhedzisela ngeno kha Vhutsi (the last one on gas). Ndi nnyi ane a ngada anwala (who can come and write)? (The following pictures display some learners reporting their groups findings by means of writing their answers on the chalkboard). These resulted in learners being active during the lesson where the teacher was teaching the properties of three states of matter as both dialogic discourse and interactive-dialogic approach was employed in the classroom. All these happened using the Tshivenḓa physical sciences scientific register". Thakhani



Examples of some learners writing their groups responses on the chalkboard

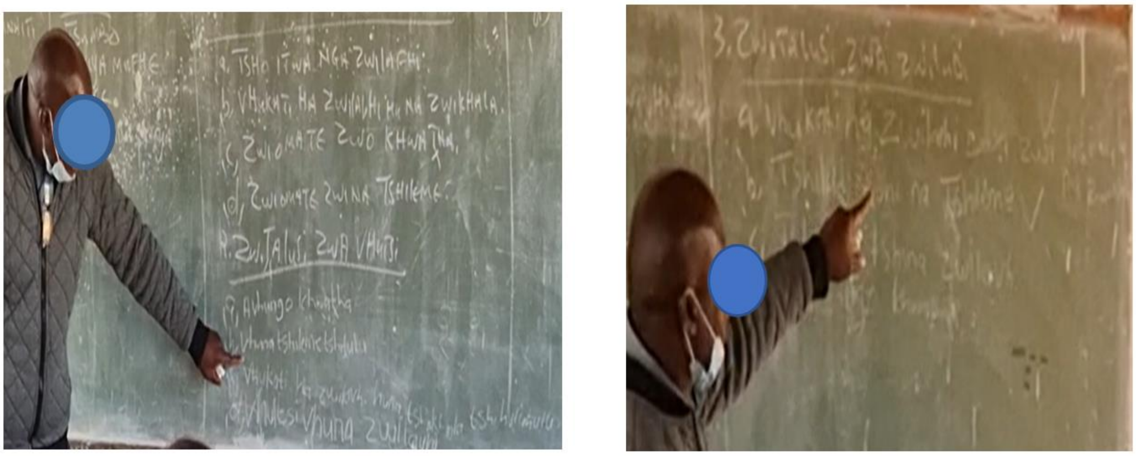
Thakhani: *holuga ari ite ndulamiso ri khou pfana athiri(okay let us do correction)?*

Learners: *Ee(yes).*

Thakhani: *ari asedze zwitalusi zwa zwiomate u thoma let us look at properties of solids (mudededzi u vhala zwea nwala kha bodo-the teacher read what she wrote). Ari sedze kha Vhutsi (let us look at gas) (mudededzi o vhalulula zwe vhagudiswa vha nwala kha bodo- Thakhani read what the learners wrote on the board). Ri khou vhona huna yo khakheaho kana ri khou vhona zwizwone zwothe (is there a wrong answer or everything is correct?)*

Learners: *Ee (yes).*

Thakhani: *ari do sedza kha zwitalusi zwa zwiludi (let us look at properties of liquids) (mudededzi u vhala zwe vhaguidiswa vha nwala kha bodo - the teacher read what learners wrote on the board)* (See following pictures):



Thakhani reading responses written by learners on the chalkboard

The researcher noted two patterns of discourse in the classroom. The initiation, response, and evaluation (IRE) is a three-fold figure wherein, firstly, the teacher initiates communication by posing a question to learners. The learner will then respond to the question, and then the teacher will finally respond, evaluating learners in the in the process. The second one is initiation, response, evaluation, response, and evaluation (IRERE), wherein the teacher initiates the lesson by probing questions followed by a response from learners. Then, the teacher will respond in a way that will probe questions to learners' responses, and finally, the teacher will give a final response to learners (IRERE).

During the lesson where Thakhani was teaching zwivhumbeo zwa zwithu na u Shanduka hazwo kana Tshanduko dza zwivhumbeo zwa zwithu (phases of matter and their changes or changes of phases of matter), Thakhani was observed employing IRE pattern of discourse. Thakhani gave learners instruction and asked learners questions to check learners understanding and learners gave their responses. This is supported by statement below:

Thakhani: *Ri khou thoma na zwivhumbeo zwa zwithu na u Shanduka hazwo kana Tshanduko dza zwivhumbeo zwa zwithu (We will start with phases of matter and their changes or changes of phases of matter). Tshanduko dzine dzavha hone rivha rikhou shandukisa zwivhumbeo zwa zwithu (Changes that are* *available we will be changing phases of matter). Tsha u thoma tshivhumbeo ndi mini (the first phase is what?)*

Thakhani and learners: *ndi zwiomate (is solids).*

Thakhani: *Ya vhuvhili yavha mini (the second one is what)?*

Learners: *Zwiludi(liquids).*

Thakhani: *zwe a amba ndi zwone (what he said is correct) Ya vhuraru yavha mini (the third one is what)?*

From the foregoing extract, Thakhani employed IRE as his questions did not require learners to provide more responses to the questions asked. During his lesson, Thakhani also used IRERE pattern of discourse as the questions asked were open-ended and learner centred. This is supported by the following extract:

Thakhani: musi zwiludi zwitshi Shanduka zwi tshivha Vhutsi. Zwi vhidzwa upfi mini (when liquids change to gas, what is the name of the change)?

Learners: u dimuwa (is evaporation), u vhila (is boiling).

Thakhani: *Hai a vha tou imisa tshanda. U dimuwa ndi musi ri tshi khou bva kha Vhutsi ritshiya kha tshiludi (no, raised up your hands. Evaporation is when gas change to liquid). Zwino eyi vha nga I vhidza uri mini, musi madi tshiludi a tshiya kha Vhutsi (so what will you call this, when water liquid change to gas).*

Learners: *U vhila (is boiling), a khou xaxara (it is boiling).*

Thakhani: *Ari tou imisa tshanda (raise up your hands).*

Learner*: A khou uxa (water is decreasing).*

Thakhani: *Madi atshiya kha Vhutsi (water change to gas).*

Learner: *ndi u fhufha (is jumping).*

Thakhani: *ndi u fhufha (is jumping)*

From the preceding extract, Thakhani used IRERE as his questions resulted in learners providing more than one responses to the question asked. He asked them and then gave feedback at a later stage. During the interviews, Thakhani mentioned that the use of developed TPSSR for PS teaching and learning positively shapes classroom interactions and discourses. He also noted that using the TPSSR in PS teaching enable learners to interact among themselves and the content taught without difficulties unlike when ESR is being used. The researcher then decided to observe the teacher teaching the same topic taught using TPSSR using ESR (Appendix T, page 287) for PS.

The following extracts serve as evidence of the classroom interaction and discourse:

> “Ndi ngauri vhana vhagudesa nga maanda musi vhanga tshavho nga maanda musi vha kha zwigwada zwitusa uri munwe asa tshikoni tshigede munwe ade natsho (Learners learnt a lot when they are working in groups, and it assists if other learner don’t know something and the other who know will assist the group). Nahone ano zwikonesa zwia munanisa uri a ise phanda (and the one who knows a lot it will encourage him/her to excel on the subject). Zwaita uri naa sakoni apfe ana mathada uri nae a ime ime uri nae adi tongise uri nae avhe murangaphanda ngauri kha zwigwada huvha hu na vharangaphanda vhe vhavha vha khou kona u ita mushumo vha kona udovha vhaya bodono vhanwala (It also encourages those who are failing to think of something so that he/ she can lead the group, because in groups there were leaders who also went and write their answers on the chalkboard)”. *Thakhani*

Table 8:Summaries of Thakhani classroom interactions and discourse with the use of TPSSR

Theme	Category	Characteristics
Classroom interaction and discourse	**Types of discourse**	Dialogic discourse
		Authoritative discourse
	Patterns of discourse	Initiation, Response, Evaluation (IRE)
		Initiation, Response, Evaluation, Response, Evaluation, (IRERE)
	Teacher questioning	Drives lesson
		Improve learning
		Develop thinking skills
		Encourage and motivate
	Communicative approach	Interactive-authoritative
		Non-interactive-authoritative
		Interactive-dialogic
		Non-interactive-dialogic

With the use of CLIF (Figure 1, page 63) the researcher was able to diagnose teacher-learners classroom interaction and discourse. Additionally, CLIF focus on aspects such as language and its influence in the classroom. Therefore CLIF assisted the researcher to discover the above mentioned discourses and interaction used by teacher Thakhani when TPSSR was employed during his physical sciences classroom practices as demonstrated in Table 8 (page 143). When using the TPSSR for PS teaching and learning, Thakhani used both authoritative and dialogic discourse. In authoritative discourse, the teacher conveyed information to learners by means of doing a lot of questioning and explanation. Therefore, learners in this case were not given chance to explore the ideas of the content taught among themselves by means of discussion or debating. However, dialogic discourse was also employed in the classroom as the teacher was observed giving learners class activity to do as groups and thereafter, they reported their discussion results by means of writing on the chalkboard. Hence, learners interact well with their teacher and among themselves. The teacher observed learners doing the group activity and reporting their discussion results to class and thereafter their teacher did corrections by means of reading what learners wrote aloud. By so doing, he commented and augmented learners’ responses where applicable. That resulted in his approach being interactive-dialogic as well as interactive-authoritative approach. Thakhani used question and answer method during his lessons, wherein he posed questions that drove the lesson, improve learning, encourage, and motivate as well as developing thinking skills. Hence, Thakhani used both IRE and IRERE pattern of discourse. During IRE, the teacher asked questions, learners responded, and the teacher evaluated their responses wherein during IRERE questions asked enable learners to practice their cognitive skills and learners gave several responses where the teacher make final decision.

Table 9: Summaries of Thakhani classroom interactions and discourse with the use of ESR

Theme	**Category**	**Characteristics**
Classroom interaction and discourse	***Types of discourse***	*Authoritative discourse*
	Patterns of discourse	*Initiation*
		Response
		Evaluation
	Teacher questioning	*Drives lesson*
		Improve learning
		Encourage and motivate
	Communicative approach	*Interactive-authoritative*
		Non-interactive-authoritative
		Interactive-dialogic
		Non-interactive-dialogic

The researcher employed CLIF (Figure 1, page 63) as it enabled her to identify teacher-learners classroom interaction and discourse. Furthermore, CLIF focus on aspects such as the use of language and its impact during teacher classroom practices. Therefore with the use of CLIF, the researcher discovered that teacher Thakhani employed the above mentioned discourses and interaction in the teaching and learning of physical sciences using ESR as demonstrated in Table 9 (page 144). Contrary to when he was using ESR for PS, the researcher observed no discussion between teacher and learners. However, the discussion was among learners themselves. Thakhani was observed conveying information by means of explanation and questioning techniques to the learners which resulted in authoritative discourse and interactive-authoritative approach. This resulted in IRE pattern of discourse which limited learners' opportunities to participate. Furthermore, the patterns of discourse he applied, which is IRE, deprived learners an opportunity to use scientific skills such as raising questions. Additionally, learners were not given chance to make reflection on the lesson taught at the end of the lesson instead learners were given homework.

Drawing from the lessons observations where TPSSR and ESR, one can conclude that the developed TPSSR did definitely shape classroom interactions and discourses, which lead to meaningful learning of PS and further resulted in better performance in the subject, as alluded to by Mortimer and Scott (2003).

6.2.2. Case two: Takalani from Remarkable secondary school

6.2.1.1. Data presentation and discussion

Nystrand, Wu, Gamoran, Zeiser and Long (2001) describe classroom discourse as a way in which teachers talk and teacher-learner interaction in the classroom takes place. In addition, it unpacks how everyday language use shapes practices, processes and content demands of the curriculum (Green & Rex, 2018). On the contrary, researchers use classroom interactions to investigate which behaviours and teaching and learning strategies can be correlated with the learner learning indices (Green & Rex, 2018). In this study, the researcher investigated how the use of the developed TPSSR influences teacher-learner interaction and discourse during PS lessons. According to Mortimer and Scott (2003), interactions and discourse in the science classroom between the teacher and learners is fundamental to learning because it is central to the meaning making process.

In this case, the two types of discourses identified were authoritative and dialogic discourses. In an authoritative discourse, a teacher conveys information and the utterances are often made up instructional questions and factual statements to promote learning (Chin, 2006). Takalani's classroom practices enabled interaction between a teacher and learners; and among learners themselves and the content taught. However, interaction among learners and the content taught was limited as he dominated lecturing method on his teaching. During Takalani classroom practices authoritative discourse was employed as he mostly conveyed a lot of information to his learners through explanations techniques. Hence, this resulted to his lessons being teacher-centred . This is supported by the citation below when Takalani was teaching using developed TPSSR (Appendix S):

> *"Namusi ri khou do funzana nga thero, kha heyi thero ya physical science ri khou do funzanana nga thero ṱhukhu ya zwiimo zwa tshithu. (Today on physical sciences we will be teaching about phases of matter). Rina zwiimo zwiraru zwa tshithu ndi zwi tevhelelaho (We have three states of matter which are as follows), zwiomate ndi tshau thoma (solids is the first one), tsha vhuvhili rina zwiludi (the second one is liquids), tshiimo tsha vhuraru rina Vhutsi (the third state we have gas). Ri vho zwi ḓivha uri tshithu ndi tshiṅwe na tshiṅwe tshine tsha vha na tshileme (we already know that matter is anything that has mass)(mudededzi o dovholola – the teacher repeated the statement), na u dzhia Tshikhala (and occupy space).(initiation-authoritative). Tsumbo inwi no dzulisa zwezwo hanefho kha desike ni na tshileme tshine na lemelisa zwone ende he na dzula hone no dzhia Tshikhala (For example, it is you when you are seated on the desk you have mass and where you are seated you have taken the space) (Mudededzi o dovholola tsumbo) The teacher repeated the example). Vhunzhi ha tshithu kha ḽifhasi ndi tshiomate, tshiluḓi na Vhutsi (Most of matter in our world is solid, liquid and gas). Hezwi zwi vhidzwa u pfi ndi*

zwiimo zwiraru zwa tshithu (This is called the three phases of matter)" (initiation, example-authoritative.)"Takalani

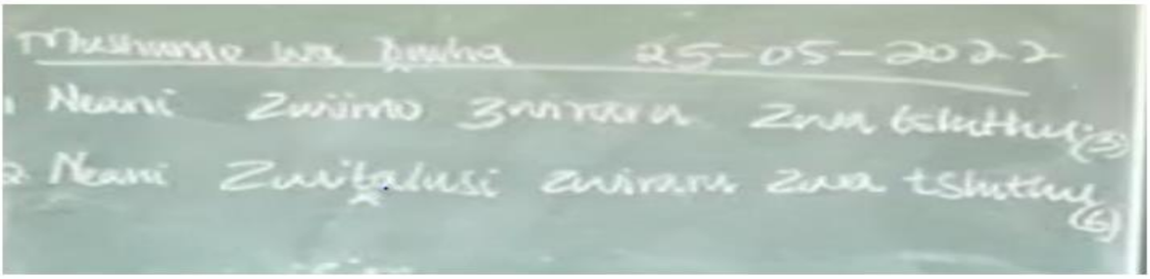
Takalani classroom practices about phases of matter were also observed when he was teaching using ESR (Appendix T) in his lesson presentation. During Takalani classroom practices authoritative discourse was employed as he conveyed more information to his learners through questioning techniques. Hence, his questioning techniques drove the lesson and enabled learners to develop thinking skills. Additionally, the questioned asked at the beginning of the lesson was based on learners' prior knowledge and experiences on the topic. This is supported by the following statement:

Takalani: *Today we are going to deal with the states of matter and kinetic theory. Define matter, yes?*
Learner*: Matter is anything that has mass and occupies space.*
Takalani*: Matter is anything that has mass and occupies space. examples of matter*
Leaner: *book.*

Chin (2006) describes dialogic discourse as a discourse that teachers use to encourage debates and challenges. This means that dialogic discourse motivates learners to learn from each other through discussing the lessons ideas among themselves. In his lesson presentations, Takalani enables learners with an opportunity to work in groups since they were instructed to do class activity in group. Hence, learners discuss the activity in their groups, but they were not given chance to present their finding to class, instead the teacher moves around marking group activity. However, though the teacher marked the activity of each group, no correction was done with the learners. This is supported by the following statement:

*"Zwa zwino nda do humbela uri ri nwale mushumo wa fhano kilasini u tevhelaho (Now I am requesting you to write the following classwork). Neani zwiimo zwiraru zwa tshithu (give three states of matter***)** *(initiation). So now seated there as a group before we proceed neh) (instruction)*

Neani zwitalusi zwirari zwa tshithu ni nwale nga group nahone munwali avhe muthihi (Give three states of matter and write as a group and one learner should write in each group)".Takalani

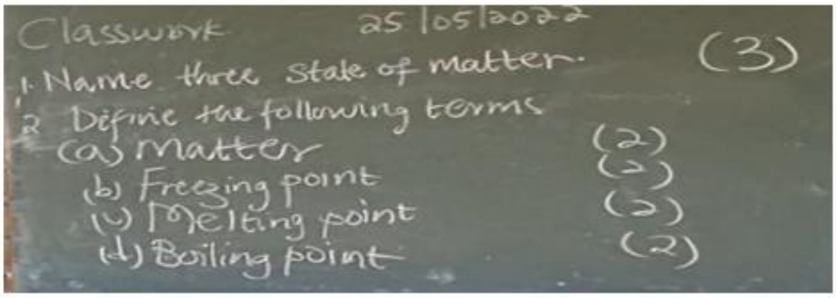


Classwork

Learners discussing classwork

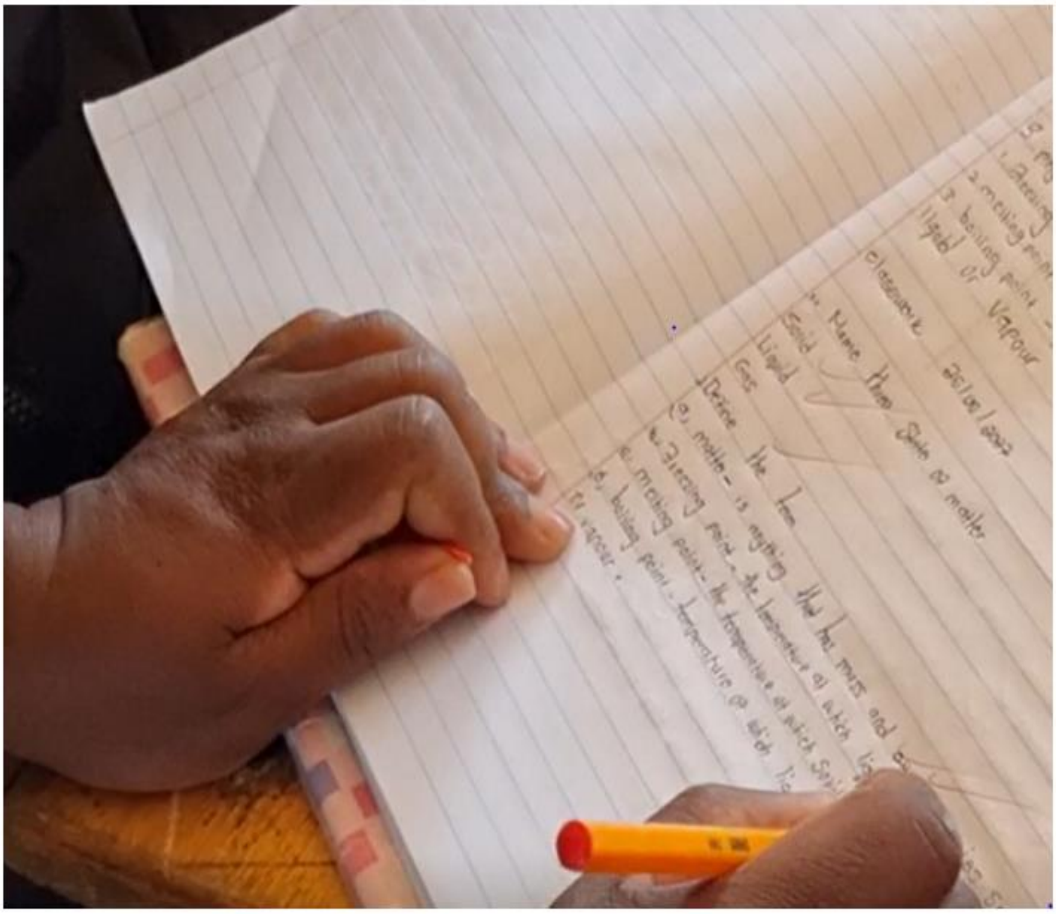
Example of a teacher marking group activity

During classroom practice where Takalani was using ESR, Takalani's initiation and interaction as well as discourse in the learning environment did encourage cognitive activity among the learners. Therefore, Takalani did employ dialogic discourse as learners were given class activity to discuss as a group. However, Takalani instead of allowing learners to present their responses to class, he marked group activity and no correction was done with the learners. This is supported by the following pictures:



Classwork

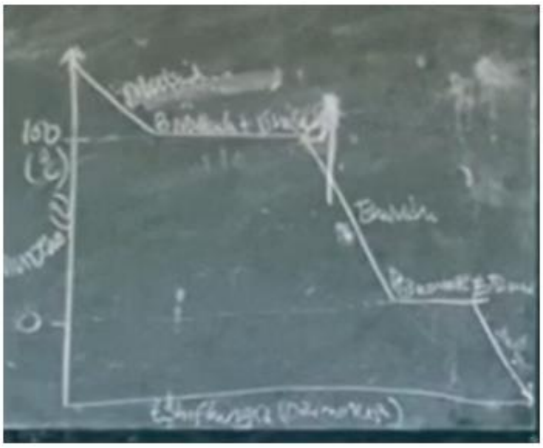
Learners discussing the activity



Teacher marking classwork

In a teaching environment, classroom conversations mostly arise with a teacher questioning the learners (Nassaji & Wells, 2000). Chin (2006) asserts that teacher questioning is a key component of classroom discourse, and they have potential in mediating the construction of knowledge in learners. In this case, the pattern of discourse during his classroom practice, Takalani used initiation, response and evaluation (IRE) pattern of discourse. Takalani explains some of the lesson ideas to his learners and thereafter he asked instructional questions based on the topic he introduced. In this pattern of discourse, learners were expected to respond to the questions posed by their teacher and thereafter the teacher made evaluation. The pattern of discourse Takalani employed was appropriate in assessing the learners' understanding on the topic proposed. Moreover, this pattern of discourse enables the teacher to diagnose learners' difficulties on the topic and assist the teacher to find alternatives that will cater learners experiencing a challenge on the topic. This is supported by the statement that follows when Takalani was teaching using developed TPSSR:

Takalani: *namusi ri khou do gudisana nga Mukombamo wa u fholisa,(today we will be teaching about cooling curve) Musi mutsiḓi wo tendelwa u fhola, u kona u sika maḓi na muxwatu(when steam is allowed to cool, to form water and finally ice). Mutalombalo u tevhelaho u ya zwi sumbedza(the following graph has shown that). vhananga ndi kha murotho ufhio une ra wana mutsiḓi na tshiludi?(my children at which temperature do we find steam and liquid) (initiation-instruction)*
learner: *kha dana (100) (answer)*
Takalani: *kha dana la digiri selishiasi (is at 100^{O}C) Khari muvhandele zwanda(Let us clap hands for him). ndi kha murotho ufhio une ra wana tshiludi na muxwatu? (at what temperature do we found liquid and solid) (initiation-questioning)*
Learner*: kha zero (is at 0). (learner response)*
Takalani: *ndi kha zero (is at 0), zwino arali ro lavhelesa hoyu mutalombalo wa vhorine u khou vhonala u khou tsela fhasi (if we can look at this curve it is decreasing). (evaluation-teacher makes judgement)*
Takalani: *kha maledere haya E na F(in these letters E and F) (mudededzi u sumba kha Mutalombalo we a u ola kha bodo- the teacher pointed on the curve he drawn on the board)kha mutalombalo wa vhorine ri na tshivhumbeo tshifhio tsha madi (so in our curve, water is in which form) ? Lufuno (demonstrate as shown with pictures below)*



Heating curve

Teacher pointing at the heating curve

Lufuno: *mutsiḓi(steam).*

Takalani: *ka ledere E na F (in letter E and F)*

Learners*: mutsiḓi (steam)*

Takalani: *a rina muxwatu (don't we have solid)?*

Learners*: muxwatu(solid)*

Takalani also employed initiation, response and evaluation (IRE) pattern of discourse when teaching PS using ESR. Takalani gave learners instructions and thereafter asked learners questions to check learners understanding. Hence, learners responded to the questions asked.

Takalani: *The main properties of solids, liquids and gases. Draw a table of three column. Under solid?? (initiation-questioning)*

Class*: solids have a solid form. (learner response).*

Takalani: *The form can only change by denting, breaking or bending it. Under liquids?*

Class*: liquids do not have a fixed form. (learner response).*

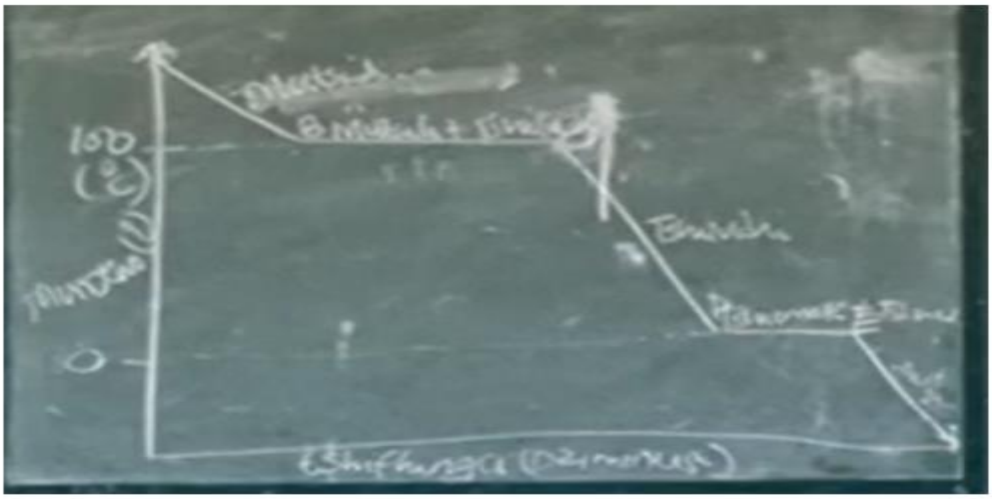
Takalani*: Under gas?*

Class*: gas do not have a fixed form. (learner response).*

During PS presentation with TPSSR and ESR for PS, same pattern of discourse was employed in the classroom. Hence, IRE was used to evaluate learners in both registers. Takalani first gave learners instructions and asked instructional questions to check for learners' understanding and the learners gave responses. The pattern of discourse proposed was appropriate for evaluating whether learners understood the content taught or not. The statements mentioned earlier indicated how IRE was employed in PS lessons with TPSSR and ESR.

In this study, the communicative approach during teacher classroom practices focuses on how a teacher works together with learners to address the ideas of a lesson. Takalani classroom practices did facilitate much of communicative and thinking skills. Takalani employed different communicative approaches, namely, interactive-authoritative, non-interactive-authoritative, interactive-dialogic, and non-interactive-dialogic.

According to chin (2006), interactive/authoritative approach is an approach where the teacher invites responses from learners but discounts their ideas since the focus is on a specific scientific idea. This is done by means of the teacher leading learners with questions, and they give responses, but the teacher will only focus on correct answers (chin, 2006). Takalani asked learners questions and only correct answers that learners gave were considered. Therefore, what Takalani said in the lesson was considered as final even though learners were invited to give responses.



Heating curve

Takalani: *Kha ledere A na B rina mini? (*in letter A and B we have what) *(interactive-authoritative)*

learners*: mutsiḓi (steam) (yes)(answer)*

Takalani: *ri na mutsiḓi (we have steam). kha ledere C na D ri na mini? (*in letter C and D we have what) *(interactive-authoritative)*

Learners: *tshiludi (liquid). (response)*

Takalani: *ri na tshiludi (we have liquid). Ri hu thihi rothe (we are together right)? (evaluate)*

Learners: *ee (yes)*

Teacher pointing at the heating curve

Takalani: *Ambani kha B na C ri wana tshivhumbeo tshifhio tsha madi? Ya (talk about B and C we find water in which form?).*

learners: *muludelo(condensation)*

Takalani: *mbudziso kha B na C ndo amba ndari mutalo musi u khou tuwa wotou tswititi rivha na zwithu zwivhili. Ya. (question, I said on B and C when the line is horizontal, we find two things) yes*

Learner: *tshiludi na mutsiḓi. (liquid and steam) (response)*

Takalani: *ari ri na mutsiḓi na tshiludi(he said we have steam and liquid). (Mudededzi ori a ri murwele zwanda-teacher asked class to clap hand for him)*

Interactive-authoritative communicative approach was identified in both TPSSR and ESR employed in the teaching and learning of PS. Hence, this approach indicated that there was a time where interaction was happening between a teacher and learners, and instructions were only initiated by the teacher. The teacher allowed learners to respond to what was asked but only correct responses given by the learners was considered. As shown in the above statements, Takalani asked questions, learners responded, and correct answers were considered.

