Teacher Practices in Science Literacy Instruction for Learners who are Deaf or Hard of Hearing in Kenya

by

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Abstract

The Kenyan Vision 2030 initiative, which aims at improving the quality of life for all citizens, has put increasing emphasis on science literacy (Amunga, Amadalo, & Musera, 2011). Even though the Kenyan secondary school curriculum is designed to accomplish the goals of the Vision 2030 initiative, learners who are deaf or hard of hearing (D/HH) score significantly below average in all required science subjects (i.e., biology, chemistry, and physics) on their Kenya Certificate of Secondary School Examination (KCSE). With the implementation of the Kenyan Vision 2030 initiative, and in light of the trailing achievement of D/HH learners in science subjects, it is paramount to explore and identify teaching practices in science education for these learners.

This study employed a descriptive survey design to explore Kenyan teachers' practices in science literacy instruction for D/HH learners, their perceptions on the effectiveness of the best practices identified in the literature, barriers to implementation, and recommendations that should be considered in efforts to improve science literacy instruction for D/HH learners in Kenya. A convenience sample of 26 science teachers participated in an online survey. Fifteen teachers also participated in in-depth focus group interviews. The results revealed that, Kenyan science teachers are aware of the cited best practices and strategies in science literacy instruction for D/HH learners, but these practices and strategies are often implemented only superficially in their classrooms.

DEDICATION

First I would like to dedicate this work to both my late parents Dr. Edward Wanyama Namukoa (1948-2001) and Florence Muhonja Namukoa (1952-2007) – their memories are a source of inspiration to me - their integrity, humility, love and compassion left an indelible impression on my life.

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LIST OF ACRONYMS

ASL	American Sign Language
CAT	Continuous Assessment Tests
CBM	Christian Blind Mission
D/HH	Deaf and Hard for Hearing
EARC	Education Assessment and Resource Centre
EFA	Education For All
GDC	Global Deaf Connection
HH	Hard of Hearing
IEP	Individualized Education Programme
LIA	Likelihood Impact Analysis
KCSE	Kenya Certificate of Secondary Examination
KIE	Kenya Institute of Education
KISE	Kenya Institute of Special Education
KNEC	Kenya National Examination Council
KSL	Kenyan Sign Language
MOE	Ministry of Education
MoEST	Ministry of Education Science and Technology

NCST	National Council for Science and Technology
NRC	National Research Council
NSEPF	National Special Education Policy Framework
PGDE	Post Graduate Diploma in Education
SEE	Signed Exact English
SEN	Special Education Needs
UN	United Nations
UNCRC	United Nations Convention on the Rights of the Child
UNCRPD	United Nations Convention on the Rights of People with Disabilities
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund.

Chapter 1: Introduction to The Study

1.0. Context of the problem

The pedagogy for learners who are deaf has experienced a long evolution. Two key historical milestones were foundational in the education of D/HH learners. The first was the 1880 *Second International Congress on the Education of the Deaf,* Milan Congress. This conference passed eight key resolutions declaring oral education (spoken language) was superior to manual education (sign language) and abolished the use of sign language in the education of D/HH learners worldwide (Leeson, 2006). As oralism, a method that relies solely on speech, lip-reading, and auditory training for language acquisition, began to take hold in the field of deaf education, it brought about what has been referred to as the Dark Age of deaf history (Krentz, 2004) where deaf people were denied access to a natural language sign language to support learning. The second key event was the 1950 publication of Stalin's *Marxism and Questions of Linguistics* that asserted that deaf people were without a language, and therefore, were abnormal (Zaitseva, Purglove, & Gregory, 1999). Together, these historical events have significantly influenced attitudes, perceptions, and educational methods in educating deaf learners. Importantly, the international community has become more tolerant of linguistic diversities over the years. In fact, in 2010 in Vancouver, Canada, the board of the 21st International Congress on the Education of the Deaf (ICED) formally voted to reject all of the 1880 Milan resolutions. Despite this progress, many myths and misconceptions about deaf learners continues to impact educational methods and delivery for these learners.