A non-interactive/authoritative approach is the approach, which is best represented by the formal lecture, where ideas are presented in a monologue (chin, 2006). Takalani employed lecturing method for learners to understand the ideas of the lessons. Takalani conveyed information to his learners in a sequence manner. See the following statement:

> *“Ri do nwala zwiomate, zwiludi, na Vhutsi. (We will write solids, liquids and gas). Fhasi ha zwiomate thaluso ya u thoma iri zwiomate zwi na tshivhumbeo kana tshiimo tsha tshiomate(under solids the first explanation says solids have a solid form). Tshivhumbeo kana tshiimo tshi nga shanduka fhedzi nga u tou boda, u tshi pwasha kana u tshi kwasha kana na u tou tshi khotha (The form can only change by denting, breaking or bending it). fhasi ha zwiludi thalutshedzo iri zwiluḓi a zwi na tshivhumbeo kana tshiimo tsho tiwaho (under liquids, liquids do not have a fixed form). Tsumbo, tshiludi ra tshi shela kha khavho tshi dzhia tshivhumbeo tsha khavho. Kana ra tshi shela kha ndilo tshi dzhia tshivhumbeo tsh ndilo(for example, if we can place a liquids in a container it will take the form of a container or if we place liquids on a plate it will take the shape of the plate). fhasi ha Vhutsi, Vhutsi a vhu na tshivhumbeo tsho tiwaho(under gas, gas do not have a fixed form). Vhutsi vhu a phaḓalala ha dzhia tshivhumbeo tsha tshithu tshine ha vha khatsho (A gas spreads to take on the form of the container it’s in)”. (initiation, non-interactive-authoritative, lecturing - example). Takalani*

> *“The teacher proceeded and said physical condition of a substance. Ice is changed into water when it is heated to its melting point (The teacher repeated the statement). Water changes into vapour when it is heated to its boiling point. The physical condition of phase that a substance is in at a certain temperature number 1 we have a freezing point, melting point number 2 and number 3 boiling point. Under number 1 we have freezing point, the temperature at which a liquid is turned into a solid. Number 2 melting point, the temperature at which a solid turned into liquid. Number last, we have got boiling point, the temperature at which a liquid is turned*

into gag of vapour". (initiation, non-interactive-authoritative, lecturing). Takalani

Lecturing method was employed which resulted in non-interactive-authoritative communicative approach in PS lessons. The use of lecturing method revealed that lessons were sometimes teacher-centred. Hence, the teacher conveys information to learners in sequence manner as indicated above.

Table 10: Summaries of Takalani classroom interactions and discourse with the use of TPSSR

Theme	Category	Characteristics
Classroom interaction and discourse	**Types of discourse**	Dialogic discourse
		Authoritative discourse
	Patterns of discourse	Initiation
		Response
		Evaluation
	Teacher questioning	Drives lesson
		Improve learning
		Develop thinking skills
	Communicative approach	Interactive-authoritative
		Non-interactive-authoritative

With the use of CLIF (Figure 1, page 63) the researcher was able to diagnose teacher-learners classroom interaction and discourse. Additionally, CLIF focus on aspects such as language and its influence in the classroom. Therefore CLIF assisted the researcher to discover the above mentioned discourses and interaction used by teacher Takalani when TPSSR was employed during his physical sciences classroom practices as demonstrated in Table 10 (page 158). Takalani was observed teaching PS using TPSSR (Appendix S) and ESR (Appendix T) for PS. When he used the TPSSR, he was observed using authoritative discourse as he did more explanation which resulted to his lesson to be teacher-centred. Hence, opportunity for learners to share their ideas on the content taught was limited. However, dialogic discourse was employed by means of giving learner class activity to do in group where learners were discussion among themselves.

Hence, learners did not report their results to class but the teacher went to the groups and marked the activity. This means that learners did not exercise their communication and thinking skills by sharing ideas with their teachers. He further used an interactive authoritative approach as he only accepted learners' responses which were correct. He also employed questioning technique during his lessons, which he used as a strategy to assess learners' prior knowledge and to develop learners cognitive skills. Additionally, Takalani also used non-interactive-authoritative approach as he sometimes conveyed information to learners in a sequence manner. The pattern of discourse used by Takalani is IRE, as he initiated the questions, learners responded and thereafter he evaluated learners' responses.

Table 11: Summaries of Takalani classroom interactions and discourse with the use of English language register

Theme	Category	Characteristics
Classroom interaction and discourse	***Types of discourse***	*Authoritative discourse* ***Dialogic discourse***
	Patterns of discourse	*Initiation*
		Response
		Evaluation
	Teacher questioning	*Drives lesson*
		Improve learning
		Encourage and motivate
	Communicative approach	*Interactive-authoritative*
		Non-interactive-authoritative

The researcher employed CLIF (Figure 1, page 63) as it enabled her to identify teacher-learners classroom interaction and discourse. Furthermore, CLIF focus on aspects such as the use of language and its impact during teacher classroom practices. Therefore with the use of CLIF, the researcher discovered that teacher Takalani employed the above mentioned discourses and interaction in the teaching and learning of physical sciences using ESR as demonstrated in Table 11 (page 159). When he was using the ESR (Appendix T) for PS, Takalani started by asking learners question in order to check learners prior knowledge and experience on the topic he introduced to them which was phases of matter. By so doing learners were given chance to engage with the content and share their thinking with class. However, Takalani was observed conveying a lot of information to the learners through explanation and questioning which resulted to authoritative discourse. Takalani sometimes explained the lesson ideas in a sequential manner without allowing learners to add their ideas. Furthermore, Takalani employed both interaction-authoritative and non-interaction-authoritative communicative approach during his lesson. Takalani employed IRE pattern of discourse as he was observed asking learners questions and learners responded and thereafter, the teacher evaluated learners' responses.

6.2.3. Case three: Leon from Remarkable secondary school

6.2.3.1. Data presentation and discussion

Nystrand, et al. (2001) explain a classroom discourse as a way in which teachers talk and teacher-learner interaction in the classroom takes place. In addition, it unpacks how everyday language use shapes practices, processes and content demands of the curriculum (Green and Rex, 2018). On the other hand, researchers use classroom interactions to investigate which behaviours and teaching and learning strategies can be correlated with the learner learning indices (Green and Rex, 2018). In this study the researcher investigated how the use of the developed Tshivenḓa scientific register influences teacher-learner interaction and discourse during PS lessons. According to Mortimer and Scott (2003), interactions and discourse in the science classroom between the teacher and learners is fundamental to learning because it is central to the meaning making process. In this study, the two types of discourse identified were authoritative and dialogic discourse.

In authoritative discourse, a teacher conveys information and the utterances are often made up of instructional questions and factual statements to promote learning (Chin, 2006). Leon's classroom interaction and discourse encourage much of cognitive activity among the learners. During Leon's classroom practices, authoritative discourse was employed as he conveys more information to his learners through explanations and questioning techniques. See the following statement:

Leon: *ee hafha shangoni ri khou tshila ro no tangana na zwithu, asi zwone kani (Yes, when we are living in this world we have come across matters, isn't it?) (initiation-authoritative)*
Vhagudiswa: *Ee **(yes)** (response).*
Leon: *Zwino thi hu na kuambele kwo doweleaho kwa uri zwithu zwithu. zwino zwithu zwine ra khou nyaga u amba nga zwo namusi ri khou toda u amba nga hazwo kha saintsi. Zwino mafhungo ndi a uri hone kha saintsi ri tshi ri zwithu rivha ri khou amba mini. Ndi nnyi ane a nga amba uri ri tshi ri zwithu nga luambo lwa saintsi ri vha ri khou amba uri mini, Uri tshithu ndi tshithu kana zwithu ndi zwithu ri do zwivhonisa hani? zwithu ndi mini? (Now, there is this familiar talk of saying matters, matters. Now matters that we need to talk about today we need to talk about them in science. So, the news is in science when we say matters what do we mean? Who can tell us when we say matters in a language of science, what are we saying? How can we identify that matter is matter or matters is matters? matters is what?) (The class was in silence, difficult-no response from learners).*
Leon: *Zwino ri tshi amba nga zwithu rivha ri tshi khou amba nga tshinwe na tshinwe tshine tshavha na tshileme tsha dovha tshavha dzhia tshikhala Tshikhala (Now, when we talk about matters, we mean anything that have mass and occupies space).*

During classroom practices where Leon presented his lessons ESR, authoritative discourse was also employed as he did more explanation and questioning. Even though Leon conveyed information to his learners during his PS classroom practices, he sometimes did it in a form of demonstrating the ideas of the lessons in order to grasp learner's attention.

Leon: *The most important thing about matter is that it got mass and it also occupies a space. Having mass, it means that we can be able to weigh the mass of the objects, the mass of the matter neh. So, in this case here with me I am holding two things (see picture below) that can be classified as matter. The first one is the water inside neh.*

Class*: Yes.*

Leon*: and the jug itself, if you can check this jug that we have it stand in here and in this position where we have place this jug of ours we can see that it has occupy a space (see picture below and the teacher demonstrated while talking) and if we place it on something that can be used to measure the weight we can be able to know the mass of the object neh.*

Leaners: *Yes.*

Leon hold a jug with water inside

Leon demostrating the space taken by the jug with water inside

Leon: *So, it means that that thing is a matter. Even this duster (see picture below) simple because it has got a mass and occupy space within this room, so it qualifies to be a matter.*

Leon Holding a duster for demonstration

Chin (2006) reported dialogic discourse as a discourse that teachers use to encourage debates and challenges. This means that dialogic discourse motivates learners to learn from each other through discussing the lessons ideas among themselves. In his Lesson presentations, Leon enables learners with opportunities to form groups to discuss the lesson ideas and present their thoughts. Therefore, learners were able to exercise their communicative and thinking skills by discussion activities given by their teacher among themselves.

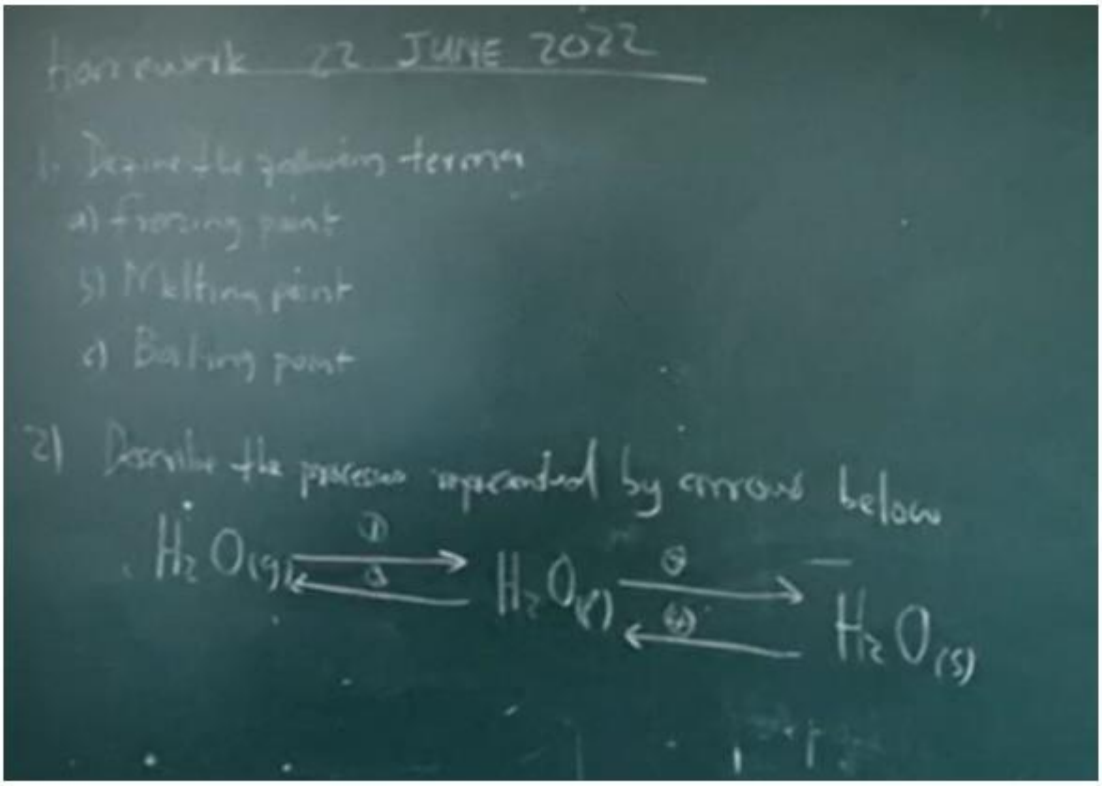
Leon: *Zwino ezwi zwiomate, na zwiludi na Vhutsi zwone ri zwi fhambanyisa hani? (initiation) Zwino ro dzula henefho nga group ri sathuya phanda thi (*how can we differentiate solids, liquids, and gases? *(initiation)*. So now seated there as a group before we proceed neh) *(instruction).*

Learners: Ee *(yes).*

Leon: *Ri khou dzula ra disikhaza ra disikhaza uri uri rine ri vhonounga Tshiomate, tshiludi na Vhutsi zwi fhambana gai?Hezwo ri do zwiita ra konou uri mini,rono disikhaza ra kono u tou zwi angaredza zwavhuḓi ra konou u wana uri ezwi zwiimo zwiraru zwa tshithu zwi fhambana nga mini. Zwiamba ri khou nwala uri Tshiomate na amba uri Tshiomate tsho ima nga ndilade, tshiludi na amba uri tshiludi tsho ima nga ndilade na kona u fhedzisela nga mini nga Vhutsi Ndi khou tou nifha minethe mitanu fhedzi na vha ni khou disikhaza uri vheiwe ni tshi tou zwivhona tshiomate na ludi na Vhutsi zwifhambana gai (You are going to discuss as a group as to how solid, liquid and gas differs? That is what you are going to* *do now thereafter we can summarise these three phases accordingly on the chalkboard on how they differ. This means that you are writing that solid and talk about how it looks like, liquids and talk about its appearance and conclude with what a gas. I am giving you only five minutes to discuss in your groups how the three phases of matter differ) (dialogic, learners discuss and share ideas among themselves as shown in pictures below)*

Learners discussing the group activity

During classroom practice where Leon was using ESR, Leon's initiation, and interaction as well as discourse in the learning environment did not encourage cognitive activity between him and learners and among the learners themselves. Therefore, Leon did not employ dialogic discourse as learners were not given an opportunity to discuss PS concepts among themselves even though they were seated as a group. So, Leon instead of allowing learners to do activities as a group he gave learners homework to do as shown in the following picture.



Learners homework

In a teaching environment, classroom talks mostly arise with a teacher questioning the learners (Nassaji & Wells, 2000). Chin (2006) indicates that teacher questioning is a key component of classroom discourse, and they have potential in mediating the construction of knowledge in learners. In this study, Leon’s questioning focused on IRE pattern of discourse. The pattern of discourse Leon used was appropriate in assessing the learners on what he taught. Hence, he was able to identify where learners were experiencing difficulties and able to resolve such difficulties experienced during the lessons. Leon gave instruction and asked instructional questions based on his explanation to check learners’ understanding and the learners gave answers and thereafter he did evaluations (See the following observation transcripts).

Leon: *Zwino tshithu ndi tshinwe na tshinwe tshine ra do tshi vhona nga mini, nga tshileme na u dzhia Tshikhala, zwi khou pfesesea musi? (Now, matter is anything that we can see by what, with mass and to take up a space. It is understood right?) (initiation-instruction)*

***Learners**: Ee (yes) (answer)*

***Leon:** zwino ndi dzifhio dzinwe tsumbo dza zwithu dzine na nga dzi amba vheiwe? (Now which examples of matter that you can say or tell me?) (initiation-questioning?)*

***Learner 1:** Desk (learner response)*

***Leon:** Nga Tshivenḓa a ri ri desike riri ndi tafula (in Tshivenḓa we don't say desk we say table) (evaluation-teacher makes judgement)*

***Learner 2:** tshidulo (chair) (learner response)*

***Leon**: Tshidulo, Tshidulo na tsho khetshi uri ndi tshi takuse hafha ndi fanela uvha ndo bvisa maanda ngauri tshia lemela ende hafha he tsha dzula hone huna tshikhala tshetsha tshi dzhia (chair, this is a chair, so I use strength to carry it because it is heavy and where the chair is placed there is a space that the chair has taken) (evaluation, teacher agreed, demonstrate as shown on the following pictures)*

(a) Leon holding a chair

(b) Leon showing the space taken by the chair

Leon: *So, we have got a solid, liquid and gas states. So, in a simple term what do you understand by the word solid or can you point out anything inside the class which is in a solid form. (initiation-questioning)*

Learner 1*: Beaker (learner response).*

Leon: *A beaker that the word that skip my mind neh, when I said a jug (evaluation, teacher agreed, demonstrate). Then another thing, yes.*

Learner 2*: Duster (learner response).*

Leon*: a duster, yes.*

Learner 3*: book (learner response).*

Leon*: a book (evaluation, teacher agreed).*

During PS presentation with TPSSR and ESR for PS, the same pattern of discourse was employed in the classroom. Hence, IRE was used to evaluate learners in both registers. Leon first gave learners instructions and asked instructional questions to check for learners' understanding and the learners gave responses. The pattern of discourse proposed was appropriate for evaluating whether learners understood the content taught or not. The statements mentioned earlier indicated how IRE was employed in PS lessons with TPSSR and ESR.

In this study, the communicative approach during teacher classroom practices focused on how a teacher works together with learners to address the ideas of a lesson. Leon classroom practices did facilitate much of communicative and thinking skills. Moreover, Leon employed different communicative approaches, namely, interactive-authoritative, non-interactive-authoritative, Interactive-dialogic, and non-interactive-dialogic (see observation transcripts).

According to Chin (2006), interactive/authoritative approach is an approach where the teacher invites responses from learners but discounts their ideas since the focus is on a specific scientific idea. This is done by means of the teacher leading learners with questions, and they give responses, but the teacher will only focus on correct answers (Chin, 2006). Leon asked learners questions and only correct answers that learners gave were considered. Therefore, what Leon said in the lesson was considered as final even though learners were invited to give responses (See the following observation transcripts).

Leon: *Zwino ari wane thebulu yashu ine yari talutshedza uri musi Tshithu tshi tshibva kha tshinwe tshi tshiya kha tshinwe zwi vhidzwa upfi mini. Tshiomate tshi tshi Shanduka uvha tshiludi ri ri ndi mini? Riri tsho ita mini?dzina la Tshanduko riri ndiu noka (Now let us get a table that will explain to us how the phases of matter change from one form to another is called what? Solid to liquid is called what? What is the name of change? We say the name of change is melts) (interactive-authoritative)*

Learners: *Ee (yes)(answer)*

Leon: *zwino ndi mini tshino itisa uri Tshithu tshi noke?* (What is it that cause matter of solid to melts?) *(interactive-authoritative)*

Learner 1: *mufhiso (heat). (response)*

Leon: *Ndi musi ro ita mini, ro fhisa (is when we heat) (evaluate)*

Leon: *Tshiomate tshi tshi Shanduka uvha Vhutsi. Dzina lahone ndi mini? (***solid change to gas?** *name of change is what) (interactive-authoritative)*

Learner 2: *u omesa (is hardness) (response)*

Leon: *Musi Tshiomate tshi tshi Shanduka uvha Vhutsi riri ndi mini? riri ndi sabulimesheni (When solid change to become gas we said is what? We say is sublimation).*

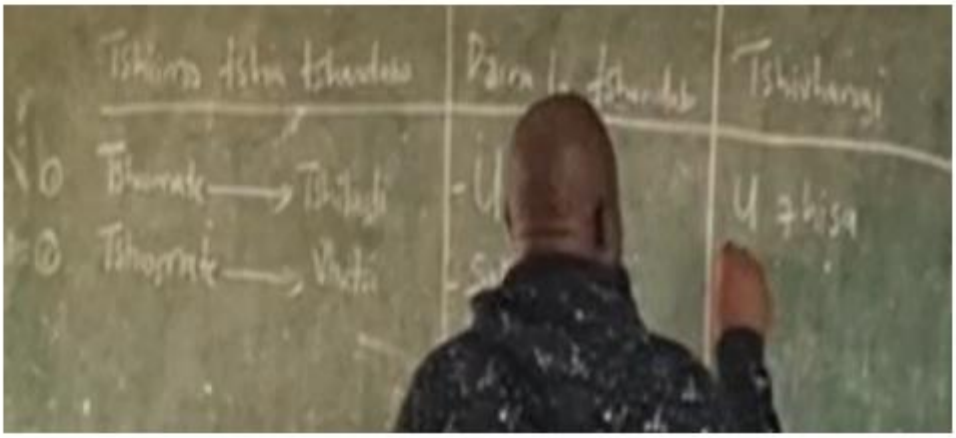


Table showing phase changes

Leon: *So, if we can have a look at something like water this water as we are seeing is on the other phase neh. A phase which we call a liquid. This water again can be able to transform into other phases it is not in all the time where we see* *water being like this in a liquid form Tell me other two states which water can appear to be in, yes(interactive-authoritative).*

Learner 1: *solid and gas.*

Leon: *this water can be a solid, at which condition can we have this water being a solid, under which circumstance are we going to see water being solid, in which form can it be solid or tell me any condition that can make this water to be in a solid form, yes. (interactive-authoritative)*

Learner 2: *When you refrigerate water, it become solid.*

Leon: *Your answer is correct, but you must speak aloud. When you refrigerate this water neh.*

Learners: *Yes.*

Leon: *It will turn into ice. So, ice is in a solid form, so then this water can also be in a form of gas at what circumstance can we find water in a form of gas., yes(interactive-authoritative).*

Learner 3: *Evaporation (incorrect).*

Leon: *evaporation is a process(evaluate)*

Interactive-authoritative communicative approach was identified in both TPSSR and ESR employed in the teaching and learning of PS. Hence, this approach indicated that there was a time where interaction was happening between a teacher and learners and instructions was only initiated by the teacher. The teacher allowed learners to respond to what was asked but only correct responses given by the learners was considered. As shown in the above statements, Leon asked questions, learners responded, and correct answers were considered.

A non-interactive/authoritative approach is the approach which is best represented by the formal lecture, where ideas are presented in a monologue (Chin, 2006). Leon employed lecturing method for learners to understand the ideas of the lessons. Leon conveys information to his learners in a sequence manner (see observation transcripts).

Leon: *Tshiomate tshi dzhia tshivhumbeo tsha tshiomate, ha fha ri khou amba uri tshi dzhia tshivhumbeo tsha u oma, tshinwe tshithu nga tshiomate futhi ndi yauri* *tshiomate uri tshi tshintshe tshivhumbeo ringa namba ra tou tshi khotha (ofara tshokho a khou sumbedzela ambodi i khopha yabva zwipida zwivhili), kana u tshi kwasha thi (Solid take the shape of solid, here we are saying it takes the shape of hardness. Another thing about solid is that for solid to change its shape we can bend or break it) (the teacher hold a chalk and break it into halve).(initiation, non-interactive-authoritative, lecturing- demonstration as shown in the next pictures)*

(a) Leon is holding a chalk (b) Leon break a chalk into two halves

Learners: ***Ee (****yes) (response).*

Leon*:* *(Zwiamba uri ringa zwi kona ngau tou tshi boda, ringa tou tshi kwasha, kana ra tou ita mini, ra tshi khotha,U khotha ndi he zwila zwine ra zwiita ri khou ita goloi dza dirata thi) it means that we can change solid form by means of denting, breaking or bending. Bending is what we do when we are doing or creating a wire car (non-interactive-authoritative, lecturing-example, demonstration as shown next).*

Leon demonstrating with his hands

Learners: *Ee (yes) (response).*

Leon*:* *Solid, liquid and gas; Gas has low mass comparing to liquid and solid. But I don't think it is weightless. I think if I can blow a balloon here the reason why it will move to a certain pace will also depend on a mass that is on the gas inside the balloon. However, after some consultation and book reading, I will give you the feedback tomorrow neh (initiation, non-interactive-authoritative, lecturing-example).*

Class: *Yes*

Lecturing method was employed which resulted in non-interactive-authoritative communicative approach in PS lessons. The use of lecturing method revealed that lessons were sometimes teacher-centred. Hence, the teacher conveys information to learners in a sequential manner as indicated earlier.

Chin (2006) reported interactive/dialogic approach as an approach where students' views are considered even though they may be alternative to the accepted scientific meaning. Leon accepted learners' ideas on the topic taught even though they are maybe alternative to the accepted scientific meaning (See the following observation transcripts).

Leon: *Zwino tshiomate tshi na tshileme tshihulwane ra nga dzhia tshiomate tshine ra vha na tsho hafha tshi a lemela thi* (mudededzi ofara tombo) (*solid is heavy, if we can take the solid that we have here it is heavy neh)* (teacher hold stone on his hands as shown in the next picture) (*initiation, interactive-dialogic)*.

Leon hold stone on his hands

Learners: Ee (yes)

Leon: *tshiludi tshone ari do amba ngatsho. Hu iteani kha tshileme tsha hone,ndi tshituku, ndi tshihulwane a tshi lemeli? aripfe* (what about liquid, let's talk about liquid. Is liquid heavy or not? Let's hear**)** *(interactive-dialogic)*

Learner 1: *tshileme tsha tshiludi ndi tshihulwane kha tsha Vhutsi mara tshavha tshituku kha tsha tshiomate* (liquid is heavy comparing to gas, but liquid is not heavy than solid).

Leon: *So, what do we call a process where solid changes to gas, what do we call the process? (initiation-reading what wrote on the board, interactive-dialogic)*

Learners: *sublimation* (response-read answer from the chalk board).

Leon: sublimation, so a process whereby gas changes into solid what do we call it?

Learners: *Deposition* (response-read answer from the chalk board).

Leon*: deposition, a process whereby liquid changes its form into a gas form what do we call it?*

Learners: *evaporation* (response-read answer from the chalk board).

Leon: *Its Evaporation, then what do we call a process whereby gas changes into liquid, what do we call it?*

Learners: *condensation* (response-read answer from the chalk board).

Leon: *Condensation, I can advise you to know this way by heart neh.*

Learners: *Yes.*

Leon: *otherwise it will help you in understanding these concepts. When liquid change into solid what do we call it?*

Learners: Freezing (response-read answer from the chalk board).

Leon*: Liquid to solid is freezing.*

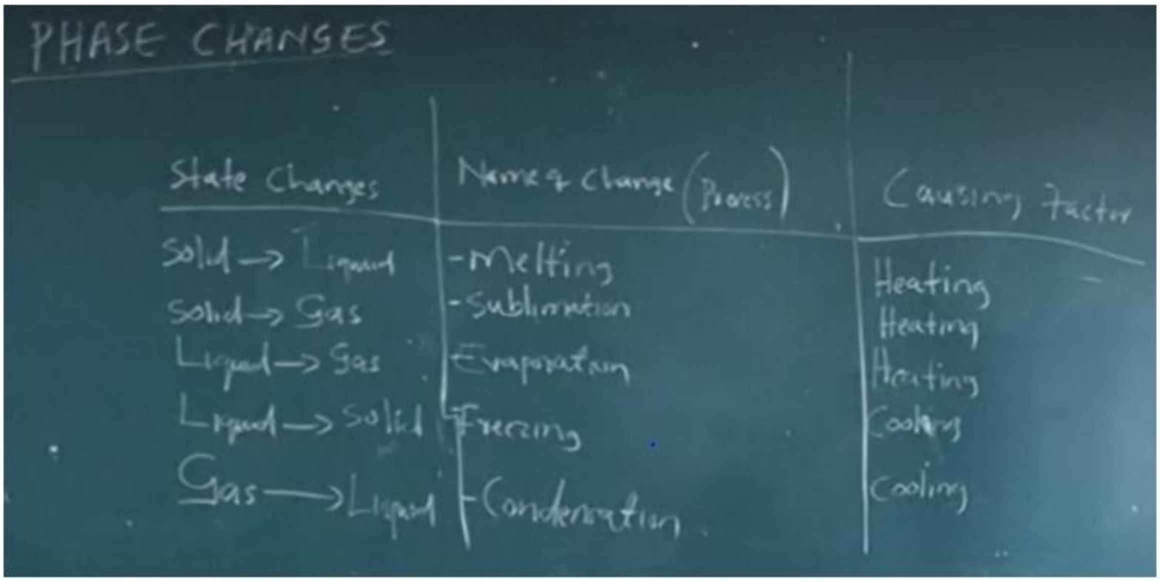


Table of phase changes

The views of learners were taken into considerations during the lessons which resulted in interactive-dialogic communicative approach. PS lessons with the use of TPSSR, the teacher facilitated thinking skills as indicated earlier. However, in lessons presented using ESR, the teacher enables learners to respond by what was already in the chalk board to avoid language barrier as learners were learning through language which was not their own. Therefore, all answers were accepted as they were already on the chalk board as indicated in statements presented using ESR.

In a non-interactive/dialogic approach, the teacher does not invite other points of view from the students but makes statements that also address other points of view in addition to the formal ones (Chin, 2006). Leon in some cases during his lesson he only make statement to address the idea of the lesson and not invite the views of learners (see observation transcripts)

Leon: *Zwino madi a nga kona u dzhia tshivhumbeo tsha tshiomate. Ra vhea madi kha tshixwatudzi a ya kona u rifha mini? muxwatu thi(liquid can take a form of solid. If we put water in the refrigerator can give us what? Ice neh (non-interactive-dialogic)*

Learners: *Ee(yes).*

Leon: *muxwatu ndi hezwila zwine vheiwe na khou ri ndi gwada zwi khou pfala musi? (ice is what you guys said is gwada, you do understand right?) (Non-interactive-dialogic)*

Learners: *Ee(yes).*

Leon: madi *aya kona u dzhia tshivhumbeo tsha tshiomate sa muxwatu. Mara madi nga mvumbo yao ndi tshiludi. mvumbo ya madi ndi tshiludi, zwiamba uri madi asathu tangana na zwe a tangana nazwo avha a kha tshivhumbeo tsha tshiludi (Water can take a form of solid like ice. But nature form of water is liquid. Form of water is liquid, which means before water being change in another is liquid) (non-interactive-dialogic, convey information)*

Leon: *Ice is an example state of a solid but that is example of how water can be in a solid state neh.*

Learners: *Yes.*

Leon: *Then in a liquid, the nature form of water is in liquid then but water when you boil water it releases a steam neh.*

Learners: *Yes.*

Leon: *And steam is in a form of a gas. Of a gas. That is why we will say that water can be in a form of a gas when you are boiling, the nature of water is in liquid form, and when you freeze water it become ice and ice take a solid form*

Leon classroom practice did employ non-interactive-dialogic as sometime the teacher did not request for learners' views. Hence, the teacher sometimes addresses the ideas of the lessons to the learners not considering that learners might have some ideas to add on the lessons. This type of communicative approached resulted in teacher-centred lesson. Additionally, learners' opportunity to interact among themselves and the content taught was limited. Table 12 and Table 13 present teacher-learner classroom interaction and discourse employed in PS lessons.

Table 12: Summaries of Leon classroom interactions and discourse with the use of TPSSR

Theme	Category	Characteristics
Classroom interaction and discourse	**Types of discourse**	Dialogic discourse
		Authoritative discourse
	Patterns of discourse	Initiation
		Response
		Evaluation
	Teacher questioning	Drives lesson
		Improve learning
		Develop thinking skills
		Encourage and motivate
	Communicative approach	Interactive-authoritative
		Non-interactive-authoritative
		Interactive-dialogic
		Non-interactive-dialogic

With the use of CLIF (Figure 1, page 63) the researcher was able to diagnose teacher-learners classroom interaction and discourse. Additionally, CLIF focus on aspects such as language and its influence in the classroom. Therefore CLIF assisted the researcher to discover the above mentioned discourses and interaction used by teacher Leon when TPSSR was employed during his physical sciences classroom practices as demonstrated in Table 12 (page 175). When using the TPSSR for PS, Leon applied authoritative and dialogic discourses. Authoritative discourse was employed when Leon conveyed more information to learners through explanation and questioning. Additionally, he sometimes conveyed the idea of the lesson in a sequence manner without pausing and give learners opportunity to say something on the content he was teaching. Hence, such resulted to Interactive-authoritative and non-interactive-authoritative communicative approach. However, dialogic discourse was also employed, learners were given activity to work in group which was encouraging and motivating and also developed learner cognitive skills. Thereafter, correction was done by both teacher and learners in their classroom. By so doing, learners was able to interact with the content taught, the teacher and among themselves. Therefore, that resulted to Interactive-dialogic communicative approach. However, non-interactive-dialogic were also employed where the teacher make statements that addresses other ideas of the lesson in addition to what learners already know. The pattern of discourse used was IRE as it was appropriate for Leon to assess learners understanding on what he taught.

Table 13: Summaries of Leon classroom interactions and discourse with the use of English language register

Theme	**Category**	**Characteristics**
Classroom interaction and discourse	***Types of discourse***	*Authoritative discourse*
	Patterns of discourse	*Initiation*
		Response
		Evaluation
	Teacher questioning	*Drives lesson*
		Improve learning
		Encourage and motivate
	Communicative approach	*Interactive-authoritative*
		Non-interactive-authoritative
		Interactive-dialogic
		Non-interactive-dialogic

The researcher employed CLIF (Figure 1, page 63) as it enabled her to identify teacher-learners classroom interaction and discourse. Furthermore, CLIF focus on aspects such as the use of language and its impact during teacher classroom practices. Therefore with the use of CLIF, the researcher discovered that teacher

Leon employed the above mentioned discourses and interaction in the teaching and learning of physical sciences using ESR as demonstrated in Table 13 (page 176). When he was using ESR for PS Leon employed authoritative discourse as he was observed conveying more information to his learners by means of explanation and questioning. Leon employed IRE pattern of discourse and the teacher was observed giving learners instruction and asked instructional questions to assess learners understanding and learners gave responses. The communicative approach that Leon used was interactive-authoritative. The interaction was mostly on teacher and learners and only the teacher gave instructions. However, there was a time where the teacher conveyed information to learners in a sequence manner without asking learners questions or input which resulted in *non-interactive-authoritative* communicative approach. Therefore, learners were not given chance to interact among themselves by means of pausing questions or giving an input based on the content.

6.3. Findings from the three cases

The study discovered that the application of developed TPSSR in the teaching and learning of PS was successful. Teachers (i.e. Thakhani, Takalani and Leon) were able to use the TPSSR in their lesson's preparation and during their classroom practices. Even though the TPSSR was successful, teachers did experience challenges in their PS lessons preparations since it was their first-time doing lessons preparations using TPSSR instead of ESR. There were few words that were presented in the developed TPSSR that were new to them and they used English-Venda dictionary as well as other translation documents to understand some of the words used in the developed register. Additionally, they reached out to their colleagues who teach Tshivenḓa to explain those words to them.

During PS lesson, the researcher noted that some learners did experience few challenges as they were used to PS words being written in ESR. Hence, teachers assisted those learners as they were able to explain those words that seem to be difficult for learners to understand them. However, lessons were also delivered through ESR and learners did experience some difficulties in understanding some of science concepts and teachers saw code switching as the best available strategy that could facilitate the learning and teaching of PS. This is confirmed by Maluleke (2019), when reporting that some teachers during their classroom practices draw on code switching as a method of teaching to support their learners in learning and understanding the ideas of the lesson taught without difficulties.

The study discovered that the teachers conveyed information to their learners by means of explanation and questioning. However, teachers encouraged discussion because learners were seated in groups and they were given activity that requires them to discuss among themselves and thereafter reported their responses to the class. Green and Rex (2018) indicate that academics employed classroom interactions to explore activities and learning and teaching approaches associated with the learner learning indices. However, in Takalani's case, the teacher marked the group activity himself. The researcher discovered that teachers used of the chalkboard in their entire lessons observed where they wrote notes for the learners and learners did copy those notes. Beside using the developed TPSSR guide given by the researcher, Leon also brought some resources that assisted in the teaching and learning of PS. The resources used during Leon's classroom practices includes stone, water, jug, beaker, containers of different shapes and other materials that were available in the classroom that relate to the lessons taught for learners to be able to understand what he was teaching using TPSSR. The same resources were also used in Leon lessons presentation which were done through ESR. However, Thakhani used the objects that were available in the classroom that were related to the lesson taught whereas Takalani depends only on developed register given by the researcher, and he did not improvise other teaching materials to help his learners to learn visualisation but he gives examples during the lessons. Hence, the way that teachers taught phases of matter topic did enable the learners to take notes during the lessons since he wrote notes for learners on the chalkboard.

During their lessons, the researcher noticed that teachers assisted their learners to learn the ideas of the lesson by means of doing many explanations, using examples, doing some demonstrations, and questioning in the classroom. All the activities that Leon and Thakhani gave their learners were marked with the learners in the classroom. However, Takalani marked group activity by himself and no corrections was done with learners. It was also noted that there were few challenges that learners' experiences during the application of TPSSR in PS lessons. Learners had difficulties in understanding words such as tshiomate (solid), muxwatu (ice), tshixwatudzi (fridge), etc which were presented in TPSSR. However, the teacher was able to identify the words learners experiences some difficulties and they assisted them by explaining the words e.g. learners did not know what fridge and ice is in their home language. Hence, after some clarity the teacher made on the word's learners find them difficult in TPSSR, learners realised that they knew those words in English as they are used to them in English language.

The researcher noted that the learners were happy and participated fully during the lessons taught through TPSSR. Msila (2010) indicated that learners learn the content of curriculum subject better when using the language that they understand and speak. Msila (2010) is supported with the finding of this study as the researcher noted that the use of TPSSR in the teaching and learning was successful because almost all the learners participated in the lesson. Chavez (2016) asserts that learners should be taught in language they know best as they will develop their competences and aid them to fully comprehend expressions and to express themselves competently and confidently. Hence, what Chaves (2016) asserted is confirmed in this study as learners were able to engage themselves by raising up their hands and give responses to questions asked using the language used in the register (Tshivenḓa). In support of the above-mentioned, Moreover, they found it easier to express their thought or the ideas of the lesson being taught through the language their familiar with.

However, during teachers' classroom practices through ESR, they asked learners questions and responses given by learners were few and mostly weak. These seemed to know that their learners have problem of English language and avoided asking them challenging questions which resulted in lessons being teacher-centred. Smith (2010) indicates that learners who are not using the language they are familiar with while learning, especially their mother tongue, are underprivileged and unlikely to perform to their best of their abilities. Teachers were able to explain the concepts in such a way that learners found easier to understand. It was also noted that teachers used various teaching methods when they taught phases of matter. The method used allowed learners to participate during the lessons. Teachers teaching methods includes examples, question and answer, lecturing by means of explanation and demonstration so that learners could understand the ideas of the lessons.

The researcher also noted that some of the questions teachers asked learners were easier for them, but they also posed questions that required learners' cognitive skills. There were also activities that learners were given as a group to discuss among themselves and such questions required their thinking skills and they were able to respond to such questions. Teachers also asked learners questions that will need responses that are based on the objects that were available in the class and learners were able to use the objects that were available inside their classroom when answering some questions that requires such objects. However, other questions teachers asked required learners to use their critical thinking and communication skills such as deductive reasoning, e.g. they were asked to differentiate the properties of three phases namely, liquid, gas, and solid. They were also asked to explain the phases changes. Learners were also excited as they were learning PS through language register which is their home language and it was easier to learn the ideas of the lessons through the language of their own. Botha (2022) reported that mother tongue assist with learner-centred teaching approach which is effective, and encourage learners to be active participants during their classroom learning experiences.

The study also revealed that the use of ESR was a barrier to the learning and teaching of PS for learners who do not have a firm foundation in English and whom English is not their home language. These resulted in learner's minimum participation, and it was not easier for them to engage themselves in lessons. Learners' limited understanding of the subject matter also contributed to the passiveness of the learners during PS lesson presented in ESR. However, the researcher had noted that some learners in class were quiet during the entire lesson.

The knowledge and methods teachers used sometimes created the opportunity for learners to interact with their teacher, among themselves and the subject matter. However, teachers also sometimes used the lecturing method to explain other ideas of the lesson. The study identified that teachers used both authoritative discourse and dialogic discourse in their classroom practice. In authoritative discourse, a teacher conveys information and the utterances are often made up of instructional questions and factual statements to promote learning (Chin, 2006). Chin (2006) describes dialogic discourse as a discourse that teachers use to encourage debates and challenges. The researcher also found that the teacher sometimes asked questions that led to an argument between the teacher and the learners e.g. the teacher asked the learners questions based on phase changes. Learners were given the opportunity to ask questions and speak their thought on the content taught but none of them posed the question to the teacher.

The study revealed that teachers assisted the learners to develop and learn process skills like oral communication that was emphasised in the science subject CAPS document for learners to develop and gain in the PS lesson. Leon gave learners an opportunity to exercise their oral communication skills by means of explaining why water exist in three states of matter, namely, gas, liquid and solid. Thakhani gave his learners an opportunity to report their findings by means of writing their responses on the chalkboard. As a result, this encourages learners to have interest on the subject matter content. However, in Takalani’s case learners opportunity to express their thought was limited as he marked class activity instead of marking with the learners. The researcher found teachers’ pattern of discourse as appropriate as they assessed the learners by means of questioning them and learners responded thereafter, they evaluated learners’ responses. There were opportunities for learners to feel like they were in control of their learning even though it was limited. Consequently, Leon and Thakhani employed both interaction-authoritative and interaction-dialogic communicative approach during their lesson whereas Takalani employed interaction-authoritative and non-interactive-authoritative.

6.4. Summary

In this section, data presentation and discussion of results from the three cases was done under appropriate themes proposed for this study. Data presented and discussed were obtained from data collection techniques namely, diary, interviews and classroom observation. The findings were presented. The next chapter presents answers to the research questions and recommendations of the study.

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1. Introduction

In this chapter, research questions are answered, contribution to the field is offered, recommendations of the study are stated, study limitations and conclusions are presented.

7.2. Research questions

This study was intended to observe the application of developed TPSSR during teacher PS classroom practices. The goal of this qualitative study was to develop and use TPSSR in the learning and teaching of PS in other schools sited in Vhembe West District, Limpopo Province. This research endeavoured to answer the research questions that follows to accomplish the study aim:

- What are the challenges and opportunities in the development of TPSSR for teaching and learning of PS?
- What are the challenges and opportunities in the use of TPSSR for the teaching and learning of PS?
- How does the use of TPSSR in the teaching and learning of PS influence interaction and discourse?
- What are the views and perceptions of PS teachers, parents, and learners towards the use of TPSSR for PS?

7.2.1. What are the challenges and opportunities in the development of TPSSR for teaching and learning of PS?

Researcher

The journey of the development of TPSSR for teaching and learning PS on the topic of phases of matter and kinetic molecular theory was not easy. In addition, no research conducted before on the subject under exploration. Consequently, such resulted in researcher experiencing challenges that nearly caused her to quit conducting the study. However, there were some opportunities the researcher experienced along the route of developing TPSSR which supported and encouraged the researcher to keep on going.

Some of the challenges the researcher experiences in her development of TPSSR are presented in the following sequence:

- ❖ The researcher had difficulties in selecting and deciding on which PS materials to use as references.
- ❖ Family and friends were not able to assist with someone who can assist with the translation of some words the researcher found difficult.
- ❖ Lack of Venda-English dictionary at three local bookshops.
- ❖ Not all the scientific words researcher found difficult were obtained from the Venda-English dictionary.
- ❖ Translator who was promising to assist could not assist owing to personal challenges.

Some of the opportunities that the researcher came across in her path in support of developing TPSSR are presented in the following sequence:

- ❖ Grade 10 PS textbooks obtained from local schools which cannot be named for confidentiality purpose namely, study and master physical science; successful physical science; mind action series physical science; siyavula physical sciences; platinum physical sciences; and physical science Grade 10 book 2 theory and workbook were used as references in the development of TPSSR.
- ❖ A colleague offers English-Venda dictionary.
- ❖ Colleagues and senior citizens assisted with the development of some Tshivenḓa scientific words and equivalent scientific words not obtained from Venda- English dictionary.
- ❖ Supportive supervisor.
- ❖ Interact with variety of people.

7.2.2. What are the challenges and opportunities in the use of TPSSR for the teaching and learning of PS?

A. Case one: Thakhani

The study found that Thakhani holds HED teaching qualification where he majored with PS and mathematics. Additionally, he had 27 years of teaching experience. The participants (i.e. Thakhani, parents and learners) in Dominance secondary school were Venda speaking people. This was diagnosed during the interviews which were conducted between the researcher and the participants. Thakhani and his learners at Dominance secondary school had challenges with the application of TPSSR which were diagnosed during the PS lessons and interviews. In this case, both Thakhani and his learners' experiences difficulties with some of scientific words in Tshiveṋḓa presented in the developed TPSSR. Hence, Thakhani and his learners were used to ESR in the learning and teaching of PS. Furthermore, they did not understand some of the words appeared in TPSSR because they were new to them. However, Thakhani used different textbooks, e.g. Venda-English dictionary and other translations documents for him understand and found alternatives words to those used in the developed register. Beside the challenges teacher and learners' experiences with the use of TPSSR, there were also opportunities. Teacher and learners interacted well during teacher classroom practices as they were able to understand each other through language used in TPSSR which was language of their own (Tshiveṋḓa). Learners were able to express their thoughts on the ideas of the lessons taught with confident as they were given chance to write activity in groups and presented their findings to the class. The teacher assisted the learners to understand the scientific words in Tshiveṋḓa by means of explaining with examples and he sometimes repeated the statements. The teacher presented PS lessons in a way that encouraged learners to participate during the entire lessons delivered by their teacher. Additionally, notes for learners were written on the chalkboard for learner to copy.

B. Case two: Takalani

The study discovered that Takalani has experience in teaching and qualified to teach PS as he majored with mathematics and PS in his HED teaching qualification. Hence, this was detected during his PS classroom practices and interviews. The participants in obtainable secondary school were Venda speaking people. This was discovered during the interviews conducted with them. Teacher and learners at obtainable secondary school experienced difficulties with the use of TPSSR which were diagnosed during the interviews with them. In this case, both Takalani and his learners experienced some difficulties with the use of TPSSR in the learning and teaching of PS since they were using ESR in the learning and teaching of PS. Additionally, they were not familiar with some of the Tshiveṋḓa scientific words. Beside the challenges the teacher and learners experienced with the use of TPSSR, there were also opportunities. Teacher and learners interact well during teacher classroom practices as they were able to understand each other through language used in TPSSR which was language of their own (Tshiveṋḓa). Learners were able to express their thought on the ideas of the lessons taught as they were given opportunity to debate the concepts of the lessons among themselves even though it was limited. The teacher assisted the learners to understand the words they find difficult by means of repeating some of statements with example. The teacher presented the lessons and his presentations mostly employed lecture approach which resulted in lessons being taught. Hence, the chance for learners to employ their cognitive skills during lessons were inadequate. However, Takalani wrote notes for learners on the board and they (i.e. learners) wrote the notes.

C. Case 3: Leon

The research revealed that participants in Remarkable secondary school were Venda speaking people. This was discovered through the interviews conducted with them. The teacher and learners at Remarkable secondary school experienced common challenges which were diagnosed during the interviews with them. In this study, both Leon and his learners experienced some difficulties with the use of TPSSR in the learning and teaching of PS since they were presently using ESR in the learning and teaching of PS. Furthermore, they did not understand some of the words appeared in TPSSR because they were new to them. Beside the challenges teacher and learners experienced with the use of TPSSR, there were also opportunities. Teacher and learners interacted well during teacher classroom practices as they were able to understand each other through language used in TPSSR which was language of their own (Tshiveṋḓa). Learners were able to express their thoughts of the lessons taught with confidence as they were familiar with the language used in TPSSR. The words the teacher found to be difficult were explained to him by his colleague who teaches Tshiveṋḓa. Subsequently, the teacher assisted the learners to understand the words they found difficult by means of explanations, demonstrations and repetition of statements. The teacher presented the instructions in a way that motivate his learners to pay attention and participate fully. Additionally, notes for learners were written on the chalkboard for learners to copy.

7.2.3. How does the use of TPSSR in the teaching and learning of PS influence interaction and discourse?

A. Case one: Thakhani

The use of TPSSR in the learning and teaching of PS created sufficient chances for learners to interact with their teacher, between themselves and the content of subject under exploration. Thakhani asked learners questions at the beginning of the lesson that required learners' experiences or prior knowledge. By so doing, learners were able to make connection with what they previously learnt with the new knowledge the teacher presented to them. Hence his questioning drove the lessons and allowed learners to exercise their cognitive skills. However, Thakhani also asked learners questions during the lesson to assess how far learners are following what he taught and that resulted to IRE pattern of discourse.

During the lesson, Thakhani used dialogic discourse as he gave learners activity which required learners to work in groups. Learners worked on the group activity and thereafter their teacher gave them chance to present their finding by means of writing their replies on the board. Hence, the activity given to learners encouraged and motivated them to participate on their learning and enable learners to express their thinking on the content taught.

Thakhani used objects within the classroom for explanatory purposes and that allowed the teacher to improve learning as learners learnt well through examples and illustration done by their teacher. Therefore, the lessons taught with TPSSR considered appropriate in such a way that teachers were able to interact with learners through questioning, explanation, demonstration and evaluation. Hence, learners responded to the questions their teacher asked very well, and they were able to interact and discuss the activity among themselves. This was so because TPSSR was appropriate for teacher and learners to understood each other. Additionally, the language used in the register was teacher and learners home language. Therefore, Thakhani used authoritative discourse in explaining ideas of the lesson and dialogic discourse exercised through learner discussion and reporting their results back to class.

B. Case two: Takalani

The knowledge and methods Takalani employed during his PS classroom practices created limited chance for learners to interact with the teacher, between themselves and the content taught. Takalani's lessons were mostly teacher-centred since there was no argument among teacher and his learners. Instead, the teacher mostly provided learners with too much information without asking learners questions. Takalani asked learners questions based on their experience but they were limited. Additionally, Takalani gave learners the opportunity to discuss the activity as a group and by so doing, he was able to develop learners critical thinking skills. Unfortunately, the teacher did not mark their activity instead the teacher marked group activity and no corrections done with the class.

During his teaching, Takalani focused only on developed TPSSR. Takalani did use demonstrations, questioning and examples to improve learning. Therefore, by so doing, the teacher interacted with his learners and that motivated them to participate in the lesson. Therefore, the use of TPSSR was appropriate in such a way that the teacher was able to interact with learners through questioning, demonstration, explanation, and feedback. Hence, learners were able to respond their teacher and learners interact easily during the time they were doing activity as a group through language used in TPSSR as they understood each other. Learners in their group activity discussed and did some explanations using examples; so, they interacted well among themselves and the concepts. Therefore, Takalani used authoritative discourse in explaining ideas of the lesson and dialogic discourse exercised through learner discussion but they were not given chance to report back to class.

C. Case three: Leon

The knowledge and methods Leon used during his PS classroom practices generated several chances for learners to interact with the teacher, among themselves and the content of PS. Leon used prior knowledge to evaluate if learners still recalled what they were previously taught. By so doing, Leon facilitated the lesson with creation of chances for learners to interact between themselves, with the teacher and with the subject matter. Therefore, learners were able to connect previously experiences on the concepts with new information. Therefore, Leon gave learners chance to discuss the activity as a group and by so doing, he was able to develop learners' critical thinking skills. Hence, the activity enables learners to exercise their reasoning skills, interacted with each other and discussed the ideas provided in the lessons.

Leon used objects like stones, chairs, tables, beakers with water inside, containers of different shapes and etc for illustration purposes. The demonstrations and examples the teacher used improve learning as it allowed interaction in the classroom and encouraged learners to take control of their learning as they engage themselves on the entire lessons. Therefore, the lessons taught with TPSSR was appropriate in such a way that teacher were able to relate with learners through questioning, demonstration, explanation, and feedback. Hence, learners were able to respond to their teacher and learners interacted easily during the time they were doing activity as a group through language used in TPSSR as they understood each other. Learners in their group activity discussed and do some explanations using examples; so, they interacted well among themselves and the concepts. Therefore, Leon used authoritative discourse in explaining ideas of the lesson and dialogic discourse exercised through learner discussion and reporting back to class.

7.2.4. What are the views and perceptions of PS teachers, parents and learners towards the use of TPSSR?

A. Case one: Thakhani

The study discovered that Thakhani has a positive perception on the application of TPSSR in the learning and teaching of PS. His perception is because TPSSR makes it easier for learners to participate with confidence without fear since language used in the register was their language (i.e. Tshivenḓa). As a result, teaching and learning PS using the developed TPSSR minimises problems like language barriers, fears, and shyness some learners experienced when learning through ESR, which is not language of their own. Learners in this case had different views on learning PS through the developed TPSSR. Some learners saw the developed TPSSR as a great opportunity to learn to the best of their ability without language hindering their understanding of content whereas others thought learning PS through language other than English is difficult as they are used to English even though they do experiences challenges in understanding some of English words. Most of the parents in this case were in support of the use of TPSSR in the teaching and learning because they think learners will perform well since language use in register is the language they mostly use in their daily basis, and they are good in the language (i.e. Tshiveṋḓa). In contrast, other parents criticised the use of the developed TPSSR based on the fact that learners did not communicate well if they meet people with different language to theirs and that English is the language mostly used in different institutions unlike Tshiveṋḓa.

B. Case two: Takalani

The study revealed that Takalani supported the use of the developed register. His perception is supported by the fact that when he gave learners class activity in both Tshiveṋḓa and English register, he noted that they performed better in Tshiveṋḓa than in English. He further noted that using TPSSR assisted learners to learn PS ideas easier since the register was written in their home language. Takalani also acknowledges the difficulties of using the language, i.e. English which is dissimilar to the language learners used at their household. In the learning environment, using English as LoTL for African learners poses many challenges in some learners with poor or little understanding on the language. Hence, Takalani reported that he used code switching for learners to understand some of science ideas. Learners shared same perceptions about the use of TPSSR to teach PS. These learners are in support of the application of TPSSR because they value it as an opportunity for them to perform better in the subject. They further indicated that learning PS using TPSSR will enable them to participate fully in the subject under exploration as they will be hearing and understanding science concepts because the language that they will be using will be the language of their own, which they understand better compare to other languages. Parents shared different perceptions about the use of Tshiveṋḓa TPSSR in the learning and teaching of PS. Some parents are in support of using

TPSSR to teach PS. They see this as their best opportunity for their learners to succeed in learning PS. Additionally, they reported that their learners' performance will improve in PS as they will understand the content taught through register written in the language (i.e. Tshivenḓa) they mostly use in their daily basis. However, other parents think learning PS through ESR is the best option as this language is mostly used in many organisations.

C. Case three: Leon

Almost all participants (i.e. Leon, parents, and learners) in this case view the use of TPSSR as imperative in improving learners' abilities to learn. The participants during interviews indicated that if the policy of language can change and the language used in TPSSR as medium of instruction for PS, they will support the policy. Additionally, if they were to choose which language register should be used in learning the subjects, they will choose TPSSR. Learning and teaching of PS with (TPSSR) make teaching and learning easier as there was no need for teachers and learners to first translate the ideas of the lesson in their mother language (Tshivenḓa) to understand the language of science.

7.3. Summary of findings

This study was conducted using qualitative case study approach as reported in chapter 4. The study revealed few findings on the development and application of Tshivenḓa physical sciences scientific register. The section focused on outlining the main findings of this study and is presented in terms of data collection tools used in the study.

A. Diary

The findings of this study reveal that the route of developing Tshivenḓa physical sciences scientific register for teaching and learning was not an easy route as Tshivenḓa is an indigenous language which is still in the process of developing. Hence, Tshivenḓa has limited scientific terms. Most of the scientific terms available in Tshivenḓa were translated and borrowed from other languages, namely English and Afrikaans. Therefore, teamwork is required in order to develop sufficient terms for this language to be developed and for it not only be recognised as an official language in South Africa but as language of learning and teaching at schools and higher education institutions as well.

Even though the progress of development of Tshivenḓa is slow, Tshivenḓa has a lot of published literature in the form of novels, poems, folklores, dramas, short stories which are written for use at schools both in primary and secondary levels. However, insufficient materials are available which has negative impact on use of Tshivenḓa and resulted in people replacing Tshivenḓa with other languages which have what they needed. Additionally, availability of Multilingual Natural Sciences & technology term list does promise that as time pass Tshivenḓa will be well developed like Afrikaans and English languages. However, there were some challenges that the researcher experience in her process of developing Tshivenḓa physical sciences scientific register which includes, selection of best materials to use as reference in the development of Tshivenḓa physical sciences scientific register. Tshivenḓa scientific words presented in Venda-English dictionary were insufficient. Even though there was the above-mentioned challenges along the way there were also opportunities the researcher experiences like interacting with variety of people, colleagues and senior citizen which assisted with other scientific word and the supervisor was also supportive throughout the process of Tshivenḓa physical science scientific register.

B. Interviews

Teachers interviews

The teacher had difficulties in understanding some words appeared in the Tshivenḓa physical sciences scientific register, but the teachers understood the words after reaching out to their colleagues and using other translation documents for explanations. The teachers wish it was possible for learners to learn physical sciences with Tshivenḓa physical sciences scientific register. The teacher reported English language register in physical sciences learning and teaching (LoLT) to be a problem as there are learners who don’t understand English which resulted in another problem of failing to understand concepts of physical sciences lessons through such language. They further indicated that these learners do not have a firm base in the English language because in their schools we can found that English is being taught in Tshivenḓa. The teachers indicated that the developed Tshivenḓa physical sciences scientific register was useful, and it inspires in such a way one can wish physical sciences can be taught with Tshivenḓa physical sciences scientific register day-to-day. Learners learnt a lot and they understood physical sciences more physical sciences concepts when taught with the developed Tshivenḓa physical sciences scientific register.

Learners interviews

Almost all the learners are in support with the use Tshivenḓa physical sciences scientific register as they indicated that the register written in their home language which is the language they understood most comparing to other languages. Additionally, they reported that they understood what they were being taught and they were able to participant during their lessons with the use of Tshivenḓa physical sciences scientific register. Some of the learners indicated that they experience challenges of failing to understand physical sciences through English scientific language register because English is not their home language. However, few learners indicated that the language used in Tshivenḓa physical sciences scientific register is difficult because during teacher classroom practices they experienced difficulties in understanding some of the words. Consequently, the teachers assisted their learners with understanding the words which were difficult to them.

Parents interviews

Majority of parents participated in this study recommended Tshivenḓa physical sciences scientific register in the teaching and learning Physical Sciences. The parents often want their children to learn with Tshivenḓa physical sciences scientific register as it is written in Tshivenḓa which is the language they understood and mostly used at their homes. Whereas other parents are in support of teaching and learning with the use of Tshivenḓa physical sciences scientific register because not all learners understand physical sciences when taught with English language register. Therefore, learning with Tshivenḓa physical sciences scientific register will enable learners to understand what they are being taught in physical sciences better compare to English language register which is not their own language. Therefore, they will support the teaching and learning subject under exploration with Tshivenḓa physical sciences scientific register if such opportunity is available.