Similarly, the education for learners who are deaf in Kenya has experienced significant positive changes tracing back to 1958 when oralism was the mode of instruction used in the first schools for learners who are deaf (Kimani, 2012). Four major factors have influenced the evolution of deaf education in Kenya:

1. The interest of missionaries in supporting education for Kenyan and African children who are deaf. For example, between 1957 and 1987, Andrew Forster, a deaf African American missionary and a graduate from Gallaudet University, facilitated the establishment of 31 schools for the deaf in Nigeria, Kenya, Uganda, and South Africa (Kiyaga & Moores, 2003).
2. Kenyan cultural change, towards the inclusion of persons who have a disability (Rieser, 2008).
3. The emergence of Kenyan professionals and advocates for quality education for D/HH children. For example, Dr. Michael Ndurumo, a deaf Kenyan educator who obtained his Ph.D. in America, influenced the Kenyan Ministry of Education (MOE) to adopt a total communication philosophy (i.e., using all modes of communication depending on the needs of the child) for D/HH learners in 1988 (Kimani, 2012). Currently, Kenyan sign language (KSL) is officially recognised as not only the primary language for learners who are deaf, but also as the mode of instruction for school curriculum (MOE, 2009; Kimani, 2012).
4. Exposure to international and national legislations that influenced key education policies and practices and impacted the evolution of special education in Kenya (Munyi, 2012). For example, Kenya is a signatory to the 1948 UN declaration of the rights of children; the 1989 Education For All Convention by the United Nation; the Convention on the Rights of Children (UNCRC) in 1989; the World Summit on children (United Nations International Children's Emergency Fund [UNICEF],

1990); the Salamanca Conference (United Nations Educational, Scientific, and Cultural Organization [UNESCO], 1994); the Dakar Forum for Action 2000; and the UN International Convention on the Rights of Persons with Disabilities (ICRPD) 2006.

According to a report by the Kenyan Ministry of Education, Science, and Technology (MoEST, 2003), the government is making commendable strides in owning and implementing recommendations from international and national legislations that support inclusive education. These efforts include the 2003 free primary education declaration which led to increased primary school learner enrolments (including D/HH students); subsidised costs for secondary school education; and the development of the National Special Education Policy Framework (NSEPF) in 2009 (Kochung, 2011).

As efforts are directed towards inclusive education in Kenya, the latest appeal by the ICRPD in 2006 created the need to promote and enhance access to general curriculum for all learners with disabilities regardless of their sociocultural backgrounds or the nature of their disability (MOE, 2009; Njoka, Riechi, Obero, Kemunto & Muraya, 2011). Additionally, the Kenyan government has been urged to implement inclusive education by focusing on transforming the school system to meet every learner's educational needs instead of just inserting learners who have a disability in existing educational programmes without any accommodations (UNICEF, 2005, MOE, 2009; Kochung, 2011). These current developments in Kenyan education reaffirm that access to curriculum involves both the physical representation of learners with disabilities in the classroom and the active engagement of these learners (MOE, 2009; Kochung, 2011). Also, the efforts are meant to ensure that each learner is guaranteed specialized instruction, support, and resources in the most enabling environment possible, regardless of their condition (MOE, 2009).

1.1. Overview of the study

The Kenyan Vision 2030 initiative aims at improving the quality of life for all citizens and puts increased emphasis on science literacy with the intention of using individuals' scientific abilities, creativity, and innovativeness in management and in solving the community's challenges regarding economic development (Amunga, Amadalo, & Musera, 2011). Although the Kenyan secondary school curriculum is designed to accomplish the Vision 2030 initiative, D/HH learners demonstrate marked differences in performance in science literacy in comparison to performance in other subject areas. In light of the importance placed on science literacy in the Kenyan Vision 2030 initiative and the economic consequences of school failure, investigation of factors that may contribute to improvement in science literacy for deaf learners is needed.

1.2. Statement of Purpose

Some teaching practices and innovations have yielded positive results for learners who are deaf /HH in other countries, although little has been done to record these results and subject these practices to empirical research (Albertini & Lang, 2000). Easterbrooks and Stephenson (2006) and Easterbrooks et al. (2006) conducted a comprehensive study on teaching practices for D/HH learners in America. The study revealed ten most cited best practices for science and mathematics instruction and another ten for literacy instruction (discussed in Chapter 2). The results of these study and the scarcity of any newer studies in science literacy for D/HH learners formed the foundation for the current study. The current study will pursue a further inquiry to confirm the views on the proposed practices with a diversified population. This is because the credibility of any research evidence can be confirmed only if the same outcomes are replicated across population and conditions (Stanovich & Stanovich, 2003; Nesje, 2007; Schirmer & Williams, 2008). In the light of the Vision 2030 initiative and deaf learners trailing achievement and performance in science subjects, it is paramount to identify and assess evidence for the best teaching practices in science education for D/HH learners in Kenya.

In this study, I will employ a descriptive survey research design that uses survey and focus group interviews to evaluate teachers' views concerning the ten cited practices and exploring their practices in science literacy instruction for D/HH learners. The study will further establish teachers' perspectives on issues and recommendations that need to be considered to improve science literacy for D/HH learners in Kenya.