C. Classroom observation

The use of Tshivenḓa physical sciences scientific register in physical sciences teaching and learning

During teachers physical sciences lesson presentations through Tshivenḓa physical sciences scientific register, almost all the learners in the classroom participated. It was easier for learners to learn and understand the content through language used in the register as it was their home language. In addition, most of the learners were able to express themselves during the lessons through language used in the register (Tshivenḓa). Maximum participation of learners during the lessons also seemed to be because lessons were also learner-centred as discussions were included in the lessons taught. Not only did the learners able to express themselves, but they seemed to understand a lot on what were presented in the Tshivenḓa physical sciences scientific register. In support of teaching and learning with Tshivenḓa physical sciences scientific register teachers improvise some other teaching aids, for example other teacher brings along some materials like stone, containers of different shape etc to use for demonstration, whereas other uses objects available within the classroom etc for demonstrations purpose. Learners indicated during their interviews that they were surprised with the learning of physical sciences with Tshivenḓa physical sciences scientific register as they were used to learn physical sciences with English language scientific register, but they were happy learning through language used in

Tshivenḓa physical sciences scientific register which is their own. The teachers also reported in theirs interview that learners learnt a lot of physical sciences concepts with the use of Tshivenḓa physical sciences scientific register. Consequently, both teachers and learners felt comfortable with the use of Tshivenḓa physical sciences scientific register in the teaching and learning of physical sciences.

The use of English language scientific register for teaching and learning of physical sciences

During teachers physical sciences classroom practices with English language scientific register, not all learners were able to participates since it was not easier to learn and understand the content through language which was not their own. In addition, some of the learners failed to express their ideas or ask questions on the concepts taught with English language scientific register even though their teacher bring along some materials, using examples in their classrooms for demonstration purpose. Moreover, lessons were sometimes teacher-centred which resulted in learners not understanding much on lessons presented with English language scientific register. The teachers also employed code-switching to facilitate the lesson because learners couldn't understand simple instruction, they presented to them. Even though code-switching was seeming as the best available strategy that could facilitate the learning and teaching, learners remained passive during the lessons. Learners indicated during their interviews that learning physical sciences with English language scientific register resulted in them not understanding some concepts. The teachers also reported during the interviews that some learners do not understand English which is again a problem when it comes in understanding language of physical sciences. Consequently, English language is a barrier to the teaching and learning of physical sciences to learners with little or poor English language background.

7.4. Contribution to the field

Previous studies on learning and teaching of PS concentrated to the use of indigenous languages together with English as LoTL in schools of South Africa.

However, this study focused was on developing and the application of developed TPSSR in the learning and teaching of PS.

The study findings reveal that developing TPSSR for teaching and learning was not an easy as Tshivenḓa is an indigenous language which is still in the process of developing. Hence, Tshivenḓa has limited scientific terms. Most of the scientific terms available in Tshivenḓa were translated and borrowed from other languages, namely, English and Afrikaans. Therefore, teamwork is required in order to develop sufficient terms for this language to be developed and for it not only be recognised as official language but as language of learning and teaching at schools and higher education institutions. Based on the TPSSR developed for this study, it means the teamwork should comprise the following people, senior citizens, PS teachers, PS learners, PS curriculum advisors and PanSALB.

Even though the progress of development of Tshivenḓa is slow, there is the availability of published literature in Tshivenḓa such as short stories, poems, etc written for use at primary and secondary schools. However, insufficient materials are available which has negative impact on use of Tshivenḓa and resulted in people replacing Tshivenḓa with other languages which have what they needed. Additionally, availability of Multilingual Natural Sciences & technology term list does promise that eventually, Tshivenḓa will be well developed like Afrikaans and English languages. However, there were some challenges that the researcher experienced in her process of developing TPSSR which include, selection of best materials to use as reference in the development of TPSSR. Tshivenḓa scientific words presented in Venda-English dictionary were insufficient. Even though there was the aforementioned challenges along the way, there were also opportunities the researcher experienced like interacting with variety of people, colleagues and senior citizens which assisted with other scientific words and the supervisor was also supportive throughout the process of TPSSR.

The teacher had difficulties in understanding some words which appeared in the TPSSR, but the teachers understood the words after reaching out to their colleagues and using other translation documents for explanations. The teachers wished it was possible for learners to learn PS with TPSSR. The teacher reported

ESR in PS learning and teaching (LoTL) to be a problem as there are learners who do not understand English which resulted in another problem of failing to understand concepts of PS lessons through such language. They further indicated that these learners lack a good foundation in the English language because in their schools we found that English was taught in Tshivenḓa. The teachers indicated that the developed TPSSR was useful, and it inspires in such a way one can wish PS can be taught with TPSSR daily. Learners learnt much and they understood PS more concepts when taught with the developed TPSSR.

Almost all the learners were in support with the use TPSSR as they indicated that the register was written in their home language which is the language they understood better compared to other languages. Furthermore, they reported that they understood what they were being taught and they were able to participate during their lessons with the use of TPSSR. However, some of the learners indicated that they experienced challenges of failing to understand PS through TPSSR because English is not their home language. However, few learners specified that language used in TPSSR is problematic because during teacher classroom practices they experienced difficulties in understanding some of the words. Consequently, the teachers assisted their learners with understanding the words which were difficult to them.

Majority of parents participated in this study recommended TPSSR in the learning and teaching of PS. The parents often want their children to learn with TPSSR as it is written in Tshivenḓa which is the language they understood and mostly used at their homes. On the contrary, other parents are in support of teaching and learning with the use of TPSSR because not all learners understand PS when taught with English language register. Therefore, learning with TPSSR will allow learners to comprehend what they are being educated in PS better compare to ESR which is not their own language. Therefore, they will support the teaching and learning subject under exploration with TPSSR if such opportunity is available.

During teachers' PS lesson presentations through TPSSR, almost all the learners in the classroom participated. It was easy for learners to learn and comprehend the content through language used in the register as it was their home language. In addition, most of the learners were able to express themselves during the lessons through language used in the register (Tshiveṋḓa). Maximum participation of learners during the lessons also seemed to be because lessons were also learner-centred as discussions were included in the lessons taught. Beside learners being able to express themselves, they also comprehend much on what were presented in TPSSR. In support of learning and teaching with TPSSR, teachers improvise some other teaching aids, for example, other teachers bring along some materials like stone, containers of different shape etc to use for demonstration, whereas others use objects available within the classroom etc for illustration purposes. Learners indicated during their interviews that they were surprised with the learning of PS with TPSSR as they were used to learn PS with ESR, but they were happy learning through language used in TPSSR which is their own. The teachers also reported in their interviews that learners learnt many PS concepts with the use of TPSSR. Consequently, both teachers and learners felt comfortable with the use of TPSSR in the learning and teaching of PS.

During teachers' PS classroom practices with ESR, not all learners were able to participate since it was not easier to learn and understand the content through language which was not their own. In addition, some of the learners failed to express their ideas or ask questions on the concepts taught with ESR even though their teacher brought along some materials, using examples in their classrooms for demonstration purposes. Moreover, lessons were sometimes teacher-centred which resulted in learners not understanding much on lessons presented with ESR. The teachers also employed code switching to facilitate the lesson because learners could not understand simple instruction presented to them. Even though code switching was seeming as the best strategy available to simplify PS teaching and learning, learners remained passive during the lessons. Learners indicated during their interviews that learning PS with ESR resulted in them not understanding some ideas. Moreover, teachers during interviews reported that some learners do not know English which is again a problem when it comes in understanding language of PS. Consequently, English language is a barricade to the learning and teaching of PS to learners with little or poor English language background. Moreover, the use of TPSSR in the learning and teaching of PS can assist in resolving challenges that come with the use of ESR in the learning and teaching of PS.

7.5 Recommendations of the study

This section provides recommendations regarding the implementation of African indigenous language (Tshivenda) in schools. The study showed that there is a lack of Tshivenda scientific terms and some of the terms available are borrowed from English and Afrikaans.

The following suggestions and recommendations based on the findings of this study which need to be adopted:

- There should be a policy on curriculum reforms in the use of TPSSR in the teaching and learning of PS.
- Teamwork is required and it should comprise the following people, senior citizens, physical sciences teachers, physical sciences learners, physical sciences curriculum advisors and PanSALB to develop sufficient terms for Tshivenda to be developed.
- There should be availability of teaching and learning materials in indigenous language (e.g. Tshivenda). The expansion of Tshivenḓa scientific terminology and Tshivenḓa science learning and teaching materials must be prioritised.
- The stakeholders within the Department of Education and universities should work together to produce expert and knowledgeable translators who will translate and produce teaching and learning materials in Tshivenda.
- There must be sufficient teacher training. PS teachers must be developed, trained and furnished with essential language skills for them to develop Tshivenḓa scientific language registers on other science topics.
- Effort should be made in developing Tshivenḓa as indigenous language in such a way that not only will it be recognised as official language but LoTL in the learning and teaching of PS as well.
- Obviously, English instruction is a barricade to PS learning and teaching. Therefore, both learners and teachers must be permitted to use TPSSR

with assurance and a contented conscience to ease learning and to supplement English-based learning and teaching.

- ❖ Home language of many learners (i.e. in this circumstance Tshivenḓa) at schools must be employed where possible to increase learners' performance

Further research

Even though the research accomplished its goal of the application of developed TPSSR in the learning and teaching of PS in three selected rural secondary schools, further studies should be conducted for:

- ❖ The expansion and application of TPSSR for PS focusing on other science topics

7.6. Limitations of the study

The research focused on the application of developed TPSSR of the selected rural secondary schools in South Africa. The three schools were selected from circuit of Vhuronga 2 situated in Vhembe West District of Limpopo Province. The participants in this research were PS teachers, learners and parents (SGB members) from the selected rural secondary schools only. For the fact that the research only focused on only three teachers of Vhuronga 2 Circuit in Vhembe West District may be regarded as limitation of the research. Nevertheless, through explanation offered in data analysis, the outcomes may be applicable to other districts with alike contexts.

7.7. Conclusion

The framework of the research indicated that classroom environment plays an important role in examining teacher-learner interaction and discourse. This is so because classroom interaction and discourse are crucial issues that have a substantial impact on the learning and teaching of PS. The study revealed that even though Tshivenḓa is an official language used in South Africa is still underdeveloped as not all scientific terms are available in Tshivenḓa. Teachers, some learners and parents who take part in the research recommended TPSSR in the learning and teaching of PS. The use of ESR was a barrier to the teaching and learning of PS as it was not their home language and learners have little English language proficiency.

The study presented the application of developed proficiency for PS teaching. The findings revealed that learners from three schools participated in the study learnt many PS concepts with the use proficiency compared to ESR in the learning and teaching of PS. This means that there is a need for teaching through language learners are familiar with as learners can be able to express their thoughts during lessons. Even though suggestions were made, stakeholders within the education subdivision must do their part for learners to receive appropriate and high-quality education.

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Appendix A: Proof of registration

UNISA university of south africa

1142

NETSHIVHUMBE N P MISS
P O BOX 153
MASHAU
0943

STUDENT NUMBER : 55131433

ENQUIRIES TEL : 0861670411
FAX : (012)429-4150
eMAIL : mandd@unisa.ac.za

2022-07-24

Dear Student

I hereby confirm that you have been registered for the current academic year as follows:

Proposed Qualification: PHD (EDUCATION) (90019)

CODE	PAPER	S	NAME OF STUDY UNIT	NQF crdts	LANG.	PROVISIONAL EXAM.DATE	EXAMINATION CENTRE(PLACE)
Study units registered without formal exams:							
TFNSE01			PhD - Education (Natural Science Education)	**	E		

You are referred to the "MyRegistration" brochure regarding fees that are forfeited on cancellation of any study units.

BALANCE ON STUDY ACCOUNT: 0.00

Yours faithfully,

Prof M S Mothata
Registrar

1031 O 00 0

UNIVERSITEIT VAN SUID-AFRIKA
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Appendix B: Interviews protocol

PHYSICAL SCIENCES TEACHERS INTERVIEW GUIDE

Pre-observation interview questions

I. Luambo lwavho lwa hayani ndi lufhio? *(What is your home language?)*

II. Pfunzo dzine vhone vha vha nadzo ndi dzifhio dza vhudededzi? *(What teaching qualifications do you have?)*

III. Thero khulwane dze vha dziita kha pfunzo yavho ya vhudededzi ndi dzifhio? *What are your major subjects in your teaching qualification?)*

IV. Kha tshikolo itshi tshine vhone vha shuma khatsho vha khou funza physical science lwa minwaha mingana? *(How long have you been teaching physical science in your current school?)*

V. Physical science afha tshikoloni tshavho ina tshifhinga kana yo fhiwa tshikhathi tshingafhani kha vhege? *(How many hours allocated for physical science per-week in your school*?)

VI. kuvhonele kana muhumbulo wavho kha u funza nga luambo lwa damuni ndi kufhio? *(What is your perception or view towards mother tongue or home language in teaching?)*

VII. Ndi dzifhio thaidzo kana khaedu dze vha tangana nadzo musi vha khou dilugisela ngudo kana pfunzo ya physical science vha tshi khou shumisa register ya Tshivenḓa? *(What problems or challenges did you encounter when preparing PS lesson using Tshivenḓa register?)*

VIII. Vha vhona u nga tshivhangi tsha khaedu kana thaidzo ye vhone vha bula afho tshi ngavha tshi tshifhio? *(What do you think may be the possible cause of the challenge or problem you mentioned?)*

IX. Ndi zwifhio zwe vha ita u tandulula kana u fhungudza khaedu ye vha i bula? *(What did you do to resolve (or minimize) the challenge or problem you mentioned?)*

X. Ndi khaedu kana thaidzo ifhio ine vha tangana nayo musi vha khou funza physical science nga Luisimane? *(Which challenge or problem do you come across when you are teaching physical science in English?)*

XI. Vha vhona u nga tshivhangi tsha khaedu kana thaidzo ye vha bula afho ndi mini? *(What do you think may be the possible cause of the challenge or problem you mentioned?)*

XII. Ndi zwifhio zwine vhaita u tandulula khaedu kana thaidzo ye vha bula? *(What do you do to resolve a challenge or problem you mentioned?)*

XIII. Ndi luambo kana nyambo dzifhio dzine vhagudiswa vha dzi shumisesa musi vhe nga ngomu kilasini na musi vha nnda ha kilasi? *(Which language/s do your learners use more often when they are in classroom and out of the classroom?)*

XIV. Musi vha tshi funza physical science ndi luambo kana ndi nyambo dzifhio dzine vha dzi shumisesa? *(When you teach physical science, which language/s do you use more often?)*

XV. Ndi ngani vha tshi shumisa nyambo dze vha bula? *(Why do you use the language/s you mentioned?)*

XVI. Vho dzudzanya zwifhio kha ngudo kana pfunzo ya namusi? Sa tsumbo, i do dzhia tshifhinga tshingafhani? *(What did you plan for today lesson? For example, how long will it takes?)*

XVII. zwinwe zwa zwithu zwine vha do zwishumisa musi vha khou funza avha vhana nga nndani ha register ya Tshivenḓa ye vhone vha neiwa yone ndi zwifhio? *Which resources or teaching aids do you intend to use beside Tshivenḓa register that you were given?)*

Post-observation interview questions

I. Kuvhonele kwavho kha register ya physical science ya Tshivenḓa ye vha i shumisa kha u funza vhagudiswa vhavho ndi kufhio? *(What is your perception towards Tshivenḓa PS register that you used when you were teaching learners?)*

II. Vha vhona unga u shumisa register ya Tshivenḓa ya physical science zwo thusa vhagudiswa u pfesesa maipfi kana luambo lwa physical science? (Do you think the use of Tshivenḓa register helps your learners understand words or language of PS?)

III. Ndi vhukondi kana khaedu dzifhio dze vha vhagudiswa vha khou tangana nadzo musi vha khou funziwa nga Tshivenḓa? *(What difficulties or challenges did your learners experienced during the lesson taught using Tshivenḓa physical sciences scientific register?*

IV. ndi zwifhio zwe vhaita u thusa vhana vhe vha vha vha khou tangana na vhukondi musi vha khou funziwa nga Tshivenḓa? *(What steps did you take to assist learners who experienced the challenges mentioned above to learn and stay focus on the lesson taught using Tshivenḓa instruction?)*

V. vhangari mini nga phimo ya vhagudiswa musi vha khou vha funza nga Tshivenḓa? *(How do you rate your learners' participation in the learning of physical sciences using Tshivenḓa instruction?)*

VI. kupasele kwa vhagudiswa kha physical science ku hani, ndi kwa vhudi, asi kwavhudi? *(How is your learners' performance in your school, good or bad?*

VII. a vha tikedze phindulo yavho

VIII. vha vhona unga luambo lune lwa khou shumisiwa khau funza physical science lu khou shela mulenzhe kha zwine vhagudiswa vho khou shumisa zwone? *(Do you think the language that is used to teach physical science has an impact on how learners are performing?)*

IX. Ndi ngani vha tshi ralo?

X. ndo vhona hafhala vha khou funza nga register heyi ya Tshivenḓa vha tshi khou itesa zwau tou talutshedzesa nga maanda u fhirisa u thamusi utou engager vhana thamusi uri vhatou discuss na mini na mini? ndi ngani vhone vhovha vha khou talutshedzesa nga maanda? *(I have observed that you did a lot of explanation while teaching, why you spent more time explaining?)*

XI. vha nga dipfa hani arali muvhuso wa nga shandukisa mulayo wa luambo lune lwa khou shumisiwa khau funza physical science wari zwino physical science kha I funziwe nga Tshivenḓa, vha nga dipfa hani? *(How will you react if the government policy were to be change and stipulates Tshivenḓa as science medium of instruction? Will you support the policy or oppose the policy?)*

XII. ndi khou livhuwa zwinzhi udi dzhenisa havho kha nyambedzano dze ra vha nadzo? *(Thank you very much for your co-operation on the interview we had.)*

Appendix C: Interview protocol

PHYSICAL SCIENCES LEARNERS INTERVIEW GUIDE

Tshipida tsha u thoma: Luambo lune lwa khou shumisiwa kha u funza na u guda

I. Luambo lwanu lwa hayani ndi lufhio?
II. Ndi luambo lufhio lune lwa shumisiwa kha u guda tshikoloni tshanu?
III. Luambo lwena lubula ni a lukonesa kana ni a lupfesesa hu si na vhuleme kana ni tou luzama kana u lu lingedza?
IV. Ndi ngani ni tshi ralo?
V. Ndi lufhio luambo kana nyambo dzine mudededzi wanu a dzi shumisa musi a tshi khou ni funza physical science?
VI. Ni vhona unga ndi ngani a khou shumisa luambo kana nyambo dze na bula?
VII. Ndi luambo kana nyambo dzifhio dzine na dzi shumisa na khonani dzani musi ni kilasini na musi ni siho kilasini?
VIII. Ndi ngani ni tshi shumisa luambo kana nyambo dze na bula?
IX. Ndi khaedu kana ndi vhukondi vhufhio hune na tangana naho misi ni khou funziwa nga luambo lune a si lwa hayani?
X. Ni vhona unga tshivhangi hu ngavha hu mini?
XI. Ndi luambo kana nyambo dzifhio dzine mudededzi wanu a dzi shumisa khau ni thusa u pfesesa maipfi a science vhukhwine?
XII. Ni vhona unga ndi ngani mudededzi wanu a khou shumisa luambo lwe na bula?

Tshipida tsha vhuvhili: U shumisiwa ha register ya Tshivenḓa kha u funza na u guda.

I. Kuvhonele kana muhumbulo wanu ndi ufhio khau guda nga luambo lwa damuni kana lwa hayani?
II. No dipfa kana no farea hani ni khou funziwa physical science nga Tshivenḓa?
III. Ndi ngani no dipfa nga u ralo?
IV. Ndi thaidzo kana khaedu dzifhio dzena tangana na dzo musi ni khou funziwa nga register ya Tshivenḓa?

V. Ni vhona u nga tshivhangi tsha thaidzo kana khaedu ye na bula hu ngavha hu mini?

VI. Ndi zwifhio zwe zwa itiwa nga mudededzi kana inwi sa mugudiswa kha u tandulula kana u fhungudza thaidzo ye na tangana nayo?

VII. Arali ha pfi nangani luambo lune na tama u funziwa ngalo, ni nga nanga Luisimane kana Tshivenḓa?

VIII. Ndi ngani ni tshi nga nanga luambo lwena lubula?

IX. Musi ni khou funziwa nga register ya Tshivenḓa zwoita uri inwi na mudededzi wanu na vhanwe vhagudiswa ni vhe na vhushaka ha hani? Musi ni khou funziwa nyambedzano dzovha dzihani vhukati hanu na mudededzi na vhanwe vhagudiswa?

Appendix D: Interviews Protocol

PARENTS (SGBs') INTERVIEW GUIDE

I. Luambo lwavho lwa hayani ndi lufhio?

II. Afha tshikoloni tshavho hu na mulayo wa luambo? Arali u hone, u ombedzela kana u khwathisedza zwifhio, hone zwine uyo mulayo wa ombedzela zwone zwi khou shuma na?

III. Ndi luambo kana nyambo dzifhio dzine vha shumisa u amba na nwana wavho musi vhe hayani? Ndi ngani vha tshi khou shumisa luambo kana nyambo dze vha bula?

IV. Ndi luambo kana nyambo dzifhio dzine vha dzi shumisa u thusa nwana wavho kha mushumo wawe wa tshikolo?

V. Ndi luambo lufhio lwe vha nanga uri nwana wavho a funziwe ngalo tshikoloni?

VI. Nwana wavho u ya pfesesa kana u konesa luambo lune a khou funziwa ngalo?

VII. Nwana wavho u khou shuma hani tshikoloni musi a khou shumisa luambo lune asi lwa hayani?

VIII. Vhangari mini nga bugu na zwinwe zwishumiswa zwine zwa thusedza kha u funza na u guda physical science zwo nwalwaho nga Luisimane? Vha dipfa hani nga nyimele yo tou raloho? Vha vhona zwi zwavhudi kana zwi si zwavhudi?

IX. Vha nga dipfa hani arali physical science ya nga funziwa nga Tshivenḓa? Ndi ngani vha khou dipfa nga u ralo?

X. Ndi lufhio luambo lune vha tama nwana wavho a tshi funziwa ngalo? Ndi ngani vha tshi tama luambo lwe vha lu bula?

XI. Vha nga tikedza u funziwa ha dzinwe thero nga Tshivenḓa? A vha tikedze muhumbulo wavho?

Appendix E: Observational tool

Classroom observation schedules for Grade 10 Physical Sciences classroom

Classroom observation schedule **School:_____________________________** **Date:____________________**				**Comment**
Types of discourse	Dialogic discourse	Encourages debates and challenges	E.g. Learners discuss/debates and share ideas among themselves.	
	Authoritative discourse	Teacher conveys information to learners	E.g. Teacher did a lot of questioning and explanation	
	Reflective discourse	Teachers use a process of negotiation of alternative ideas	E.g. Teacher and learners decide on best ideas or suitable responses	
Patterns of discourse	Initiation	Teacher gave instruction and asked question based on the explanation	E.g. Teacher asked question to check learner understanding	
	Response	Learner/s gave answers	E.g. Learner/s respond to the question asked.	
	Evaluation	Teacher makes judgment/provid	E.g. Teacher agreed, comment or asked	

		e feedback based on learner/s response	question based on learner response for clarity purpose.	
Teacher questioning	Drives lesson	Prior knowledge and experience	E.g. teacher asked questions based on what learners learned on previous grades/lesson about the topic	
	Improve learning	Explanatory framework	E.g. Illustrations/ demonstrations/examples	
	Develop thinking skills	Cognitive activity	E.g. Learners do explanations/give examples/discuss	
	Encourage and motivate	Activities	E.g. Classwork/ homework/ investigation/project/experiment	
Communicative approach	Interactive-authoritative	Teacher invites responses from learners but discounts their ideas	E.g. Teacher asked questions, learners respond but only correct answers will be considered	
	Non-interactive-authoritative	**Teacher use lecturing method**	**E.g. Teacher convey information to learners in sequence manner**	

	Interactive-dialogic	Learners views are taken into consideration	E.g. Ideas of learners are accepted even though they are maybe alternative to the accepted scientific meaning assessment	
	Non-interactive-dialogic	Teacher do not invite learners view	E.g. Teachers only makes statements that address other points of view in addition to the formal ones	

APPENDIX F: Letter to the District Senior Manager

College of Education

Department of Science and Technology Education

Request for permission to conduct research at schools

Title: Developing and using the Tshivenḓa scientific register for physical science.

29 April 2022

The District Senior Manager
Vhembe West Department of Education

Dear Sir/ Madam

I, Ndivhuwo Prudence Netshivhumbe, am doing research under supervision of A.V. Mudau, a professor in the Department of Science and Technology Education towards a Doctor's Degree in education with a specialization in Natural Sciences at the University of South Africa. There is no funding involved. I am requesting a written permission to use the schools that will participate in a study entitled, "Developing and using the Tshivenḓa scientific register for physical science''.

The aim of the study is to investigate the challenges and opportunities in the development and use of the Tshivenḓa scientific register for the teaching of physical science. Hence, it will also explore the attitudes and views of physical science teachers and learners towards Tshivenḓa physical science scientific register. Your department has been selected because the main objective of the study is to investigate how the use of Tshivenḓa language in the teaching and learning of physical science influence meaningful learning and interaction and discourse and such objective can be achieved within your department. The study will request consent from physical sciences teachers of Vhembe District to participate in this study, the recording devices (i.e. audio tape and video) will be used and the participants' permission will be requested prior to interviews and classroom observation. Once the participants agreed to take part in the study, I will work with them throughout the research process. In this study, one teacher from each school will be observed and interviewed.

The benefit of this study will be for all schools positioned in Vhembe district. The study will provide an insight on the nature of teaching using Tshivenḓa physical science scientific register, problem encountered in teaching practice and provide possible solution to assist teachers in this regard. There are no known potential risks associated with this study. The names of schools that will be elected in this study and participants will be kept confidential. All the data that will be obtained from each participant will remain confidential and will be used for research purpose only. There will be no reimbursement or any incentives for participation in the research. Participants will receive a summary of research findings on request.

For more information regarding the study, please contact me at: 079 588 1662 or email: ndivhuprudiey@gmail.com and my supervisor professor A.V. Mudau can be reached at: 012 429 6353 or email; mudauav@unisa.ac.za

Yours sincerely

Netshivhumbe NP (Researcher)

Appendix G: Letter to the Circuit Manager

College of Education

Department of Science and Technology Education

Request for permission to conduct research at schools

Title: Developing and using the Tshivenḓa scientific register for physical science.

29 April 2022
The Circuit Manager
Department of Education

Dear Sir/ Madam

I, Ndivhuwo Prudence Netshivhumbe, am doing research under supervision of Awelani Victor Mudau, a professor in the Department of Science and Technology Education towards a Doctor's Degree in education with a specialization in Natural Sciences at the University of South Africa. There are no funding involved. I am requesting a written permission to use the schools that will participate in a study entitled, "Developing and using the Tshivenḓa scientific register for physical science''.

The aim of the study is to investigate the challenges and opportunities in the development and use of the Tshivenḓa scientific register for the teaching of physical science. Hence, it will also explore the attitudes and views of physical science teachers and learners towards Tshivenḓa physical science scientific register. Your department has been selected because the main objective of the study is to investigate how the use of Tshivenḓa language in the teaching and learning of physical science influence meaningful learning and interaction and discourse and such objective can be achieved within your department. The study will request consent from physical sciences teachers of Vhembe District to participate in this study, the recording devices (i.e. audio tape and video recorder) will be used and the participants' permission will be requested prior to interviews and classroom observation. Once the participants agreed to take part in the study, I will work with them throughout the research process. In this study, one teacher from each school will be observed and interviewed.

The benefit of this study will be for all schools positioned in Vhembe District. The study will provide an insight on the nature of teaching using Tshivenḓa physical science scientific register, problem encountered in teaching practice and provide possible solution to assist teachers in this regards. The names of schools that will be elected in this study and participants will be kept confidential. All the data that will be obtained from each participant will remain confidential and will be used for research purpose only. There will be no reimbursement or any incentives for participation in the research. Participants will receive a summary of research findings on request.

For more information regarding the study, please contact me at: 079 588 1662 or email: ndivhuprudiey@gmail.com and my supervisor professor A.V. Mudau can be reached at: 012 429 6353 or email; mudauav@unisa.ac.za

Yours sincerely

Netshivhumbe NP (Researcher)

Appendix H: Letter to principal

College of Education

Department of Science and Technology Education

Request for permission to conduct research at your school

Title: Developing and using the Tshivenḓa scientific register for physical science.

29 April 2022
The Principal
Department of Education

Dear Sir/ Madam

I, Ndivhuwo Prudence Netshivhumbe, am doing research under supervision of Awelani Victor Mudau, a professor in the Department of Science and Technology Education towards a Doctor's Degree in education with a specialization in Natural Sciences at the University of South Africa. There are no funding involved. I wish to invite your school participate in a study entitled, "Developing and using the Tshivenḓa scientific register for physical science''.

The aim of the study is to investigate the challenges and opportunities in the development and use of the Tshivenḓa scientific register for the teaching of physical science. My research will also explore the attitudes and views of physical science teachers and learners towards Tshivenḓa physical science scientific register. Your school has been selected because it is sited in the district under study and you also have physical science teacher. Furthermore, the main objective of the study is to investigate how the use of Tshivenḓa language in the teaching and learning of physical science influence meaningful learning and interaction and discourse and such objective can be achieved within your school. If you agree for your school to participate in this research, I will request consent from physical sciences teacher to participate in this study. The recording device (i.e. audio tape and video recorder) will be used and the participant permission will be requested prior to interviews and classroom observation. Once the participants agreed to take part in the study, I will work with him/her throughout the research process. In this study, one teacher from each school taking part in the study will be observed and interviewed.

The benefit of this study will be for all schools positioned in Vhembe District. The study will provide an insight on the nature of teaching using Tshivenḓa physical science scientific register, problem encountered in teaching practice and provide possible solution to assist teachers in this regards. There are no known potential risks associated with this study. The identity of your school and participant will not be revealed. All the data that will be obtained from each participant will remain confidential and will be used for research purpose only. There will be no reimbursement or any incentives for participation in the research. Participants will receive a summary of research findings on request.

For more information regarding the study, please contact me at: 079 588 1662 or email: ndivhuprudiey@gmail.com and my supervisor professor A.V. Mudau can be reached at: 012 429 6353 or email; mudauav@unisa.ac.za

Yours sincerely

Netshivhumbe NP (Researcher)

Appendix I: Letter to Physical Sciences teachers

College of Education

Department of Science and Technology Education

Date: 29 April 2022

Title: Developing and using the Tshivenḓa scientific register for physical science.

DEAR PROSPECTIVE PARTICIPANT

My name is Ndivhuwo Prudence Netshivhumbe. I am doing research under the supervision of Awelani Victor Mudau, a professor in the Department of Science and Technology Education towards a Doctor’s Degree in education with a specialization in Natural Sciences at the University of South Africa. We have no funding. I am requesting you to participate in a study entitled, “Developing and using the Tshivenḓa scientific register for physical science”. This study will collect important information that could fulfil the main objective of the study, which is to investigate how the use of Tshivenḓa language in the teaching and learning of physical science influence meaningful learning and interaction and discourse. You are requested to take part in the study because you are a suitable candidate as you are teaching physical sciences in school positioned in Vhembe District where the study will be undertaken. I do not have your contact details.

I am hereby requesting for your permission to observe you while teaching physical science in your classroom and make use of video recorder as well as making use of audio recording during interviews. The questions to be asked will be regarding the teaching of physical science. The time allocation for interview will be 30-40 minutes long and the research will be conducted for a period of four months.

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason. There are no potential benefits of taking part in this study. There are no negative consequences for participant if he/she participates in the research project. The information that you convey to the researcher will not be divulge to your seniors or colleagues and your identity will be kept confidential. Hard copies of your answers will be stored by the researcher for a period of one year in a locked cupboard/filing cabinet for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval. The researcher will destroy all information under her control one year after the completion of the study. There will be no receiving of payment or any incentives for participating in this study. Participants will receive a summary of research findings on request.

If you may require any information regarding the study, please contact me at: 079 588 1662 or email ndivhuprudiey@gmail.com and my supervisor Professor A.V. Mudau can be reached at: 012 429 6353 or email; mudauav@unisa.ac.za

Thank you for taking time to read this information sheet.

Kind regards,

Ndivhuwo Prudence Netshivhumbe (Researcher)

Appendix J: Consent form for teacher

College of Education

Department of Science and Technology Education

CONSENT FORM FOR PHYSICAL SCIENCES TEACHERS

I, ____ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the ____

___________________________ (insert specific data collection method).

I have received a signed copy of the informed consent agreement.

Participant Name & Surname (please print) ______________________________

____

____

Participant Signature Date

Researcher's Name & Surname (please print) Ndivhuwo Prudence Netshivhumbe

29 April 2022________

Researcher's signature Date

Appendix K: Letter to parents (SGB)

College of Education
Department of Science and Technology Education

Date: 29 April 2022
Title: Developing and using the Tshivenḓa scientific register for physical science.

DEAR PROSPECTIVE PARTICIPANT

My name is Ndivhuwo Prudence Netshivhumbe. I am doing research under the supervision of Awelani Victor Mudau, a professor in the Department of Science and Technology Education towards a Doctor's Degree in education with a specialization in Natural Sciences at the University of South Africa. We have no funding. I am requesting you to participate in a study entitled, "Developing and using the Tshivenḓa scientific register for physical science". This study will collect important information that could fulfil the main objective of the study, which is to investigate how the use of Tshivenḓa language in the teaching and learning of physical science influence meaningful learning and interaction and discourse. You are requested to take part in the study because you are a suitable candidate as you are SGB member in school positioned in Vhembe District where the study will be undertaken. I do not have your contact details.

I am hereby requesting for your permission to interview you and make use of audio recording during interviews. The questions to be asked will be regarding the language and teaching of physical science in your school. The time allocation for interview will be 30 minutes long and the research will be conducted for a period of four months.

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason. There are no potential benefits of taking part in this study. There are no negative consequences for participant if he/she participates in the research project. The information that you convey to the researcher will not be divulge to your seniors or colleagues and your identity will be kept confidential. Hard copies of your answers will be stored by the researcher for a period of one year in a locked cupboard/filing cabinet for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval. The researcher will destroy all information under her control one year after the completion of the study. There will be no receiving of payment or any incentives for participating in this study. Participants will receive a summary of research findings on request.

If you may require any information regarding the study, please contact me at: 079 588 1662 or email ndivhuprudiey@gmail.com and my supervisor professor A.V. Mudau can be reached at: 012 429 6353 or email; mudauav@unisa.ac.za

Thank you for taking time to read this information sheet.

Kind regards,

Ndivhuwo Prudence Netshivhumbe (Researcher)

Appendix L: Consent form for parents (SGB)

College of Education

Department of Science and Technology Education

CONSENT FORM FOR PARENT (SGB)

I, ____ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the _______________________________________

_________________________ (insert specific data collection method).

I have received a signed copy of the informed consent agreement.

Participant Name & Surname (please print) _________________________________

____

____

Participant Signature Date

Researcher's Name & Surname (please print) Ndivhuwo Prudence Netshivhumbe

Researcher’s signature

29 April 2022________

Date

Appendix M: Letter to parents parental consent for minors to participate in the study

UNISA university of south africa

College of Education

Department of Science and Technology Education

Date: 29 April 2022

Title: Developing and using the Tshivenḓa scientific register for physical science.

Dear Parent

Your child is invited to participate in a study entitled, ‘’ Developing and using the Tshivenḓa scientific register for physical science”. I am undertaking this study as part of my Doctor’s research at the University of South Africa. The purpose of the study is to investigate the challenges and opportunities in the development and use of the Tshivenḓa scientific register for the teaching of physical science and the possible benefits of the study are the improvement of teaching and learning physical sciences in schools. I am asking permission to include your child in this study because the study wishes to observe physical sciences teacher delivering the lesson to the learners using Tshivenḓa instruction in the classroom. I am inviting all Tshivenḓa speakers’ children to participate in the study.

If you allow your child to participate, I shall request him/her to be available during physical sciences lesson. Your child permission will be requested prior to classroom observation. Any information that is obtained in connection with this study and can be identified with your child will remain confidential and will only be disclosed with your permission. His/her responses during classroom observation will not be linked to his/her name or your name or the school’s name in any written or verbal report based on this study. Such a report will be used for research purposes only.

There are no foreseeable risks to your child by participating in the study. Your child will receive no direct benefit from participating in the study; however, the possible benefits to education is to know and understand how physical sciences is taught using Tshivenḓa instruction and come up with possible strategies that can make physical sciences teaching and learning to be more effective. Neither your child nor you will receive any type of payment for participating in this study. Your child's participation in this study is voluntary. Your child may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly you can agree to allow your child to be in the study now and change your mind later without any penalty.

The study will take place during regular classroom activities with the prior approval of the school and your child's teacher. However, if you do not want your child to participate, an alternative activity will not be available. In addition to your permission, your child must agree to participate in the study and you and your child will also be asked to sign the assent form which accompanies this letter. If your child does not wish to participate in the study, he or she will not be included and there will be no penalty. The information gathered from the study and your child's participation in the study will be stored securely on a password locked computer in my locked office for one year after the study. Thereafter, records will be erased.

The benefit of this study are for all schools positioned in Vhembe District. The study will provide an insight on the nature of teaching, problem encountered in teaching practice and provide possible solution to assist teachers in this regards. There are no known potential risks associated with this study. There will be no reimbursement or any incentives for participation in the research.
If you have questions about this study please ask me or my study supervisor, Prof A.V. Mudau, Department of Science and Technology, College of Education, University of South Africa. My contact number is 079 588 1662 and my e-mail is ndivhuprudiey@gmail.com. The e-mail of my supervisor is

mudauav@unisa.ac.za. Permission for the study has already been given by principal and the Ethics Committee of the College of Education, UNISA.
If you decide allowing your child to participate in this study, I will be grateful. Your signature below will indicate that you have read the information provided above and have decided to allow him or her to participate in the study. You may keep a copy of this letter.

Sincerely

Netshivhumbe N.P (Researcher)

______________________________ ____________________________ ________________

Parent/guardian's name (print) Parent/guardian's signature: Date:

Netshivhumbe Ndivhuwo Prudence  29 April 2022

Researcher's name (print) Researcher's signature Date:

Appendix N: Letter to learners

College of Education

Department of Science and Technology Education

Title: Developing and using the Tshivenḓa scientific register for physical science.

Dear Learner Date 29 April 2022

I am doing a study on '' Developing and using the Tshivenḓa scientific register for physical science" as part of my studies at the University of South Africa. Your principal has given me permission to do this study in your school. I would like to invite you to be a very special part of my study. I am doing this study so that I can understand how your teacher will be teaching physical sciences using Tshivenḓa instruction and what challenges your teacher encounters when teaching physical sciences using Tshivenḓa scientific register. This may help me and many other teachers of different schools to gain knowledge in the teaching and learning of physical sciences and come up will possible solutions to resolve the issues that are hindering the effectiveness of physical sciences teaching.

This letter is to explain to you what I would like you to do. There may be some words you do not know in this letter. You may ask me or any other adult to explain any of these words that you do not know or understand. You may take a copy of this letter home to think about my invitation and talk to your parents about this before you decide if you want to be in this study.

I am requesting you to be available when your teacher will be delivering physical sciences lesson in the classroom. I would not ask you questions/interview you or request you to complete questionnaire, but your present will be highly appreciated since one of the objectives in the study is to evaluate how the use of Tshivenḓa language in the teaching and learning of physical science influence meaningful learning and interaction and discourse in the classroom.

I will write a report on the study but I will not use the name of your school in the report or say anything that will let other people know your school. Participation is voluntary and you do not have to be part of this study if you don't want to take part. If you choose to be in the study, you may stop taking part at any time without penalty. You may tell me if you do not wish to take part in the study. No one will blame or criticise you. When I am finished with my study, I shall return to your school to give summary of research findings on request. The benefits of this study are for all schools positioned in Vhembe District. The study will provide an insight on the nature of teaching, problem encountered in teaching practice and provide possible solution to assist teachers in this regards. There are no known potential risks associated with this study. You will not be reimbursed or receive any incentives for your participation in the research.

If you decide to be part of my study, you will be asked to sign the assent form. If you have any other questions about this study, you can talk to me or you can have your parent or another adult call me at 079 588 1662 and my supervisor professor A.V. Mudau can be reached at: 012 429 6353. Do not sign the written assent form below until you have all your questions answered and understand what I would like you to do.

Kind regards,

Netshivhumbe Ndivhuwo Prudence (researcher)

Appendix O: Assent for learners

WRITTEN ASSENT FOR LEARNERS

I have read this letter which asks me to be part of a study at my school. I have understood the information about my study and I know what I am expected to do. I am willing to be in the study.

Learner's name (print): Learner's signature: Date:

Witness's name (print) Witness's signature Date:

(The witness is over 18 years old and present when signed.)

Parent/guardian's name (print) Parent/guardian's signature: Date:

<u>Ndivhuwo Prudence Netshivhumbe</u> N-PNetshivhumbe **<u>29 April 2022</u>**

Researcher's name (print) Researcher's signature: Date:

Appendix P: Ethical clearance

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2021/06/09

Ref: **2021/06/09/55131433/14/AM**
Name: Ms NP Netshivhumbe
Student No.:55131433

Dear Ms NP Netshivhumbe

Decision: Ethics Approval from 2021/06/09 to 2026/06/09

Researcher(s): Name: Ms NP Netshivhumbe
E-mail address: ndivhuprudiey@gmail.com
Telephone: 079 588 1662

Supervisor(s): Name: Prof A.V. Mudau
E-mail address: mudauav@unisa.ac.za
Telephone: 012 429 6353

Title of research:

Developing and using the Tshivenda scientific register for physical science.

Qualification: PhD Natural Science Education

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2021/06/09 to 2026/06/09.

*The **medium risk** application was reviewed by the Ethics Review Committee on 2021/06/09 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

Appendix Q: Limpopo Province Department of Education approval letter

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

CONFIDENTIAL

Ref: 2/2/2 Enq: Makola MC Tel No: 015 290 9448 E-mail:MakolaMC@edu.limpopo.gov.za

Netshivhumbe NP
P O Box 153
Mashau
0943

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

1. The above bears reference.
2. The Department wishes to inform you that your request to conduct research has been approved. Topic of the research proposal: **"DEVELOPING AND USING THE TSHIVHENDA SCIENTIFIC REGISTER FOR PHYSICAL SCIENCE "**
3. The following conditions should be considered:

3.1 The research should not have any financial implications for Limpopo Department of Education.

3.2 Arrangements should be made with the Circuit Office and the School concerned.

3.3 The conduct of research should not in anyhow disrupt the academic programs at the schools.

3.4 The research should not be conducted during the time of Examinations especially the fourth term.

3.5 During the study, applicable research ethics should be adhered to; in particular the principle of voluntary participation (the people involved should be respected).

3.6 Upon completion of research study, the researcher shall share the final product of the research with the Department.

REQUEST FOR PERMISSION TO CONDUCT RESEARCH : NETSHIVHUMBE NP Page 1

Cnr 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X 9489, Polokwane, 0700
Tel:015 290 7600/ 7702 Fax 086 218 0560

The heartland of Southern Africa-development is about people

4 Furthermore, you are expected to produce this letter at Schools/ Offices where you intend conducting your research as an evidence that you are permitted to conduct the research.

5 The department appreciates the contribution that you wish to make and wishes you success in your investigation.

Best wishes.

Mashaba KM
DDG: CORPORATE SERVICES

25/04/2022
Date

Cnr 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X 9489, Polokwane, 0700
Tel:015 290 7600/ 7702 Fax 086 218 0560

The heartland of Southern Africa-development is about people

Appendix R: Circuit Manager approval letter

Limpopo Province
Department of Education
VHURONGA TWO CIRCUIT

P/Bag X1248
VUWANI
0952
Tel: (015) 961 5417
Fax: 0159615417

Ref : 81137109
Enq : Thivhafuni TJ
Tel : 015 961 5417
Cell : 082 094 4500

23 May 2022

To: Netshivhumbe N.P

PERMISSION TO CONDUCT RESEARCH IN VHURONGA 2 CIRCUIT

1. The above matter refers.
2. Vhuronga 2 Circuit Office wishes to inform you that permission to conduct research is granted on condition that you adhere to research ethics.
3. Furthermore, you are requested to make arrangements with the principals of schools where data will be collected on time.
4. All the best with your research study.

TJ Thivhafuni
Thivhafuni TJ

Vhuronga 2 Circuit

23/05/2022
Date

DEPARTMENT OF EDUCATION
VHURONGA 2 CIRCUIT
23 -05- 2022
P/BAG X1248, VUWANI, 0952
TEL: 015 961 5417
LIMPOPO PROVINCE

Vuwani Magistrate Buildings, Vuwani 0952.
Tel/Fax 015 961 5417 Cell No: 079 497 1884
The heartland of Southern Africa- development is about people

Appendix S: Tshivenḓa Physical Sciences Scientific Register

TSHIVENḒA PHYSICAL SCIENCES SCIENTIFIC

2021

COMPILED BY Ms Ndivhuwo Prudence Netshivhumbe

12/31/2021

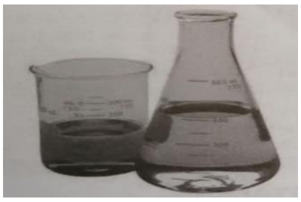
ZWIIMO ZWA TSHITHU

Zwiimo zwiraru zwa tshithu

Ri vho zwi ḓivha uri tshithu ndi tshiṅwe na tshiṅwe tshine tsha vha na tshileme, na u dzhia tshikhala. Vhunzhi ha tshithu kha ḽifhasi ḽashu ndi **tshiomate, tshiluḓi** kana **vhutsi**. Hezwi zwi vhidzwa u pfi ndi **zwiimo zwiraru zwa tshithu.** Maḓi ndi tshithu tshine ra ṱangana natsho nga kha hezwi zwiimo zwiraru, sa muxwatu, maḓi a tshiluḓi na maḓi a mutsiḓi. Ri nga kona u fhambanyisa zwiomate, zwiluḓi na vhutsi ngauri ndi zwithu zwine zwa vha na zwiṱalusi zwo fhambananaho. Tshiṱalusi ndi zwine tshithu tsha vha zwone.

Zwiṱalusi zwa ndeme zwa zwiomate, zwiluḓi na vhutsi zwo pfufhifhadzwa nga nḓila i tevhelaho:

Zwiomate	Zwiluḓi	Vhutsi
1. Zwiomate zwi na tshivhumbeo kana tshiimo tsha tshiomate. Tshivhumbeo kana tshiimo tshi nga shanduka fhedzi nga u tou boda, u tshi pwasha (kwasha) kana nga u tou tshi khotha. 2. Zwiomate zwo khwaṱha (u nga si kone u pfukisa munwe nga kha gwada ḽa muxwatu) 3. Zwiomate zwi na tshileme tshihulwane (gwada ḽihulwane ḽa muxwatu ḽi a lemela)	1. Zwiluḓi a zwi na tshivhumbeo kana tshiimo tsho tiwaho. Zwi dzhia tshivhumbeo tsha tshithu tshine zwa vha khatsho. 2. Zwiluḓi a zwi ngo khwaṱha (u nga kona u dzhenisa munwe nga ngomu ha bigiri ya maḓi) 3. Zwiluḓi zwi na tshileme tshihulwane (maḓi manzhi a ya lemela) 4. Zwiluḓi a zwi koni u nga kwanyeledzwa (u nga si kone u kwanyeledza maḓi are kha tshipeiṱi)	1. Vhutsi a vhu na tshivhumbeo tsho tiwaho. Vhutsi vhu a phaḓalala ha dzhia tshivhumbeo tsha tshithu tshine ha vha khatsho. 2. Vhutsi a vhu ngo khwaṱha (u nga kona u kwanyeledza baḽoni ḽi re na muya nga munwe) 3. vhutsi vhu na tshileme tshiṱuku (baḽoni ḽi re na muya a ḽi lemelesi) 4. Vhutsi vhu a kwanyeledzea hu sina vhuleme (tshipeiṱi tsho ḓadziwaho nga

4. Zwiomate a zwi koni u nga kwanyeledzana 5. Zwiomate a zwi eleli (nga nnḓani ha musi zwi nga zwipiḓa zwiṱuku-ṱuku) 6. Zwiomate zwi na vhungomu ho tiwaho.  Haya matombo o oma kana o khwaṱha, tshiimo na vhungomu ha o a zwi shanduki.	5. Zwiluḓi zwi a elela 6. Zwiluḓi zwi na vhungomu ho tiwaho.  Tshiluḓi tshi dzhia tshivhumbeo tsha tshithu tshine tshavha khatsho.	muya tshi nga kwanyeledzwa) 5. Vhutsi vhu a elela 6. Vhutsi vhu na vhungomu ho tiwaho. vhu a phaḓalala ha ḓadza tshithu tshine ha vha khatsho.  Vhutsi vhu a ḓadza na u dzhia tshivhumbeo na vhungomu ha tshithu tshine ha vha khatsho.

Vha nga ḓivha vho no zwi pfa vhathu vha tshi khou amba nga tshiṅwe tshiimo tsha vhuṋa tsha tshithu, tshi ḓivheaho sa vhutsi ho fhiswaho lwo kalulaho. Vhutsi ho fhiswaho lwo kalulaho hu itea musi hu na mufhiso na u kwayeledzwa ho kalulaho nahone sa tsumbo vhu wanala kha ḓuvha na mapala/dzithanda dza ḽifhasi kha tshiitea tshine tsha vhidzwa u pfi aurora boreaḽisi. Kha ngudo dzashu, ri guda fhedzi zwiimo zwiraru zwa tshithu zwine zwavha tshiomate, tshiluḓi na vhutsi.

TSHITHU TSHI NA ZWILAVHI

Musi ri tshi lavhelesa kha u phaḓalala, ri a kona u vhona uri tshithu tshi na zwilavhi. U phaḓalala ndi u tshimbila tshimbila ha zwilavhi. U phaḓalala hu nga vhonala kha u ṱanganelana na u phaḓalala ha zwilavhi zwine zwa vhanga u ḓisedza ha zwilavhi. U nga kona u vhona u phaḓalala musi wo shela shotha ḽa muvhala kana ennge kha maḓi. Muvhala kana ennge i ḓo phaḓalala nga u ongolowa kha maḓi. U phaḓalala ndi mvelelo dza u sudzuluwa ha zwilavhi. Kha khethekanyo ino tevhela ya thyiori ya khainthikhi moḽekhuḽu ya tshithu ri ḓo amba zwinzhi nga ha u phaḓalala ha zwilavhi.

Vho- Robert Brown (1773 -1858), mugudazwimela wa Scottish, vho guda muvula nga kha tshivhonazwiṱuku kana tshihudzambonalo. Vho vhea muvula kha shotha ḽa maḓi. Vho-Brown vho mbo ḓi vhona muvula u tshi ita zwa u tsukunyea hu songo ḓoweleaho, u sudzuluwa lwa masongesonge, ha tou nga zwo tou dzinginyea nga zwoṱhe. Vha humbula uri zwilavhi zwa maḓi, zwe zwa vha zwi zwiṱukuṱuku kha uri zwi vhonale zwo vha zwone zwe zwa kuḓana na muvula ha kona-ha u vha na u dzinginyea. U sudzuluwa uhu ho vha vhone vha u thoma u hu vhona na u hu ṱalutshedza nga nḓila yone. U sudzuluwa uhu Vho- Robert Brown vho mboḓi u nea dzina ḽa u pfi **u sudzuluwa ha Burauniene.** U phaḓalala na u sudzuluwa ha burauniene ndi ndeme ya u phaḓalala ha zwilavhi zwinzhi.

Arali tshikolo tshavho tshi na tshivhonazwiṱuku na sele ya mutsi vha nga kona u vhona zwavhuḓi u sudzuluwa ha Burauniene.

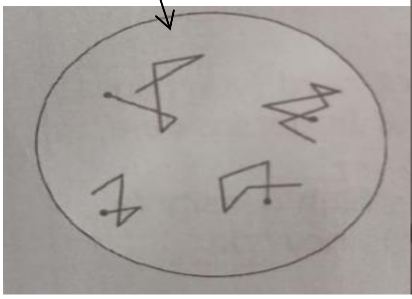
U sudzuluwa ha Burauniene

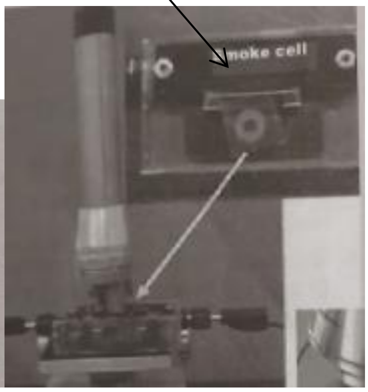
Mudededzi wavho u ḓo vha dzudzanyela sele ya mutsi nga kha phaiphi ṱhukhu i dugaho mulilo kana u bva kha tshipeiṱi. Ngilasi i re nṱha ha tshubu i ḓo thivhela vhutsi uri vhu sa bve. Ngilasi i ḓo vhonetshelwa nga tshedza tshihulwane yo thusedzwa nga lugilasi lulapfu lusekene. Musi vha tshisedza nga tshivhonazwiṱuku kha tshubu ya ngilasi ine yo ḓadzwa nga vhutsi, vha tea u vha vha khou kona u vhona zwilavhi zwa vhutsi zwine zwa khou vhonetshelwa nga tshedza (tshivhonazwiṱuku tshi vha tsho lugiselwa kha luṱa lune zwilavhi zwa vhutsi zwa kona u vhonala).

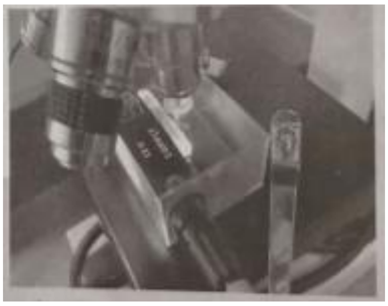
Arali vha sedzesa kha zwilavhi zwa vhutsi, sa zwine zwa khou vhonala sa tshedza swiswini, vha ḓo kona u vhona uri zwilavhi zwi khou ya phanda na murahu. Nga maṅwe maipfi, zwi vha zwi khou ita masongesonge.

Vha humbule uri vha nga si kone u vhona zwilavhi zwi zwoṱhe zwa vhutsi kha tshivhonazwiṱuku ngauri zwo ṱukufhalesa. Vha khou vhona zwilavhi zwa vhutsi zwine zwa vha zwipiḓa zwa khaboni zwine zwa khou kuḓana na zwilavhi zwa muya zwi sa vhonali.

U sudzuluwa ha Burauniene **Sele ya mutsi**







Mutshimbilo uyu u ḓivhea sa u sudzuluwa ha burauniene ngauri ho yu ndi wone mutshimbilo we Vho-Brown vha u vhona nga tshivhonazwiṱuku musi vhopoṱiela muvula maḓini.

TSHIIMO TSHI VHONALAHO TSHA TSHITHU

Muxwatu u shanduka u vha maḓi musi wo fhiswa u swika a tshi ṇoka. Maḓi a shanduka u vha mutsiḓi musi o vhiswa u swika a tshi vhila. Tshiimo tshi vhonalaho tshine tshithu tsha vha kha mufhiso kana murotholo wo imaho ngauri, zwi bva kha u vhila, u ṇoka na muxwatudzo.

- Murotholo wa musi tshiluḓi tshi tshi shanduka u vha tshiomate zwi vhidzwa u pfi muxwatudzo
- Mufhiso wa musi tshiomate tshi tshi shanduka u vha tshiluḓi zwi vhidzwa u pfi u ṇoka.
- Mufhiso wa musi tshiluḓi tshi tshi shanduka u vha vhutsi (kana mutsiḓi) zwi vhidzwa u pfi u vhila.

Ri shumisa tshikalo tsha mufhiso/murotholo u kala mufhiso/murotholo. Tshikalo tsha mufhiso/murotholo tshi ḓivhea khwine kha rine ndi, tshikalo tsha selishiasi tshi re na yunithi ya digirii selishiasi (℃). Mbuno mbili dzo tiwaho dza tshikalo tsha murotholo/mufhiso ndi muxwatudzo wa maḓi (0℃) na u vhila ha maḓi (100℃).

Thebuḽu ire afho fhasi i sumbedza u ṋoka na u vhila ha zwiṅwe zwa zwishumiswa.

Tshishumiswa	**U ṋoka (℃)**	**U vhila (℃)**
Gesehambe	-210	-196
Muyamufhe	-218	-183
Gesedungi	-87	-78
Halwa ha thoro ya zwimedzwa	-117	-78
Maḓi	0	100
Muṋo (Sodiamu Kuḽoraidi)	801	1 467
Musina/koporo	1 083	2 595
Tsimbi	1 535	3 000
Khaboni (Daimane)	3 550	4 827

U ṋoka na u vhila ha zwishumiswa.

- **U wanulusa tshiimo tshi vhonalaho tsha tshithu**

Tshiimo tshi vhonalaho tsha tshithu kha murotholo/mufhiso wo ṋetshedzwaho zwi nga wanuluswa nga zwi tevhelaho arali u ṋoka na u vhila ha tshithu hu tshi khou ḓivhea.

- Murotholo wo linganelaho < U ṋoka → **Tshiomate**
- U ṋoka < Mufhiso wo linganelaho < U vhila → **Tshiluḓi**
- Mufhiso wo linganelaho >U vhila → **vhutsi**

Tsumbo ya u thoma

Thebuḽu i sumbedza mafhungo nga ha zwithu zwa rathi **A, B, C, D, E na F.** (Dzhiani murotholo kana mufhiso wo linganelaho sa 30^{0}C)

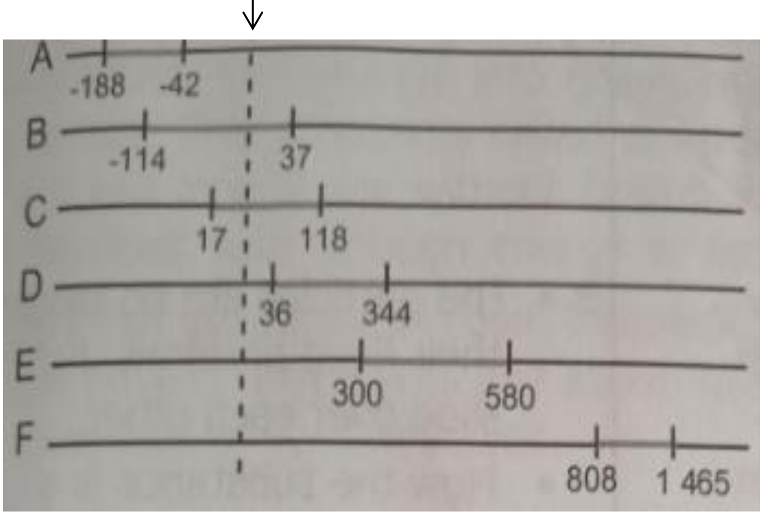
Tshishumiswa	**U ṋoka (^{0}C)**	**U vhila (℃)**
A	-118	-45
B	-114	37
C	17	118
D	36	244
E	300	580
F	808	1465

1. Fhambanyani zwishumiswa A u ya kha F sa tshiomate, tshiluḓi kana vhutsi kha mufhiso/murotholo wo linganelaho
2. Ndi tshifhio tshishumiswa tshine tsha ḓo shanduka u bva kha tshiluḓi u ya kha tshiomate musi tsho vhewa kha tshixwatudzi (murotholo 4℃)?
3. Ndi tshifhio tshishumiswa tshine tsha ḓo shanduka u ya kha tshiluḓi kha ḓuvha ḽi dudelaho (37℃)?
4. Ndi tshifhio tshiṅwe tshishumiswa tshine tsha ḓo shanduka tshiimo tshatsho kha ḓuvha ḽi dudelaho (37℃)?
5. Ndi tshifhio tshishumiswa tshine tsha vha tshiluḓi?

Thandululo

Olani mitalo ire afho fhasi na u ṅwala tshiimo tsha u ṋoka na u vhila kha tshithu tshiṅwe na tshiṅwe.

Murotholo kana Mufhiso wo linganelaho 30℃



1) A ndi mutsiḓi. B na C ndi zwiluḓi. D,E na F ndi zwiomate
2) C
3) D
4) B
5) B

TSHANDUKO DZA ZWIIMO

Tshanduko ya tshiimo i vha hone musi tshithu tshi tshi shanduka u bva kha tshiimo tshatsho tshi vhonalaho (Tshiomate, Tshiluḓi, kana vhutsi) u ya kha tshiṅwe. muxwatu u shanduka nga zwiṱuku nga zwiṱuku uya kha tshiimo tsha maḓi musi wo vheiwa fhethu hu ne ha dudela. Maḓi a shanduka u vha mutsiḓi musi o fhiswa u swika a tshi vhila. Kha murotholo ure fhasi na gesedungi i ya kona u vha nga kha tshiimo tsha tshiomate (muxwatu wo omaho).

Tshiimo tsha tshanduko tshi a kona u humela murahu. Sa tsumbo, musi vha tshi khou bika, maḓi a shanduka u vha mutsiḓi, musi vha tshi fholisa maḓi o vhilaho mutsiḓi u ya shanduka wa vhuelela kha tshiimo tsha maḓi a tshiluḓi.

Ri shumisa tshiṱalusi Δ u sumbedza mufhiso, sa tsumbo:

$$\mathbf{H_2O\ (s)} \xrightarrow{\Delta} \mathbf{H_2O\ (l)} \xrightarrow{\Delta} \mathbf{H_2O\ (g)}$$

Muxwatu Maḓi Maḓi a Mutsiḓi

U fhisa U fhisa

U fhola U fhola

Tshiimo tsha Tshanduko	Dzina la Tshanduko	Tshivhangi
Tshiomate → Tshiluḓi	**U ṋoka**	**u fhisa**
Tshiomate → Vhutsi	**Sabiḽimesheni**	**u fhisa**
Tshiluḓi → Vhutsi	**Muḓimuwo**	**u fhisa**
Tshiluḓi → Tshiomate	**U xwatudza**	**u fholisa**
Vhutsi → Tshiluḓi	**Muluḓeo**	**u fholisa**
Vhutsi → Tshiomate	**Muluḓeo**	**u fholisa**

Tshanduko ya fulufulu kha tshanduko ya tshiimo

Musi tshishumiswa kana tshithu tsho **fhisiwa**, ri a zwi ḓivha nga tshenzhemo uri **mufhiso** watsho u ya **nṱha** musi tshi kha ḓi vha kha tshiimo tshithihi. Izwi zwi itea ngauri fulufulu la khainethikhi ḽo linganelaho ḽa zwilavhi (sa tsumbo, Moḽekhuḽu) ḽo ya nṱha/u engedzea musi ḽi tshi fhisiwa. Kha tshanduko ya tshiimo musi tshiomate tshi tshi **ṋoka** kana tshiluḓi tshi tshi **vhila,** fulufulu ḽa khainethikhi ḽo linganelaho ḽa tshishumiswa, naho zwo ralo, a ḽi ngo shanduka. Naho fulufulu ḽa mufhiso ḽi tshe hone, ḽo ya kha tshishumiswa musi hu tshi vha na tshanduko ya tshiimo, fulufulu (mufhiso) ḽo netshedzwaho, ḽi shumiswa u kunda u kungea ha maanḓa a moḽekhuḽu ya ngomu ine ya vha hone vhukati ha zwilavhi, na zwilavhi zwa tshishumiswa zwaita uri zwi yele kule na kule uri zwi dise/u bveledza, sa tsumbo tshiimo tsha tshiluḓi kana vhutsi. Mufhiso u dzula wo ralo/a u shanduki.

Musi tshishumiswa tshi tshi fholiswa mufhiso watsho u a tsela fhasi. Zwilavhi zwi sudzuluwa nga zwiṱuku na fulufulu ḽa khainethikhi ḽo linganelaho ḽa tsela fhasi. Musi wa tshanduko ya tshiimo hune vhutsi kana u xwatudzea zwo bva nga kha u fholisa, mufhiso a u shanduki. Fulufulu ḽine ḽa ḓisedzwa, ḽi vhanga uri zwilavhi zwi si fhambane na fulufulu ḽa khainethikhi. U xelelwa nga fulufulu ḽa mufhiso zwi vhanga u gonyela nṱha ha maanḓa a moḽekhuḽu ya ngomu i ne ya kona u ita uri zwilavhi zwi kuvhangane na u sudzuluwa zwi tshi ya tsini na tsini. Mufhiso u dzula wo ralo.

Mufhiso une wa bveledzwa musi wa tshanduko ya tshiimo kana u ṋetshedzwa u vhidzwa upfi mufhiso wa tshanduko kana mufhiso wa u dzumbama.

U ṋoka

Musi tshishumiswa tshi tshi shanduka u bva kha tshiomate uya kha tshiluḓi zwi vhidzwa upfi ndi u ṋoka.

Hu itea mini kha zwilavhi zwa tshishumiswa tshine tsho fhisiwa u swikela tshi tshi ṋoka?

Masiandoitwa a u fhisa zwilavhi kha tshiomate.

1. - Musi tshiomate tsho fhiswa, mufhiso u kokodziwa nga zwilavhi zwa tshiomate.

- Fulufulu ḽa mufhiso ḽi shandukiswa u vha fulufulu ḽa khainethikhi, zwilavhi zwa thoma u tshimbila nga nungo nnzhi.

2. - Kha tshiimo tsha u ṋoka, zwilavhi zwi thoma u dzinginyea nga maanḓa mahulu zwa fhenya mannḓa a moḽekhuḽu ya ngomu (maanḓa vhukati ha moḽekhuḽu).
    - Tshiomate uri tshi ṋoke, fulufulu ḽa khainethikhi ḽa zwilavhi ḽi tea u vha ḽo linganelaho u nga kona u kunda maanḓa a moḽekhuḽu ya ngomu ine ya khou kuvhangana zwilavhi zwa vha tshithu tshithihi.
3. - Zwilavhi a zwi tsha vha kha tshiimo tshithihi, fhedzi zwi khou suvha kha zwiṅwe.
    - Zwino tshishumiswa ndi tshiluḓi.

U xwatudza

Musi tshiluḓi tshi tshi shanduka u vha tshiomate, zwi vhidzwa u pfi u xwatudza.

Hu itea mini kha zwilavhi zwa tshiluḓi musi tshi tshi fholiswa u swikela tshi tshi xwatudzea?

Masiandoitwa a u fholisa zwilavhi zwa tshiluḓi

1. - Musi tshiluḓi tshi tshi fholiswa, fulufulu ḽi re kha zwilavhi zwa tshiluḓi ḽi a litshedza.
    - Zwilavhi zwi a fhambana na fulufulu ḽa khainethikhi zwa thoma u sudzuluwa nga u tou ongolowa.
2. - U kokodzea ha maanḓa a moḽekhuḽu ya ngomu zwi a engedzea.
    - Zwilavhi kha tshixwatudzi zwi vha zwi si tshena maanḓa o linganelaho u nga kona u sudzuluwa.
3. - Zwilavhi zwi nga kona fhedzi u nga dzinginyea kha tshiimo tsho tiwaho.
    - Tshiomate tsho sikiwa.

U vhila

Musi tshiluḓi tshi tshi shanduka u ya kha vhutsi kana mutsiḓi, ri ri tsho vhila.

- Musi tshiluḓi tsho vhiswa, fulufulu ḽa mufhiso ḽi kokodzwa nga kha zwilavhi zwa tshiluḓi
- Zwilavhi zwi wana fulufulu ḽa khainethikhi, zwa thoma u sudzuluwa nga u ṱavhanya sa musi mufhiso wo engedzea.

Mufhiso

- Ngauralo, zwilavhi zwi na fulufulu ḽo linganaho nga kha tshiluḓi u nga kona u fhenya maanḓa a moḽekhuḽu ine ya ita uri zwi dzule zwo kuvhangana.

- Zwilavhi zwino zwi a kona u phaḓalala na u sudzuluwa zwi tshi ya kha masia oṱhe.
- Tshishumiswa zwa zwino ndi vhutsi.

Hu iteani mini kha zwilavhi zwa tshiluḓi zwo fhiswaho u swikela zwi tshi vhila?

Muḓimuwo

Musi vha tshi vhea shotha ḽa halwa ya thoro ya zwimedzwa kana tshinukheleli kha tshanḓa tshavho, hu itea mini kha shotha ḽa tshiluḓi nga murahu ha tshifhinga nyana? Shotha ḽa tshiluḓi ḽo fhelelafhi? Tshiṅwe tshifhinga zwiluḓi zwi a shanduka u vha vhutsi kha mufhiso une wa vha fhasi kha tshiimo tsha u vhilisa. Maitele aya ndi ane a vhidzwa u pfi **muḓimuwo**. Muḓimuwo ndi tshanduko ya tshiluḓi u ya kha vhutsi hu songo vha na u vhilisa. Muḓimuwo u itea musi zwilavhi zwa tshiluḓi zwi na fulufulu ḽo linganaho u nga kona u shavha kha vhunnḓa ha tshiluḓi. Zwiluḓi zwine zwa ḓimuwa kha mufhiso wo linganelaho zwi vhidzwa upfi **zwiluḓi zwo ḓimuwaho**. Zwi na u vhila nga nṱha ha mufhiso wo linganelaho. Tshivhaswa na tshinukheleli ndi tsumbo yavhuḓi ya zwiluḓi zwo ḓimuwaho.

Zwoṱhe u vhilisa na muḓimuwo zwi katela u shandukisa tshiluḓi u ya kha vhutsi, fhedzi u vhilisa zwo fhambana na muḓimuwo nga nḓila nṉa (4) sa zwe zwa sumbedza kha thebuḽu i tevhelaho:

U vhilisa	**Muḓimuwo**
• U vhilisa hu vha hone musi ho vha na u vhilisa • U vhilisa zwi itea kha tshiluḓi nga vhuphara • U vhilisa zwi a ṱavhanya • Mufhiso u dzula wo ralo musi hu tshi khou vhilisiwa.	• Muḓimuwo u itea musi mufhiso u fhasi ha muvhiliso • Muḓimuwo u itea kha vhunnḓa ha tshiluḓi • Muḓimuwo u itea nga u ongolowa • Muḓimuwo u vhanga u fholisa ngauri mufhiso u vha wo kokodzea u bva kha mupo.

Mulṷḓeo

Musi vhutsi vhu tshi fhola vhu shanduka u vha tshiluḓi. Izwi zwi vhidzwa upfi Mulṷḓeo. Musi mutsiḓi u tshi kwamana na vhunnḓa ha murotholo, Mulṷḓeo u ya vha hone na tshiluḓi tsha sikiwa.

Hu iteani musi zwilavhi zwa vhutsi zwi tshi ita tshiluḓi?

Kha vha humbule Mulṷḓeo sa phambano ya u vhilisa. Fulufulu ḽa mufhiso ḽi a laṱelwa nga musi wa Mulṷḓeo. Musi mufhiso u tshi khou tsela fhasi, zwilavhi zwa vhutsi zwi ṱutshelwa nga nungo zwa sudzuluwa nga u tou ongolowa. Maanḓa a moḽekhuḽu ya ngomu a u kunga a kokodza zwilavhi zwa vha tsini na tsini. Zwo ralo, tshiluḓi tsha sikea.

Sabiḽimesheni

Tshiomate tshi nga kona u shanduka u vha vhutsi tshi songo thoma u shanduka u vha tshiluḓi?

Musi muxwatu (gesedungi ya tshiomate) wo n̥etshedzwa kha mufhiso u re nṱha ha -78 ℃ tshi shanduka u vha vhutsi ha gesedungi tshi songo thoma tsha noka. Sa muxwatu, zwiṅwe zwa zwilavhi zwishanduka u ya kha vhutsi zwi songo thoma u vha kha tshiimo tsha tshiluḓi. Izwi zwi vhidzwa u pfi **Sabiḽimesheni.**

Sabiḽimesheni i itea ngauri zwilavhi zwa tshiomate zwi na fulufulu ḽo linganelaho u nga kona u kwasha u bva kha vhunnḓa ha tshiomate na u phaḓalala sa vhutsi. Muno mutshena wa kuḽoraidi ya amonia na wa ayodini ndi tsumbo ya zwiomate zwine zwa **Sabiḽimeitha** (u shanduka u bva kha tshiomate u ya kha vhutsi). Zwishumiswa zwine zwa sabiḽimeitha zwi nga kona u shanduka u bva kha vhutsi u ya kha tshiomate zwi songo vha kha tshiimo tsha tshiluḓi. Zwenezwo zwa vhidzwa u pfi **Mulṷḓeo.**

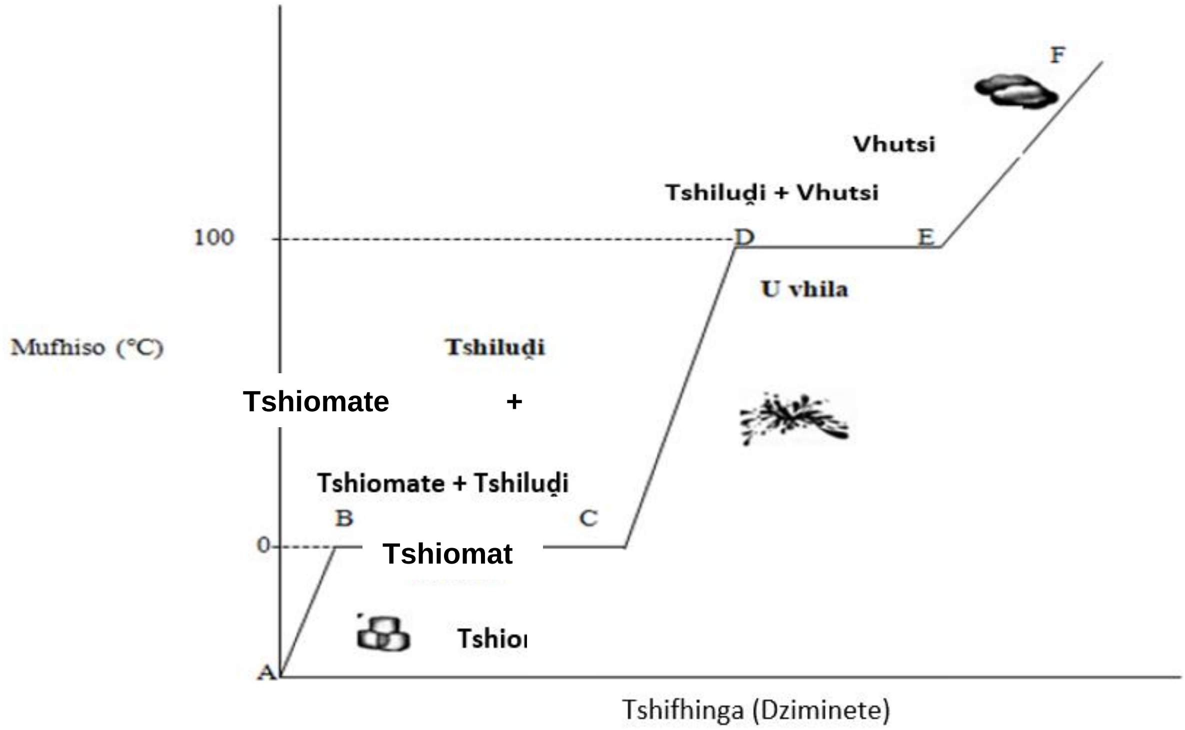
Sabiḽimesheni i shumesa hafhaḽa hune tshiomate tsha shumiswa kha nḓowetshumo dza tshirothodzi na u endedza zwiḽiwa zwo xwatudzwaho. I shuma kha u rothodza zwiḽiwa sa muxwatu wa tshimunemune na n̥ama ngauri i ita uri zwiḽiwa zwi dzule zwi khou rothola na muxwatu u shanduka u vha mutsiḓi u songo sia na tshiluḓi.

MUKOMBAMO WA U FHISA NA U FHOLISA

Ri nga ola mukombamo wa u fhisa na u fholisa u kona u ṱoḓisisa tshanduka vhukati ha zwiimo zwa tshithu. U ola mukombamo, mufhiso na tshifhinga zwo dzhiwa kha tshikhala tsho tiwaho, sa tsumbo muthethe muṅwe na muṅwe. Mufhiso u vha kha mutaladzi wa tswititi ngeno tshifhinga tshi kha mutaladzi wa murambaladzo. mukombamo wa u fholisa u vha na tshiimo tshi no fana na tsha mukombamo wa u fhisa nga nnḓa ha uri u pfukekanya kha sia ḽo fhambanaho.

Mukombamo wa u fhisa

Musi muxwatu wo vhewa kha tshifaredzi tsho fhiswaho nga zwiṱuku kha mufhiso wo lingaelaho, u tshi khou rithelelwa, ri wana mutalombalo ure afho fhasi. Ndi mukombamo wa u fhisa maḓi.



A - B: Muxwatu (Tshiomate). Mufhiso wa muxwatu u gonyela nṱha hu si na u ṋoka ha muxwatu. U engedzwa ha mufhiso zwi gonyisa fulufulu ḽa khainethikhi ya moḽekhuḽu ya maḓi na mufhiso wa tshiomate.

B - C: Muxwatu wo ṋoka (tshiomate na tshiluḓi). Afha ndi hune tshifhinga tsha vha tshi khou ya phanḓa fhedzi mufhiso u dzula wo ralo. Hafha ndi hune ha sumbedza tshiimo tsha tshanduko u bva kha tshiomate uya kha tshiluḓi (u ṋoka), na mufhiso une wa vhonala, ndi kha u ṋoka. Musi mufhiso wo swika kha tshiimo tsha u ṋoka, tshiimiswa tsha magwada a muxwatu tsha tshiomate tshi a kwashekana tsha shanduka u vha tshiluḓi. Maanḓa a moḽekhuḽu ya ngomu vhukati ha moḽekhuḽu zwi a nyeṱha na moḽekhuḽu ya si tsha dzudzanyea. Ngauri mufhiso u dzula wo ralo fulufulu ḽa u sudzuluwa a ḽi shanduki. Fulufulu ḽa mufhiso ḽe ḽa dzhiiwa hafha, ḽi shumiswa u kona u fhenya maanḓa a u kokodza ane a vha hone vhukati ha moḽekhuḽu, hu u itela uri moḽekhuḽu i kone u nyeṱha i kone u vha na u sudzuluwa i sa khakhiswi.

C - D : Maḓi (Tshiluḓi). Musi muxwatu wo noka, mufhiso wa maḓi u gonyela nṱha nga luvhilo lwo linganelaho u swika u tshi thoma u vhila. U engedzwa ha mufhiso zwi engedza fulufulu ḽa u sudzuluwa ḽa moḽekhuḽu na mufhiso wa maḓi.

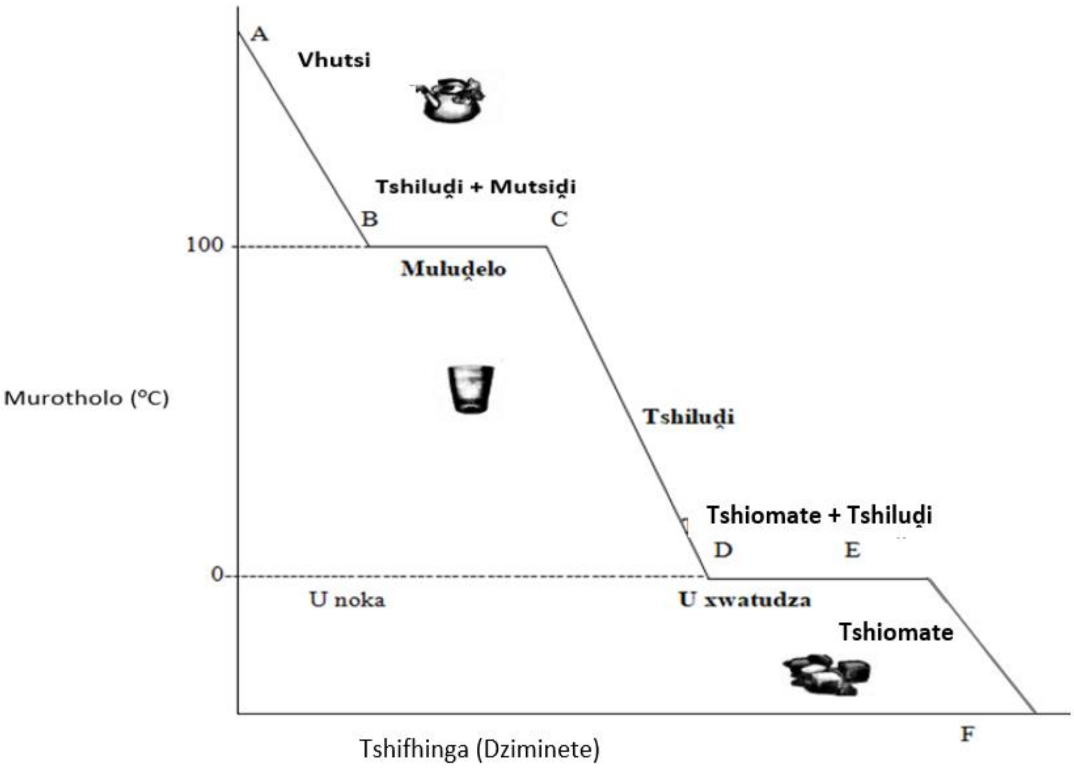
D - E: U vhila ha maḓi (Tshiluḓi u ya kha vhutsi). Afha tshifhinga tshi ya phanḓa, fhedzi mufhiso u sa shanduke. Tshipiḓa i tshi tshi sumbedza tshiimo tsha tshanduko u bva kha tshiluḓi u ya kha vhutsi (Muḓimuwo), na mufhiso u ne wa dzhia ndango kha tshiimo tsha u vhila. Ngauri mufhiso kha tshiimo tsha u vhila a u shanduki, fulufulu ḽa u sudzuluwa ḽa moḽekhulu ḽi dzula ḽo ralo. Mufhiso wo ṋetshedzwaho u shumiswa u nyeṱhisa maanḓa a u kunga vhukati ha moḽekhuḽu ya ngomu i ne ya khou ita uri zwi dzule zwi kha tshivhumbeo tsha tshiluḓi. Moḽekhuḽu ya maḓi i ya litshedzana ya sia tshiluḓi. Tshiluḓi tshi bva kha tshiimo tsha tshiluḓi tsha shanduka u vha vhutsi.

E - F: Mutsiḓi (vhutsi). Musi mufhiso u tshi khou engedzea, fulufulu ḽa khainethikhi ya moḽekhuḽu ḽi a engedzea hafhu. U sudzuluwa ha moḽekhuḽu dza maḓi dzi sa thithiswi dzi vha na fulufulu ḽinzhi dza bva kha dziṅwe u kona uri maanḓa a u kunga a si vhe hone.

Mukombamo wa fholisa

Musi mutsiḓi wo tendelwa u fhola, u kona u sika maḓi na muxwatu, mutalombalo u tevhelaho u ya zwi sumbedza.

Uyi ndi mukombamo wa u fholisa maḓi.



Musi mutsiḓi, maḓi na muxwatu zwi tshi fhola, mufhiso u tsela fhasi (khethekanyo **AB**, **CD** na **EF**). Zwilavhi zwi sudzuluwa nga zwiṱuku na u vha na fulufulu la khainethikhi.

Kha tshiimo tsha u shanduka hune mutsiḓi wa shanduka u vha maḓi (Muluḓeo) na hune maḓi a shanduka u vha tshiomate (u xwatudza) mufhiso a u shanduki. Fulufulu ḽi ṋetshedzwa kha phoindi iyi (**BC** na **DE**) a zwi vhangi u xelelwa ha fulufulu ḽa khainethikhi. U xelelwa ha fulufulu zwi vhanga u gonya ha maanḓa a moḽekhuḽu ya ngomu ine ya kuvhanganya zwilavhi.

Mufhiso a u shanduki kha khethekanyo hedzi.

NḒOWE-NḒOWE DZA ZWIIMO ZWIRARU ZWA TSHITHU.

Nḓowe-nḓowe ya u thoma

1. Tshiimo tshi vhonalaho tsha tshithu tsha tshishumiswa kha mufhiso/murotholo wo ṋetshedzwaho zwi bva kha tshiimo tsha u vhiliswa, u ṋoka na u xwatudza. A vha ṱalutshedze maipfi a tevhelaho:

   1.1 Tshiimo tshivhonalaho tsha tshishumiswa

   1.2 Tshiimo tsha u vhilisa

   1.3 Tshiimo tsha u ṋokisa

   1.4 Tshiimo tsha u xwatudza

2. Thebuḽu i re afho fhasi i sumbedza mafhungo a zwishumiswa zwiṱanu A,B,C,D na E

Tshishumiswa	**U ṋokisa (℃)**	**U vhilisa (℃)**
A	-189	-186
B	-219	-183
C	-7	58
D	29	222
E	660	2 450

2.1. Kha mufhiso wo linganelaho (20℃), ndi zwifhio zwishumiswa zwine zwa vha

2.1.1. Tshiomate?

2.1.2. Tshiluḓi?

2.1.3. Vhutsi?

2.2 Kha vha ṱalutshedze uri hu iteani kha zwilavhi zwa tshishumiswa C musi tshi tshi fholiswa u bva kha 80℃ u ya kha -10℃.

Nḓowe-nḓowe ya vhuvhili

1. Tshiimo tsha u ṋokisa na u vhilisa zwa zwishumiswa zwiraru zwo ṋetshedzwa kha thebuḽu afho fhasi:

Tshishumiswa	U ṋokisa (℃)	U vhilisa (℃)
A	25	115
B	-46	59
C	107	249

   1.1. Ndi zwifhio zwishumiswa zwine kha mufhiso wo linganelaho zwa vha kha

1.1.1. Tshivhumbeo tsha tshiomate?

1.1.2. Tshivhumbeo tsha tshiluḓi?

1.2. Arali zwishumiswa izwi zwiraru zwo fhisiwa u bva kha 0℃ u ya kha 100℃, ndi tshifhio tshishumiswa tshine tshaḓo:

1.2.1. Shanduka u bva kha tshiomate u ya kha tshiluḓi?

1.2.2. Shanduka u bva kha tshiluḓi u ya kha vhutsi?

2. Ndi tshifhio tshivhumbeo tshi vhonalaho tsha tshishumiswa arali

2.1 Tshiimo tsha u nokisa tshi nṱha u fhira mufhiso wo linganelaho?

2.2 Tshiimo tsha u vhilisa tshi fhasi ha mufhiso wo linganelaho?

2.3 Tshiimo tsha u ṋokisa tshi fhasi ha mufhiso wo linganelaho, tshiimo tsha u vhilisa tshi nṱha ha mufhiso wo linganelaho?

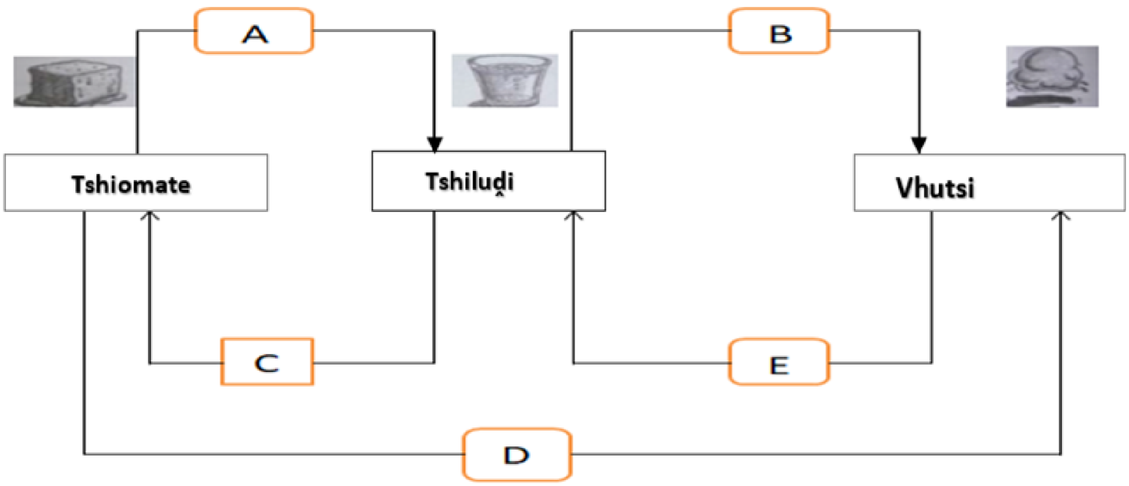
3.

3.1. Ndi lini hune tshiimo tsha tshanduko tsha bvelela?

3.2. Ndi ngani ri tshi nga ri tshiimo tsha tshanduko tshi a humiselea murahu?

Nḓowe-nḓowe ya vhuraru

1. A vha gude nyolo i tevhelaho i ne ya sumbedza tshiimo tsha tshanduko.



1.1. Kha vha ambe dzina ḽa tshanduko i ne ya khou sumbedziwa u bva kha A u swika E kha nyolo. Vha sumbedze na ṱhalutshedzo.

1.2. Ndi kha tshifhio tshiimo hune mufhiso (fulufulu) wa kokodzea?

1.3. Ndi kha tshifhio tshiimo hune mufhiso (fulufulu) wa bviswa?

1.4. Ndi mufhiso ufhio une wa kokodziwa kana u bvisiwa nga musi wa tshiimo tsha tshanduko?

1.5. Hu iteani kha mufhiso (fulufulu) une wa kokodziwa kana u bviswa nga tshifhinga tsha tshiimo tsha tshanduko?

1.6. Ndi kha tshanduko dzifhio, A u swika E, hune

1.6.1. Maanda a u kunga vhukati ha zwilavhi a vha a sina nungo?

1.6.2. Zwilavhi zwa ṱutshela u vha kule na kule zwa vha tsini na tsini?

Zwilavhi zwia khethekana kana u fhambana zwa bva he zwa dzula hone zwa sokou sudzuluwa na masia o fhambanaho

1.7. Kha vha ṱalutshedze tshanduko dzine dza itea nga kha u sudzuluwa na tshikhala tsha zwilavhi kha

1.7.1. A

1.7.2. D

Nḓowe-nḓowe ya vhuṇa

Tshidungi tsha ḽaurikhi ($C_{12}H_{24}O_2$) ndi tshiomate kha mufhiso wo linganelaho hune tsha shumiswa sa thimbanywa dza tshisibe, makhanḓela na zwiḓolo. Tshiedzwa tsha dungi tsha ḽaurikhi tsho shelwa kha tshubu ya u linga ye ya dzheniswa kha tshifaredzi tshire na maḓi a u dudela, ya fhiswa u swika tshiedzwa tshi tshi ṋoka. Mufhiso wa tshiedzwa u kalwa nga murahu ha mithethe iṅwe na iṅwe ya furaru, ya ṅwalwa kha thebuḽu.

U FHISIWA

Tshifhinga (dziminete)	Mufhiso (℃)
0	30,0
0,5	31,2
1,0	32,4
1,5	35,7
2,0	36,0
2,5	37,3
3,0	39,6
3,5	40,0
4,0	41,2
4,5	42,5
5,0	44,8
5,5	44,0
6,0	44,0
6,5	44,0
7,0	44,0
7,5	44,8
8,0	45,8
8,5	46,7
9,0	47,6

U FHOLISA

Tshifhinga (dziminete)	Mufhiso (℃)
0	55,0
0,5	53,1
1,0	49,5
1,5	47,7
2,0	46,0
2,5	44,0
3,0	44,0
3,5	44,0
4,0	44,0
4,5	44,0
5,0	44,0
5,5	44,0
6,0	44,0
6,5	44,0
7,0	44,0
7,5	43,7
8,0	43,0
8,5	43,4
9,0	42,8

9,5	48,6
10,0	49,1
10,5	50,0
11,0	51,3

9,5	42,0
10,0	42,8
10,5	41,9
11,0	41,5

Tshubu yau linga i re na tshiedzwa tsho ṋokaho yo ḓo konaha u vhewa kha khaphu i re na muxwatu uri i kone u fhola u swika i tshi xwatudzea. Mufhiso wa tshiedzwa wo dovha wa kaliwa nga murahu ha mithethe iṅwe na miṅwe ya furaru, ya ṅwalwa kha thebuḽu.

1.1. Vha humbula uri ndi ngani ho shumiswa maḓi a u dudela kha iyi ṱhoḓisiso?

1.2. A vha ṅwale khumbulelo ya ṱhoḓisiso musi tshidungi tsha ḽaurikhi tshi tshi fhiswa.

1.3. Kha vha ṅwale khumbulelo ya ṱhoḓisiso iyi musi tshidungi tsha ḽaurikhi tshi tshi fholiswa.

1.4. Kha vha ambe tshivangi tsho ḓiimisaho.

1.5. Kha vha ambe tshivangi tshi songo ḓiimisaho.

1.6. Kha vha ole mutalombalo wa u fhiswa ha tshidungi tsha ḽaurikhi.

1.7. Kha vha ṱalutshedze tshanduko i vhonalaho ye ya vha hone u bva kha dziminete miṱanu u ya kha dziminete ya sumbe.

1.8. Kha vha ṱalutshedze uri ndi ngani mufhiso wo dzula u sa shanduki u bva kha dziminete miṱanu u swika kha ya sumbe.

1.9. Kha vha ṱalutshedze uri ndi ngani mufhiso wo gonya hafhu nga murahu ha dziminete ya sumbe.

1.10. Kha vha ole mutalombalo wa u fholiswa ha tshidungi tsha ḽaurikhi.

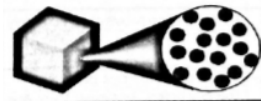
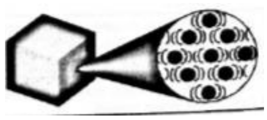
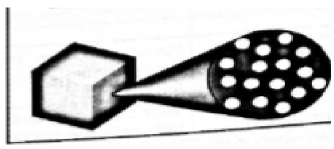
1.11. Kha vha ṱalutshedze tshanduko dzi vhonalaho dze dza vha hone ubva kha dziminete miraru u ya kha ya sumbe.

1.12. Kha vha ṱalutshedze uri ndi ngani mufhiso u songo shanduka u bva kha dziminete miraru u ya kha ya sumbe.

THYIORI YA KHAINETHIKHI MOḼEKHUḼU

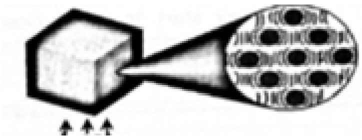
Zwiimo zwiraru zwa tshithu

Kha khethekanyo yo fhiraho ro amba nga ha phambano ya zwiimo (tshiomate, tshiluḓi na vhutsi) zwa tshithu ho shumiswa zwiimiswa zwa nga kuvhonale kuṱukusa sa u vhilisa, u ṋoka na muḓimuwo. U ṱalutshedza izwi, ri tea u pfesesa zwine zwa itea kha tshiita tshithu na tshiimiswa tsha moḽekhuḽu tsha zwishumiswa. Izwi ndi luṱa lwa zwiimiswa zwa nga kuvhonale kuṱukusa. A ri koni u vhona zwiita tshithu kana moḽekhuḽu fhasi ha tshivhonazwiṱuku, fhedzi ri kona u vhona tshivhumbeo tshazwo kha u thusedziwa nga dzi nyolo sa kha moduḽu 1. Luvhilo lune moḽekhuḽu ya gidima ngalwo na tshikhala vhukati hadzo musi dzi tshi shanduka zwi ya itea, sa tsumbo u bva kha tshiluḓi u ya kha vhutsi. Thyiori ya khainethikhi moḽekhuḽu ndi modele, ndi yone nḓila ya u ṱalutshedza mbonalo ya zwiimiswa zwa nga kuvhonale kuṱukusa kha luṱa lwa moḽekhuḽu. U phaḓalala na u sudzuluwa ha Buraunieni zwi tou vha khwaṱhisedzo ya kuvhonale kuṱukusa kwa zwiimiswa zwa nga kuvhonale kuṱukusa kwa tshithu, zwa sumbedza uri tshithu tshina zwilavhi. Khainethikhi ri vha ri khou amba u sudzuluwa, naho hu uri thyiori ya khainethikhi moḽekhuḽu i tshi vhambedza u sudzuluwa ha moḽekhuḽu kha zwiimo zwo fhambanaho. Ri dovha hafhu ra shumisa thyiori u ṱalutshedza mufhiso kha khethekanyo yo fhiraho. Thyiori ya khainethikhi moḽekhuḽu i sumbedza vhushaka ha zwiimiswa zwa nga kuvhonale kuṱukusa ha tshiomate, tshiluḓi kana vhutsi, na vhushaka ha zwiimo na luvhilo lwa zwilavhi. Thyiori ya khainethikhi moḽekhuḽu i pfufhifhadzwa nga nḓila i tevhelaho:

1. Tshithu tsho vhumbwa nga zwilavhi zwiṱuku (zwiita tshithu, moḽekhuḽu)	2. Zwilavhi zwi sudzuluwa nga u tevhekana (zwoṱanganana na fulufulu ḽa u sudzuluwa)	3. Hu na zwikhala vhukati ha zwilavhi.
		

4. Nga nṱhani ha u tevhekana ha u sudzuluwa ha zwilavhi, zwi sia zwi tshi kuḓana na zwiṅwe na luvhondo lwa khontheina.

5. Mufhiso wa zwishumiswa ndi tshikalo tsha fulufulu ḽa u sudzuluwa ḽa zwilavhi.



U fhisa

kha tshifhinga tshiṅwe na tshiṅwe tsho ṋewaho zwilavhi zwa tshiedzwa zwa tshithu, a zwi na luvhilo lwa u fana zwo ralo na fulufulu ḽa u sudzuluwa. Zwiṅwe zwa zwilavhi zwi thoma u sudzuluwa nga u ṱavhanya u fhira zwiṅwe. U fhisa zwiita uri zwilavhi zwi sudzuluwe nga u ṱavhanya. Naho zwi si zwilavhi zwoṱhe zwine zwa ḓo sudzuluwa nga luvhilo luthihi, fhedzi arali luvhilo zwa zwilavhi lwavha lu nṱha, mufhiso i ḓo vha nṱha.

6. Maanḓa a kungaho avha hone vhukati ha zwilavhi musi zwi na vhushaka ha tsini na tsini, ngeno maanḓa a u lambana a tshi vha hone musi zwi tsini na tsini.
7. Tshiimo tsha tshanduko tshi vha hone musi fulufulu ḽa zwilavhi ḽo shanduka nahone ḽa dovha ḽa ṱanganyisa u dzudzanywa hafhu ha zwilavhi

Zwino ri nga kona, nga u shumisa thyiori ya khainethikhi moḽekhuḽu u ṱalutshedza mbonalo ya zwiimiswa zwa nga kuvhonale kuṱukusa zwa zwiomate, zwiluḓi na mutsiḓi kha luṱa lwa kuvhonale kutukusa.

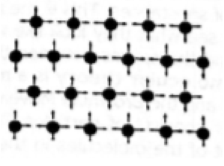
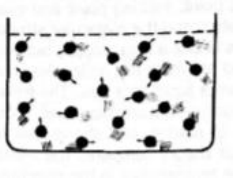
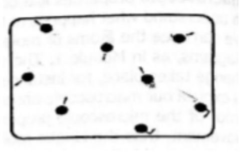
Tshiimo	**Mbonalo ya zwiimiswa zwa nga kuvhonale kuṱukusa**	**Ṱhalutshedzo ya kuvhonale kutukusa**
Tshiomate	Tshi na vhungomu na tshivhumbeo tsho tiwaho	Zwilavhi zwo dzudzanywa kha vhuimo ho iewaho
	A tshi eleli	Zwilavhi a zwi koni u sudzuluwa na u kuḓana nga tshazwo
	A tshi kwanyeledzwi kana u ṱukufhadzwa	Hu na tshikhala tshiṱuku vhukati ha zwilavhi

Tshiluḓi	Tshi dzhia tshivhumbeo tsha tshithu tshine tshavha khatsho	Zwilavhi zwi a sudzuluwa na u kuḓana nga tshazwo
	Tshi elela zwoleluwa	Zwilavhi zwi a sudzuluwa na u kuḓana nga tshazwo
	A tshi ṱukufhadzwi zwo leluwa	Hu na tshikhala tshiṱuku vhukati ha zwilavhi
Vhutsi	Tshi ṱanganya tshithu ṱshothe tshine tshavha khatsho.	Zwilavhi zwi sudzuluwa zwo leluwa
	Vhu elela zwo leluwa	Zwilavhi zwi a sudzuluwa zwi tshi fhirana
	Vhu ya kwanyeledzwa	Hu na tshikhala tshinzhi vhukati ha zwilavhi

- Zwiluḓi na zwiomate zwi vhidzwa tshiimo tsha tshiluḓifhadzi ngauri zwilavhi zwi vha zwitsini na tsini
- Zwiluḓi na vhutsi zwi vhidzwa u pfi zwiluḓi ngauri zwilavhi zwi a kona u sudzulua kha zwiṅwe.

U SHUMISWA HA THYIORI YA KHAINETHIKHI MOḼEKHUḼU U ṰALUTSHEDZA ZWIOMATE, ZWILUḒI NA VHUTSI.

Zwa zwino ri nga ṱalutshedza phambano vhukati ha zwiomate, zwiluḓi na muya nga kha thyiori ya khainethikhi moḽekhuḽu.

	Tshiomate	**Tshiluḓi**	**vhutsi**
Zwiimiswa zwa tshithu			

Zwikhala vhukati ha zwilavhi	Zwikhala zwiṱuku vhukati ha zwishumiswa	Tshikhala tshihulwane hu tshivhambedzwa na zwiomate, fhedzi zwa vha zwiṱuku hu tshi vhambedzwa na mutsiḓi	Zwikhala zwihulwane vhukati ha zwilavhi
Fulufulu la zwilavhi	Fulufulu liṱuku	Fulufulu linzhi u fhira zwiomate, fulufulu ḽiṱuku hu tshivhambedza na mutsiḓi	Fulufulu linzhi
U sudzuluwa ha zwilavhi	Zwilavhi zwi sudzuluwa zwiṱuku na u dzinginyea kha vhuimo hazwo	Zwilavhi zwi mona mona na u dzinginyisea lwa mutevhetsindo	Zwilavhi zwi sudzuluwa zwi sa thithiswi
Maanḓa a u kunga/ kokodza vhukati ha zwilavhi	Maanḓa mahulu vhukati ha zwilavhi (fulufulu la moḽekhuḽu ya ngomu); tshiomate tshi vhuelela kha tshivhumbeo tshatsho	U fhela nungo u fhira zwiomate, fhedzi zwa khwaṱha u fhira mutsiḓi	U fhela nungo hu sina maanḓa vhukati ha zwilavhi ngauri zwi kule na kule.
U shanduka ha zwiimo	Tshiomate tshi vha tshiluḓi musi tsho fhisiwa; zwilavhi zwi thoma u sudzuluwa nga u	Tshiluḓi tshi vha tshiomate musi tsho fholiswa, na mutsiḓi musi tsho vhiliswa.	Mutsiḓi I shanduka u vha tshiluḓi musi I tshi fhola, fulufulu ḽa zwilavhi ḽa tsela fhasi, ḽa thoma u sudzuluwa tsini na

	ṱavhanya kule na zwiṅwe, izwi zwi nyeṱhisa maanḓa a u kokodza vhukati ha zwilavhi.		tsini, maanḓa a u kokodza a gonya/aluwa, u sudzuluwa zwa fhungudzea

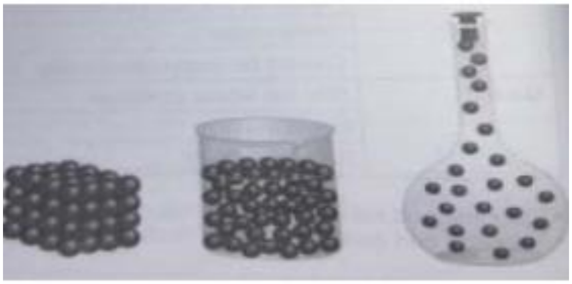
NḒOWE-NḒOWE DZA THYIORI YA KHAINETHIKHI MOḼEKHUḼU

<u>Nḓowe nḓowe ya u thoma</u>

1.1. Thyiori ya khainethikhi moḽekhuḽu ndi mini?

1.2. A vha ṅwale zwipiḓa zwiṋa zwa ndeme zwa thyiori ya khainethikhi moḽekhuḽu.

2. Tshifanyiso tshi tevhelaho tshi sumbedza modele wa zwilavhi kha tshiimo tsha tshiomate, tshiluḓi na vhutsi.



A vha shumise thyirori ya khainethikhi moḽekhuḽu u ṱalutshedza mishumo ya tshiomate, tshiluḓi na vhutsi kha luṱa lwa kuvhonale kuṱukusa.

Mishumo ya tshiomate	Ṱhalutshedzo ya kuvhonale kuṱukusa
Tshivhumbeo tsha tshiomate	
Vhungomu ha tshiomate	
Vhutandekani vhu re nṱha	
U sa kona u kwanyeledzwa zwoṱhe	
A zwi koni u elela	

Mishumo ya tshiluḓi	Ṱhalutshedzo ya kuvhonale kuṱukusa
U sa vha kha tshivhumbeo tsha tshiomate	
Vhungomu ha tshiomate	

Vhutandekani ho lavheleswaho	
U sa kona u kwanyeledzwa zwoṱhe	
Zwi a kona u elela	

Mishumo ya vhutsi	Ṱhalutshedzo ya kuvhonale kuṱukusa
U sa vha kha tshivhumbeo tsha tshiomate	
Vhungomu hu so ngo tiwaho	
Vhutandekani vhu re fhasi	
Zwi a kona u kwanyeledzwa zwoṱhe	
A zwi koni u elela	

<u>Nḓowe-nḓowe ya vhuvhili</u>

A vha nee ipfi kana themo ḽithihi ḽa ṱhalutshedzo dzi tevhelaho.

1. U sudzuluwa ha masongesonge ha zwilavhi kha vhutsi.
2. Fulufulu ḽa zwilavhi ḽe ḽa vhangwa nga u sudzuluwa.
3. Maitele a u sudzuluwa ha zwilavhi u bva kha u sudzuluwa vhukati ha zwishumiswa zwo fhambanaho u swika zwi tshi phaḓalala.
4. Tshikalo tshi re vhukati tsha fulufulu ḽa u sudzuluwa ha zwilavhi zwa zwishumiswa.
5. Modele ndi nḓila ine ya ṱalutshedza mbonalo ya zwiimiswa zwa nga kuvhonale kuṱukusa kha luṱa lwa moḽekhuḽu.
6. Zwo ne zwa bvelela musi fulufulu ḽa zwilavhi ḽi tshi shanduka, ḽa kwama na u dzudzanywa ha zwilavhi.

Mulingo wa kiḽasini: Tshiimo tsha tshithu na thyiori ya khainethikhi moḽekhuḽu.

<u>Mbudziso 1</u>

A vha nee ipfi kana themo ḽithihi ḽa ṱhalutshedzo dzitevhelaho

1.1. Tshiimo tsha tshanduko u bva tshiomate u ya kha vhutsi

1.2. Tshiimo tsha tshanduko u bva kha tshiluḓi u ya kha vhutsi

1.3. Maitele a u bva kha vhutsi u ya kha tshilṷdi

1.4. Mufhiso une tshilṷdi tsha shanduka tshiimo tshatsho tsha vha vhutsi

Mbudziso 2

Ma̭di a vhiliswa kha 100℃

2.1. Kha vha ṱalutshedze u vhilisa

2.2. Ndi ifhio tshanduko ya tshiimo ine ya vha hone musi tshilṷdi tshi tshi vhila?

Mbudziso 3

Ndi ngoho kana a si ngoho? Arali i si ngoho, kha vha khakhulule tshitatamennde:

3.1. U ṋoka ndi maitele ane tshiomate tsha shanduka u vha tshilṷdi

3.2. Maitele a u humisela murahu (tshanduko ya tshiimo u bva kha vhutsi u ya kha tshilṷdi) i vhidzwa u pfi ndi mṷdimuwo

3.3. Daifushini/ u pha̭dalala ndi u sudzuluwa ha zwilavhi u bva kha ṱanganyisa zwiṱuku u ya kha u ṱanganyisa zwihulu

3.4. Mṷdimuwo u bva kha vhunṋda ha tshilṷdi zwi nga itea nga kha mufhiso ure nṱha.

Mbudziso 4

Kha vha ole siketshe tshine tsha sumbedza moḽekhuḽu dza tshishumiswa hu tshi khou u vha na tshanduko

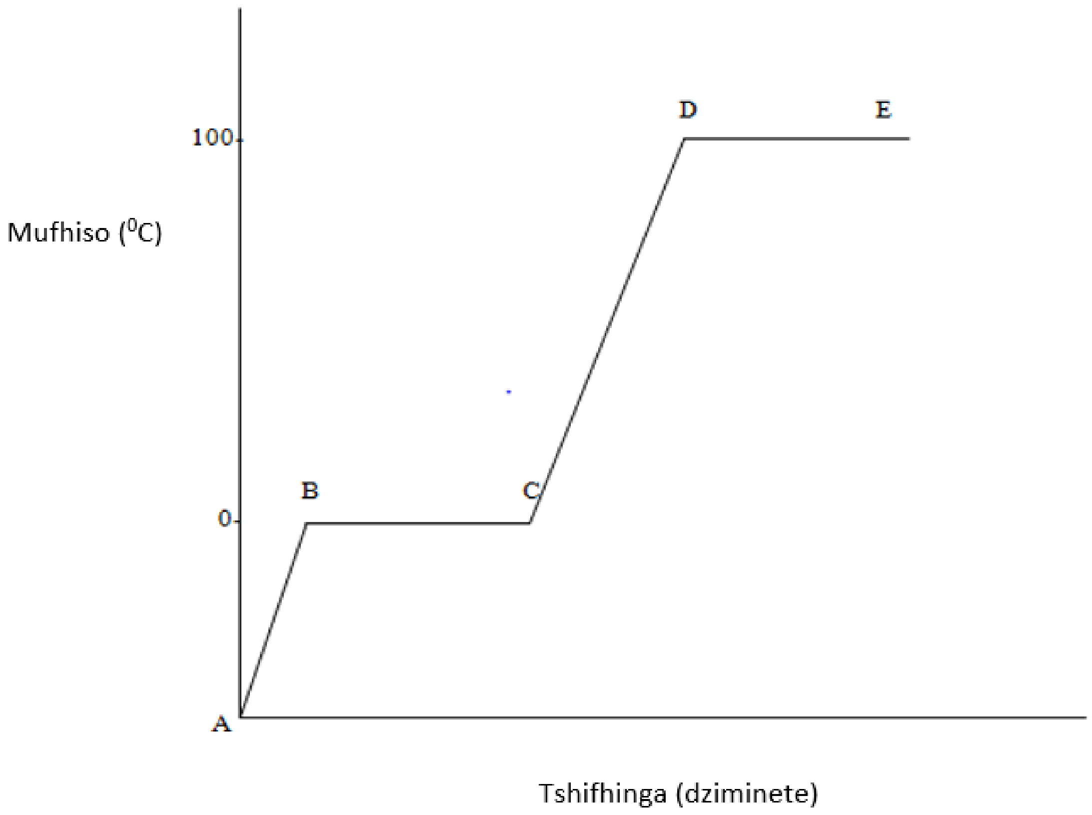
1.1. U xwatudza

1.2. Mṷdimuwo

1.3. Sabiḽimesheni

Mbudziso 5

Musi wa ṱho̭disiso kha ma̭di na zwiṱalusi, Precious o dzhia magwada a muxwatu, a a dzhenisa kha tshifaredzi a dzi fhisa nga tshikenzekenze. A dzhia mufhiso nga kha tshikhala tsho ̭doweleaho, a ola mutalombalo wa mvelelo. Mutalombalo wo sumbedzwa afho fhasi.



Nga kha u gonyela nṱha ha mufhiso, maanḓa vhukati ha moḽekhuḽu, zwikhala vhukati ha moḽekhuḽu, fulufulu ḽa u sudzuluwa vhukati ha moḽekhuḽu, tshiimo tsha tshanduko, u engedzedzea ha fulufulu ḽo faredzwaho na u vhila/ u fhisa, kha vha ṱalutshedze zwine zwa khou itea:

5.1. Vhukati ha tshiga tsha A na B

5.2. Kha tshiga tsha B

5.3. Vhukati ha tshiga tsha B na C

5.4. Zwiimo zwi khou shanduka kha tshanduko i vhonalaho kana khemikhaḽa? Kha vha ṱalutshedze.

5.5. Arali vha dzulela u fhisa maḓi u fhirisa kha tshiga tsha E, vha nga kona u fhambanyisa mutsiḓi kha haidirodzheni na muyamufhe? Kha vha ṱalutshedze.

Appendix T: English Scientific Register for Physical Sciences

ENGLISH SCIENTIFIC REGISTER FOR PHYSICAL SCIENCES

States of matter and the kinetic molecular theory 3

States of matter ESAAK

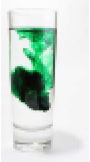
In this chapter we will explore the states of matter and then look at the kinetic molecular theory. Matter exists in three states: solid, liquid and gas. We will also examine how the kinetic theory of matter helps explain boiling and melting points as well as other properties of matter.
See introductory video: (Video: VPajx at www.everythingscience.co.za)

All matter is made up of particles. We can see this when we look at diffusion.

> ### DEFINITION: Diffusion
>
> Diffusion is the movement of particles from a high concentration to a low concentration.

Diffusion can be seen as a spreading out of particles resulting in an even distribution of the particles. You can see diffusion when you place a drop of food colouring in water. The colour slowly spreads out through the water. If matter were not made of particles that are constantly moving then we would only see a clump of colour when we put the food colouring in water, as there would be nothing that could move about and mix in with the water.

Food colouring in water



Picture by LadyDayDream on Flickr.com

Diffusion is a result of the constant thermal motion of particles. In 1828 Robert Brown observed that pollen grains suspended in water moved about in a rapid, irregular motion. This motion has since become known as **Brownian motion**. Brownian motion is essentially diffusion of many particles. Brownian motion can also be seen as the random to and fro movement of particles.

Matter exists in one of three states, namely solid, liquid and gas. A solid has a fixed shape and volume. A liquid takes on the shape of the container that it is in. A gas completely fills the container that it is in. Matter can change between these states by either adding heat or removing heat. This is known as a **change of state**. As we heat an object (e.g. water) it goes from a solid to a liquid to a gas. As we cool an object it goes from a gas to a liquid to a solid. The changes of state that you should know are:

- **Melting**

> *DEFINITION: Melting point*
>
> The temperature at which a *solid* changes its phase or state to become a *liquid*. The process is called melting.

- **Freezing**

> *DEFINITION: Freezing point*
>
> The temperature at which a *liquid* changes its phase to become a *solid*. The process is called freezing.

- **Evaporation**
  Evaporation is the process of going from a liquid to a gas. Evaporation from a liquid's surface can happen at a wide range of temperatures. If more energy is added then bubbles of gas appear inside the liquid and this is known as boiling.

> *DEFINITION: Boiling point*
>
> The temperature at which a *liquid* changes its phase to become a gas. The process is called evaporation

- **Condensation** is the process of going from gas to liquid.
- **Sublimation** is the process of going from a solid to a gas. The reverse process is called deposition.

If we know the melting and boiling point of a substance then we can say what state (solid, liquid or gas) it will be in at any temperature.

The figure 3.1 summarises these processes:

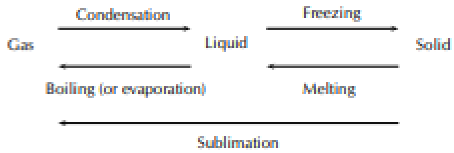


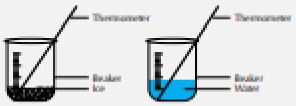
Figure 3.1: Changes in phase

Formal experiment: *Heating and cooling curve of water*

Aim: To investigate the heating and cooling curve of water.

Apparatus:

- beakers
- ice
- Bunsen burner
- thermometer
- water



Method:

1. Place some ice in a beaker.
2. Measure the temperature of the ice and record it.
3. After 1 minute measure the temperature again and record it. Repeat every minute, until at least 3 minutes after the ice has melted.
4. Plot a graph of time versus temperature for the heating of ice.
5. Heat some water in a beaker until it boils. Measure and record the temperature of the water.
6. Remove the water from the heat and measure the temperature every 1 minute, until the beaker is cool to touch.

Warning:
Be careful when handling the beaker of hot water. Do not touch the beaker with your hands, you will burn yourself.

Results:

1. Record your results in the following table:

Heating of ice		Cooling of boiling water	
Time (min)	**Temperature (in °C)**	**Time (min)**	**Temperature (in °C)**
0		0	
1		1	
2		2	
etc.		etc.	

2. Plot a graph of time (independent variable, x-axis) against temperature (dependent variable, y-axis) for the ice melting and the boiling water cooling.

Discussion and conclusion: You should find that the temperature of the ice increases until the first drops of liquid appear and then the temperature remains the same, until all the ice is melted. You should also find that when you cool water down from boiling, the temperature remains constant for a while, then starts decreasing.

In the above experiment, you investigated the heating and cooling curves of water. We can draw heating and cooling curves for any substance. A **heating curve** of a substance gives the changes in temperature as we move from a *solid* to a *liquid* to a gas. A **cooling curve** gives the changes in temperature as we move from gas to *liquid* to *solid*. An important observation is that as a substance melts or boils, the temperature remains constant until the substance has changed state. This is because all the heat energy goes into breaking or forming the bonds between the molecules.
The following diagram gives an example of what heating and cooling curves look like:

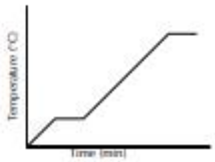


Figure 3.2: Heating curve

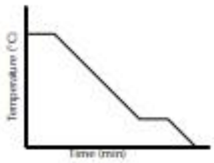


Figure 3.3: Cooling curve

The kinetic molecular theory

ESAAL

The **kinetic theory of matter** helps us to explain why matter exists in different *phases* (i.e. solid, liquid and gas), and how matter can change from one phase to the next. The kinetic theory of matter also helps us to understand other properties of matter. It is important to realise that what we will go on to describe is only a *theory*. It cannot be proved beyond doubt, but the fact that it helps us to explain our observations of changes in phase, and other properties of matter, suggests that it probably is more than just a theory.

Broadly, the kinetic theory of matter says that all matter is composed of **particles** which have a certain amount of **energy** which allows them to move at different speeds depending on the temperature (energy). There are **spaces** between the particles and also **attractive forces** between particles when they come close together.

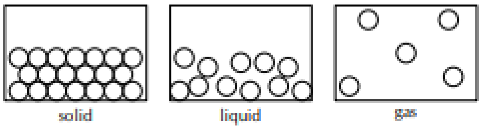


Figure 3.4: The three states of matter

Table 3.2 summarises the characteristics of the particles that are in each phase of matter.

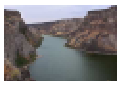
Taking copper as an example we find that in the solid phase the copper atoms have little energy. They vibrate in fixed positions. The atoms are held closely together in a regular pattern called a *lattice*. If the copper is heated, the energy of the atoms increases. This means that some of the copper atoms are able to overcome the forces that are holding them together, and they move away from each other to form *liquid copper*. This is why liquid copper is able to flow, because the atoms are more free to move than when they were in the solid lattice. If the liquid is heated further, it will become a gas. Gas particles have lots of energy and are far away from each other. That is why it is difficult to keep a gas in a specific area! The attractive forces between the particles are very weak. Gas atoms will fill the container they are in. Figure 3.1 shows the changes in phase that may occur in matter, and the names that describe these processes.

Activity:	*The three phases of water*

Property of matter	**Solid**	**Liquid**	**Gas**
Particles	Atoms or molecules	Atoms or molecules	Atoms or molecules
Energy and movement of particles	Low energy - particles vibrate around a fixed point.	Particles have more energy than in the solid phase but less than in the gas phase.	Particles have high energy and are constantly moving.
Spaces between particles	Very little space between particles. Particles are tightly packed together.	Bigger spaces than in solids but smaller than in gases.	Large spaces because of high energy.
Attractive forces between particles.	Very strong forces. Solids have a fixed volume.	Weaker forces than in solids, but stronger forces than in gases.	Weak forces because of the large distance between particles.
Changes in phase.	Solids become liquids or gases if their temperature is increased.	A liquid becomes a gas if its temperature is increased. A liquid becomes a solid if its temperature decreases.	In general a gas becomes a liquid or solid when it is cooled. Particles have less energy and therefore move closer together so that the attractive forces become stronger, and the gas becomes a liquid or a solid.

Water can be in the form of steam, water liquid or ice. Use marbles (or playdough or clay) to represent water molecules. Arrange the marbles to show the three phases of water. Discuss the properties of each of the phases and the processes and energy in changing from the one phase to the other.

Picture by stevendepolo on Flickr.com



Picture by Alan Vernon on Flickr.com

Chapter 3 | Summary

See the summary presentation (Presentation: VPdgh at www.everythingscience.co.za)

- There are three states of matter: solid, liquid and gas.
- **Diffusion** is the movement of particles from a high concentration to a low concentration. Brownian motion is the diffusion of many particles.
- **Melting point** is the temperature at which a *solid* changes its phase to become a *liquid*. The process is called melting.
- **Freezing point** is the temperature at which a liquid changes its phase to become a solid. The process is called freezing.
- Evaporation is the process of going from a liquid to a gas. Evaporation from a liquid's surface can happen at a wide range of temperatures.
- **Boiling point** is the temperature at which a liquid changes phase to become a gas. The process is called evaporation. The reverse process (change in phase from gas to liquid) is called **condensing**.
- Sublimation is the process of going from a solid to a gas.
- The **kinetic theory of matter** attempts to explain the behaviour of matter in different phases.
- The kinetic theory of matter says that all matter is composed of **particles** which have a certain amount of **energy** which allows them to **move** at different speeds depending on the temperature (energy). There are **spaces** between the particles and also **attractive forces** between particles when they come close together.

Chapter 3 End of chapter exercises

1. Give one word or term for each of the following descriptions.
   a. The change in phase from a solid to a gas.
   b. The change in phase from liquid to gas.
2. Water has a boiling point of $100°$ C
   a. Define boiling point.
   b. What change in phase takes place when a liquid reaches its boiling point?
3. Describe a solid in terms of the kinetic molecular theory.
4. Refer to the table below which gives the melting and boiling points of a number of elements and then answer the questions that follow. (*Data from http://www.chemicalelements.com*)

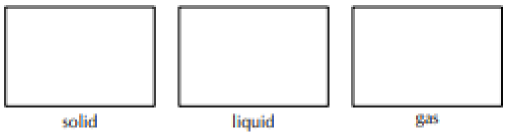
Element	Melting point (°C)	Boiling point (°C)
copper	1083	2567
magnesium	650	1107
oxygen	-218,4	-183
carbon	3500	4827
helium	-272	-268,6
sulphur	112,8	444,6

a. What state of matter (i.e. solid, liquid or gas) will each of these elements be in at room temperature (25°C)?

b. Which of these elements has the strongest forces between its atoms? Give a reason for your answer.

c. Which of these elements has the weakest forces between its atoms? Give a reason for your answer.

5. Complete the following submicroscopic diagrams to show what magnesium will look like in the solid, liquid and gas phase.



More practice video solutions or help at www.everythingscience.co.za

(1.) 000f (2.) 000g (3.) 000h (4.) 000i (5.) 000j

Appendix U: Data Analysis Scheme (DAS)

Theme	Category	Characteristics
Development of Tshivenḓa Physical Sciences scientific register	**Development**	Challenges
		Opportunities
Perceptions of participants toward the application of Tshivenḓa physical sciences scientific register	**Areas of difficulties**	Participants perceptions
	Opportunities	Participants perceptions
Classroom interactions and discourse	**Types of discourse**	Dialogic discourse
		Authoritative discourse
		Reflective discourse
	Patterns of discourse	Initiation-teacher
		Response- learner
		Evaluation-teacher
	Teacher questioning	Drives lesson
		Improve learning

		Develop thinking skills
		Encourage and motivate
	Communicative approach	Interactive-authoritative
		Non-interactive-authoritative
		Interactive-dialogic
		Non-interactive-dialogic

Appendix V: Coded Tshivenḓa observation transcripts

Thakhani coded Tshivenḓa physical sciences observation transcript: June 2022 at Dominance Secondary School in Grade 10

Day one lesson

Line	Description
1.	**0-5 minutes**
2.	Mudededzi o thoma nga u lumelisa *ndi matsheloni*? Vhagudiswa vho fhindula
3	ngauri *ndi matsheloni avhuḓi*. Mudededzi o i sa phanḓa na ndumeliso *no*
4	*vuwa hani?* Vhagudiswa vha fhindula vhoṱhe vhari *zwavhuḓi vhone vho vuwa*
5	*hani? Mudededzi ori na nne ndo vuwa.* Mudededzi o vhudza vhagudiswa uri
6	*zwino namusi kha thero ya namusi ri khoyo funzana nga zwivhumbeo zwa*
7	*zwithu thiri*? Vhagudiswa vha fhindula ngauri *Ee*. Mudededzi ari ee *kha*
8	*zwivhumbeo zwa zwithu ringa nwala uri zwivhumbeo kana zwiimo zwa*
9	*zwithu, ri khou pfana?* Vhagudiswa vha fhindula ngauri ee. Mudededzi a tshi
10	khou nwala bodoni a tshi khou amba ari *zwiimo zwa zwithu, ri khou pfana thi?*
11	Vhagudiswa vha fhindula ngauri ee. Mudededzi u isa phanḓa na u amba so
12	*kha zwivhumbeo kana zwiimo zwa zwithu ri na zwivhumbeo zwono swika*
13	*zwiraru, zwiimo zwingana? Vhagudiswa vha fhindula ngauri* zwiraru.
14	Mudededzi ari *hezwi zwivhumbeo zwa vho rine ndi zwiraru ende zwi zwiraru*
15	*roṱhe ri ngavha ri tshi zwihumbulela uri hungavha hu zwifhio thi*? Vhagudiswa
16	vha fhindula ngauri ee. Mudededzi a tshi isa phanda *tsha u thoma tshi ngavha*
17	*tshifhio?* Vhagudiswa vha fhindula ngauri *zwiluḓi*. Mudededzi a tshi dovholola
18	phindulo ya vhagudiswa *zwiluḓi*. Mudededzi a tshi isa phanḓa na u amba *kha*
19	*zwiluḓi ni ḓivha zwingana zwine ra nga zwiamba, tshakha dza zwiluḓi tsha u*
20	*thoma ndi mini*? Vhagudiswa vha fhindula ngauri *maḓi*. Mudededzi a
21	dovholola zwe vhagudiswa vha amba *maḓi*. Mudededzi ari maḓi roṱhe ri a a
22	divha thiri? Vhagudiswa vha fhindula ngauri ee. Munwe mugudiswa ari
23	nyamuanaithi. Mudededzi ari *nyamunaiti, inwe tsumbo, ya?* Munwe
24	mugudiswa ari *tshikhambeleni*. Mudededzi o vhudzisa vhagudiswa *ari ri na*
24	*tshikhambeleni nga tshivenḓa?* Vhagudiswa vha fhindula ngauri ee.
26	Mudededzi a isa phanḓa na u vhudzisa *inwe ndi ifhio?* Munwe mugudiswa ari
27	tie, munwe ari dizele, munwe ari ole, munwe ari mirundo (mudededzi o nwala
28	phindula dzoṱhe dze vhagudiswa vha dzi amba bodono). Mudededzi a tshi

Takalani coded Tshivenḓa physical sciences observation transcript: June 2022 at Obtainable Secondary School in Grade 10

Day one lesson

Description
0-5 minutes
Vhagudiswa vhovha vho dzula kha dzidesike. Vhagudiswa vho dzula nga zwigwada nga murahu ha musi mudededzi ovha vhudza uri vha dzule nga zwigwada zwa vhathu vhatani. Mudededzi o vhudza vhagudiswa uri vha bvise tsha u ṅwala na tsha u ṅwalela. Mudededzi o thoma nga u lumelisa vhagudiswa *ndi masiari vhananga?* Vhagudiswa vho fhindula ngauri *ndi masiari avhuḓi*. Mudededzi ori *namusi ri khou ḓo funzana nga thero, kha heyi thero ya physical science ri khou ḓo funzana nga thero ṱhukhu ya zwiimo zwa tshithu.* Mudededzi wa dovholola *zwiimo zwa tshithu, ya zwiimo zwa tshithu*. Mudededzi vho isa phanda *ri na zwiimo zwiraru zwa tshithu ndi zwi tevhelelaho, zwiomate ndi tshau thoma, tsha vhuvhili rina zwiluḓi, tshiimo tsha vhuraru ri na Vhutsi.*
5-10 minutes
Mudededzi u isa phanda *ri vho zwi ḓivha uri tshithu ndi tshiṅwe na tshiṅwe tshine tsha vha na tshileme, ri vho zwi ḓivha uri tshithu ndi tshiṅwe na tshiṅwe tshine tsha vha na tshileme, na u dzhia tshikhala.* Mudededzi u isa phanda *tsumbo inwi no dzulisa zwezwo hanefho kha desike ni na tshileme tshine na lemelisa zwone ende he na dzula hone no dzhia tshikhala.* Mudededzi uya dovholola *tsumbo ndi inwi he na dzula hone ni na tshileme na uri no dzhia tshikhala.* Mudededzi u i sa phanda vhunzhi ha tshithu kha ḽifhasi *ndi tshiomate, tshiluḓi na Vhutsi. Hezwi zwi vhidzwa u pfi ndi zwiimo zwiraru zwa tshithu. Maḓi ndi tshithu tshine ra tangana natsho nga kha hezwi zwiimo zwiraru, sa muxwatu, sa muxwatu* (mudededzi u amba a khou ṅwala kha bodo), *maḓi a tshiluḓi na maḓi a mutsiḓi.*
10-15 minutes
Nga saintsi ri ṅwala uri maḓi a muxwatu sa open brackets sa zwiomate, maḓi tshiluḓi na maḓi mutsiḓi (mudededzi o ṅwala kha bodo). *Ri nga kona u fhambanyisa zwiomate, zwiluḓi na vhutsi ngauri ndi zwithu zwine zwa vha na zwitalusi zwo fhambananaho* (mudededzi o vhudza vhana uri vha pfuke mutalo muthihi). Mudededzi uya isa phanda zwitalusi zwa ndeme zwa zwiomate, zwiluḓi na vhutsi zwo pfufhifhadzwa nga nḓila i tevhelaho.
15-20 minutes
Mudededzi u thutha bodo a ṅwala thebulu ine yo khethekana zwiimo zwiraru zwa tshithu. Mudededzi u a isa phanḓa ri do ṅwala zwiomate, zwiluḓi, na Vhutsi. Fhasi ha

Leon coded Tshivenḓa physical sciences observation transcript: June 2022 at Remarkable Secondary School in Grade 10

Day one lesson

Line	Description
	0-5 minutes Vhagudiswa vhovha vho dzula kha dzidesike vhanwe vhagudiswa vhovha vha khou shumisa zwidulo. Vhagudiswa vhovha vho dzula nga zwigwada. Mudededzi o thoma nga u lumelisa vhagudiswa *ndi matsheloni?* Vhagudiswa vho fhindula ngauri *ndi matsheloni avhuḓi*. Mudededzi o i sa phanda na ndumeliso *hurini?* Vhagudiswa vha fhindula vhoṱhe vhari *ri hone*. Mudededzi o i sa phanḓa ngauri *hai na rine ro takala*. Mudededzi ori *eh hafha shangoni ri khou tshila ro no ṱangana na zwithu, asi zwone kani?* Vhagudiswa vhothe vho fhindula nga *ee*. Mudededzi vho isa phanda *Zwino thi hu na kuambele kwo ḓoweleaho kwa uri zwithu zwithu, zwino zwithu zwine ra khou nyaga u amba nga zwo namusi ri khou ṱoda u amba nga hazwo kha saintsi. Zwino mafhungo ndi a uri hone kha saintsi ri tshi ri zwithu rivha ri khou amba mini. Ndi nnyi ane a nga amba uri ri tshi ri zwithu nga luambo lwa saintsi ri vha ri khou amba uri mini, uri tshithu ndi tshithu kana zwithu ndi zwithu ri do zwivhonisa hani? zwithu ndi mini?* (Mudededzi o vhudzisa vhagudiswa mbudziso mara vhagudiswa vho sumbedza usa ḓivha uri tshithu ndi mini ngauri ahuna o fhindulaho). Mudededzi o mbodi i sa phanḓa na u amba *okay, zwino ndi ḓo sokou ri a si luambo ro lu ḓowelaho thi, mara ri ḓo kona u zwi vhona uri zwithu ndi zwithu zwo leluwaho. Zwino ri tshi amba nga zwithu rivha ri tshi khou amba nga tshinwe na tshinwe tshine tshavha na hezwi zwithu ndi zwone zwandeme thi tshileme tsha dovha tshavha na mini na tshikhala* (Mudededzi u ṱalutshedza vhagudiswa uri tshithu ndi mini a tshi khou nwala kha bodo a tshi sumbedza na maipfi a ndeme kha ṱhalutshedzo ya tshithu). *Maipfi a ndeme kha tshithu ndi mini ndi tshileme na mini na tshikhala thi* (Mudededzi o talela maipfi a ndeme kha ṱhalutshedzo ye a i nwala bodoni). *Zwino tshileme ri khou amba mini, ri khou amba uri tshithu tsha hone tshi fanela u vha tshi tshi lemela thi.* Vhagudiswa vho fhindula ngauri *ee*. Mudededzi o i sa phanḓa na u amba *ndi tshone tshi no pfi ndi tshileme. Tshileme ri vha ri khou tou amba uri hu tshi pfi ndi tshithu ri ḓo zwi vhona*

Appendix W: Coded English observations transcripts

Thakhani coded English physical sciences observation transcript: June 2022 at Dominance Secondary School in Grade 10

Day one lesson

Description
0-5 minutes
Learners seated on the desks and all learners are on their school uniform. The learners were seated in different groups. Teacher started his lesson by greeting his learners' *good afternoon class* and the learners said *good afternoon our teacher.* Teacher continued, *how are you?* And all the learners responded *we are Fine, thank you and how are you teacher*? Teacher said *I am doing well, thank you*. Teacher introduced the topic of the lesson and said *today lesson we are going to learn about phases of matter* (the teacher wrote the topic on the chalkboard and learners copy the topic). The teacher said *phases of matter, the first one is what?* Both teacher and learners responded *is solid.* The teacher proceeds *the second one is what?* Learners said *liquid.* The teacher said *the third one is what?* Learners said *gas.* The teacher said *all these are the three phases of matter, you can name the example of solid, the example of liquid, the example of gas, isn't it?* Learners said *yes*. The teacher proceeds *Let us try to list the example of solid, yes* (learners raised up their hands and the teacher pointed one learner at a time to give responses). Learner 1 said *rocks,* Learner 2 bricks. The teacher said *another one, yes?* Learner 3 said *ice. Teacher said* another one. Learner 4 said tombstone. The teacher said another one. Learner 5 desks. The teacher said they are many, yes. Learner 6 said matches. The teacher then said but let's talk about what we see around here, Yes. Learner 7 said Window frame. The teacher said or what, Window what? window paint (teacher ask and then responded as learners were silent). Window paint is a glass that you see (teacher pointed at the glass he was talking about). The teacher pointed at another learner and said yes. Learner 8 said wood. The teacher then said they are many my friend. Class answered *yes*. The teacher proceeds and said but I want the last one. Learner 9 said Door (teacher wrote the examples of solid on the chalk board and learners were taking notes and he then he repeated all learners' responses).
5-10 minutes
Thereafter teacher said let's talk about liquids, examples of liquids, yes. yes. Learner said water. teacher said water is one of them. Yes. Another learner said juice. teacher said Juice. Another learner said Coldrinks. Teacher said another one. Another learner said Oil. Teacher said Oil, yes. Another learner said fish oil, yes. Another learner said tea. Teacher said Tea, another one. Another learner said alcohol.

Takalani coded English physical sciences observation transcript: June 2022 at Obtainable Secondary School in Grade 10

Day one lesson

Description

0-5 minutes

Learners seated on the desks. All the learners wore their school uniform and they were seated in groups. Teacher greeted the learners *Morning afternoon learners* and the learners said *good afternoon sir*. Teacher continued *How are you?* And all the learners responded *we are fine and, how are you*? Teacher said *I'm fine*. Learners said thank you. Teacher said *Today we are going to deal with the states of matter and kinetic theory (the teacher was talking while he was erasing the chalkboard). The teacher proceeds and said define matter, yes (Learners raised up their hands and the teacher pointed at the learner he wants to respond).* Learner responded as follows *matter is anything that has mass and occupies space.* The teacher said *matter is anything that has mass and occupies space. The teacher said examples of matter, Ya. Learner responded* book. Teacher said we have three states of matter (the teacher repeated the statement writing on the board). Number 1 we have what? Class responded solid. Number 2? Class responded Liquid. The teacher said Number 3? Class responded Gas. Teacher said gas, symbol of solid is what? Teacher and learners said S. liquid is? L. Gas is? G. Thereafter teacher ask example of solid? Learners said ice. Teacher said we have water as ice. Example of liquid? Learners said water. Teacher said liquid water. Example of gas? Learners said vapour. Teacher said water vapour. The teacher said we have ice, liquid water and water vapour (the teacher wrote all the answers on the chalkboard).for example we have water as solid ice and when we increase temperature it form H_2O liquid and when we increase temperature it form H_2O gas

5-10 minutes

Teacher said Water in solid state it has a fixed volume while liquid water it occupies space and take the shape of the container. Water vapour it takes the volume of the container. The main properties of solids, liquids and gases are summarized below. Draw a table of three column. Under solid? Teacher and learners said solids have a solid form. The form can only change by denting, breaking or bending it. Under liquids? Learners said liquids do not have a fixed form. Under gas? Learners said gas do not have a fixed form. Number 2 under solid? Learners said solid are hard. Teacher said solid are hard. Teacher and learners said you can't push your finger into a block of ice. Number 2 under liquids? Learners said liquids are not hard. The teacher said

Leon coded English physical sciences observation transcript: June 2022 at Remarkable Secondary School in Grade 10

Day one lesson

Line	Description
	0-5 minutes
	Learners seated on the desks whereas others were using table and chairs. All the learners wore their school uniform and they were seated in groups. Teacher greeted the learners *Morning class* and the learners said *Morning sir*. Teacher continued *How are you doing today?* And all the learners responded *Fine and you*? Teacher said *I'm doing well*. Teacher said *Today we are going to study about phases of matter. But before we proceed it is however important for us to go back to the prior knowledge of what we have done in previous classes. So, before we analyse all those phases of matter it is however important for us to start by revising or going back of what we understand by the term matter* (the teacher wrote matter on the board). *Who still recall what matter is, what is a matter*? (Learners raised up their hands and the teacher pointed the learner he wants to respond) Learner responded as follows *matter is anything that has mass and occupies space.* The teacher said *Can you take off your mask so that I can hear you*. The learner takes off his mask and repeated what he said *matter is anything that has mass and occupies space*. Teacher said isn't true. Class answered *yes*. Thereafter teacher explain the term matter as follows *matter is anything that has mass and also occupies space* (teacher wrote the definition of matter on the chalk board and learners were taking notes). *The most important thing about matter is that it got mass and it also occupies a space. Having mass it means that we can be able to weigh the mass of the objects, the mass of the matter neh.so in this case here with me I am holding two things that can be classified as matter* (the teacher hold a jug with water inside for demonstrating purpose). *The first one is the water inside neh?* Class responded *Yes*. Teacher continued *and the jug itself, If you can check this container that we have it stand in here and if this position where we have place this container of ours we can see that it has occupy a space* (the teacher is demonstrating while talking) *and if we place it on something that can be used to measure the weight we can be able to know the mass of the object neh*. Leaners said *Yes*. Teacher said *So it means that that thing is a matter. Even this duster simple because it has got a mass and occupy space within this room so it qualify to be a matter,* (teacher holding a duster showing that it has occupy a space in the classroom) *So if we can have a look at something like water this water as we are seeing is on the*

Appendix X: Coded diary

DIARY FOR THE DEVELOPMENT OF TSHIVENDA PHYSICAL SCIENCES SCIENTIFIC REGISTER

Date	Action
5th of April 2021	On the 5th of April 2021 I initiated /started a process of collecting the information for developing Tshivenda Physical Sciences scientific register. The following grade 10 physical sciences textbooks were obtained from local schools which cannot be named for confidentiality purpose: study and master physical science, successful physical science, mind action series physical science, siyavula physical sciences, platinum physical sciences, physical science grade 10 book 2 theory and workbook.
6 April 2021 to 13 April 2021	From 6 April 2021- 13 April 2021 I went through the grade 10 physical sciences textbooks obtained focusing on the topic of phases of matter and kinetic molecular theory of matter which fall under the knowledge area of matter and material. After going through all the textbooks I find two textbooks to be useful namely , siyavula physical sciences and physical science grade 10 book 2 theory and workbook, but I struggle to decide on which one to use in the development of Tshivenda Physical Sciences scientific register. Then I decided to reach out for second opinion from a colleague who use both textbooks on daily basis. At the end of the day physical science grade 10 book 2 theory and workbook was considered because it is self-explanatory.
19 April 2021 to 26 April 2021	From 19 April 2021 to 26 April 2021 I asked colleagues, friends, family and relatives if they know of anyone who can assist me with translation (translating some of the English words to Tshivenda). I told them that I want to develop Tshivenda Physical Sciences scientific register for physical sciences. Most of the people whom I reach out to promise to assist. None of them came back with a useful feedback. I continue to reach out to people. That when I decided to get myself Venda-English dictionary so that I can get some work going. It was not any easy journey to acquire such dictionary. I approached 3 bookshops trying to check if they have Venda-English dictionary instore and none of them had any and they were not even willing to order one for me. Four weeks later my sister in law came to my rescue, she

Appendix Y: Coded interview transcript

Coded Interview transcript

Researcher: *Kuvhonele kwavho kha register ya physical science ya Tshivenḓa ye vha i shumisa kha u funza vhagudiswa vhavho ndi kufhio?*

Leon: *Register heyi ndi yavhudi ya dovha hafhu ya shumisea iya tutuwedza na muthu kha kuhumbulele kune ngavhe physical science yovha I tshi kona u funziwa duvha na duvha na nga luambo lwa tshivenda ina luambo lwo kunaho ende ndi tshi sedza nda wana uri iya talutshedza nga ndila ino pfesesea*

Researcher: Okay ndiye kha mbudziso i tevhelaho

Leon: *Ee*

Researcher: *Vha vhona unga u shumisa register ya Tshivenda ya physical science zwo thusa vhagudiswa u pfesesa maipfi kana luambo lwa physical science?*

Leon: *Ndi tshi zwi sedza ndi vhona uri vhana vho guda nga maanda nahone vhokona u pfesesa zwinzhi zwa physical science zwo talutshedzwa nga tshivenda ngudo yovha yavhudi*

Researcher: *Ndi vhukondi kana khaedu dzifhio dze vha vhagudiswa vha khou tangana nadzo musi vha tshi khou vha funza nga Tshivenda?*

Leon: *Khaedu khulwanesa ye vhana vhatangana nayo idinga yeneyi nthihi ye nan ne nda tangana nayo musi ndi khou ita ndugiselo maipfi manzhi a luvenda ono xela vhathu ri tshi katela na vhana , vhana luambo lwa tshivenda nda vhone lono vhashavha avha tsha divha maipfi manzhi a tshivenda ndingazwo nangwe maipfi manzhi ovha a tshivenda vhana vhovha vha sikhou divha uri elo ipfi ndi lifhio , udo wana uri nwana udivha helo ipfi nga tshikhuwa fhedzi nga tshivenda ha li divhi, kha tshikhuwa ndi luambo lwawe lwa duvha na duvha fhedzi kha tshivenda ndi manwe maipfi ane avha atshi vhonala sa maswa sa tsumbo ahuna nwana asa divhi firidzhi, nwana munwe na munwe udivha uri huna firidzhi ende udivha uri firidzi ashela madi haala madi ashanduka avha aisi zwino utshi vho amba nga ha tshixwatudzi nwana uvha asitsha divha uri tshixwatudzi ndi mini mara tshixwatudzi utshi vhona duvha na duvha , utshi amba nga ha muxwatu , nwana hadivhi uri muxwatu ndi mini fhedzi ice udzi vhona duvha na duvha heyo ndi ye nda vhona uri ndi*

Appendix Z: Turnitin report

DEVELOPING AND USING THE TSHIVENDA SCIENTIFIC REGISTER FOR PHYSICAL SCIENCE

ORIGINALITY REPORT

19%	19%	4%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	hdl.handle.net Internet Source	5%
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7	www.tandfonline.com Internet Source	<1%
8	Submitted to University of South Africa Student Paper	<1%
9	ulspace.ul.ac.za Internet Source	<1%

Appendix AA: Language editing certificate

EDITING AND PROOFREADING CERTIFICATE

7542 Galangal Street

Lotus Gardens

Pretoria

0008

13 November 2022

TO WHOM IT MAY CONCERN

This certificate serves to confirm that I have language edited NP Netshivhumbe's thesis entitled, **"Developing and using the Tshivenda scientific register for Physical Science."**

I found the work easy and intriguing to read. Much of my editing basically dealt with obstructionist technical aspects of language, which could have otherwise compromised smooth reading as well as the sense of the information being conveyed. I hope that the work will be found to be of an acceptable standard. I am a member of Professional Editors' Guild.

Hereunder are my contact details:

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Associate Member

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