Chapter 2: Literature review

2.0. Introduction

In this chapter, I will define the best teacher practices in science literacy as identified in the literature, discus education for learners who are deaf in Kenya, review the literature related to the ten most cited best teacher practices highlighted under science and mathematics in the study by Easterbrooks and Stephenson (2006) and Easterbrooks et al. (2006) and highlight problems affecting general education for D/HH learners. The chapter will also highlight research questions and significance of the study. Although there has been limited research on science literacy for D/HH learners (Lang, 1994), I will analyze the pertinent research findings on each of the practices as related to education for D/HH learner in Kenya.

2.1. Best Practices/Strategies in Science Literacy for D/HH learners

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), best practices in education are (a) defined as successful initiatives which have a demonstrable effect on improving learning quality and performance; (b) the result of effective partnership between the stakeholders; and (c) socially, culturally, economically and environmentally sustainable (Zafeirakou, 2007). A major objective discussed in the Kenyan National Special Education Policy Framework is to ensure that specific needs for learners who are struggling to access the curriculum due to any form of disability are well provided for within a school setting (Kochung, 2009; MOE, 2009). Teachers can play a major role in mediating the process of curriculum delivery by implementing strategies that are specific to the needs of D/HH learners (Brokop & Persall, 2009). Although teacher practices in science literacy for D/HH learners have been observed as a critical area for curriculum development (Kluwin & Stewart, 2001; Adoyo, 2002), research focused on science literacy for D/HH learners is still limited (Cooney, Luckner, Miuri, Sebald, & Young, 2006).

Studies in science literacy for D/HH learners have defined "best practices" as those which are learner-centered and which emphasize active learner engagement (Yore, 2000). In teaching science, best practices involve pedagogical practices that address learners' initial understandings and preconceptions about topics, provide a foundation of factual knowledge and conceptual understanding, help learners take control of their learning, and allow learners to learn together (Bransford & Donovan, 2005). With these attributes in mind, the current study will consider best teacher practices or strategies in science literacy as practices and innovations that efficiently mediate high school science curriculum, wholesomely engage learners in the classroom, and positively contribute to the performance of D/HH learners in high school science education.

2.2. Science literacy

According to the National Research Council (NRC, 1996) Science literacy is defined as "The knowledge of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (p. 22). It involves a process of searching to understand the natural world through observations that includes quantifying and testing ideas (Albertini & Lang, 2001). Aikenhead (1996) suggested that it is possible to regard learning science as part of culture and recommends that all learners need assistance as they travel from their day-to-day world into the world of science found in their classrooms. It has also been suggested that strategies for teaching biology, chemistry, and physics vary very little. Consequently, the three subjects cannot be isolated from one another (Ware, 1992). As explained by Ware (1992) in a study on the education of secondary science teachers in developing countries: “The old disciplinary boundaries are fading in the dynamic world of science research. Biology is becoming chemistry, which is becoming biology, touching on physics which shades into chemistry” (p. 5). Therefore, teachers need to implement teaching strategies that utilise learners’ background knowledge developed from other science subjects for consistency and easy understanding (Ware, 1992). Moreover, as curriculum mediators, teachers need to diversify their teaching methods by using all approaches that maximize curriculum delivery other than just focusing on a few or some of the teaching strategies/practices (Adoyo, 2002; Kluwin & Stewart, 2001).

2.3 Education for D/HH learners in Kenya

Although the status of special education in Kenya has improved in recent years, improvement in educational outcomes for D/HH learners has not been realized. Many teachers and professionals working in specialized schools for these learners continue to focus on or believe that deafness is a barrier to learning. For example, inability to understand the ‘spoken/written language’ used in both curriculum delivery and assessment is considered to be a consequence of deafness rather than an outcome of insensitive teaching practices and incompatible teaching strategies that are used (Adoyo, 2002). Hence, teachers emphasize methods of communication (e.g., auditory-oral, manually coded English systems), which are inaccessible to many deaf learners on the assumption that this will facilitate the process of curriculum delivery to their students (Adoyo, 2007). Ironically, while the focus is on communication modes, very few teachers of D/HH learners in Kenya have the necessary language competency in Kenyan Sign Language (KSL) to allow deaf children full access to the curriculum and to facilitate smooth classroom communication with learners (Kihingi, 2011). Consequently, reports by the MoEST have repeatedly revealed that D/HH learners perform poorly on both school continuous assessment tests (CATs) and in the Kenyan national examinations (Ndurumo, 1993; Okombo, 1994; MoEST, 2004).

Initiatives to ensure that D/HH learners receive their education in an environment that supports their learning have not been well implemented due to lack of curriculum accommodations. This is because Kenyan curriculum was designed with the assumption that children arrive at school with age-appropriate language skills that will support them in learning the content of the curriculum. This assumption is seldom true for deaf children. Due to stigma experienced by parents and families of D/HH children, identification of hearing loss and appropriate language intervention is often delayed until the age of 5 to 7 years old (see review in Wilson, 2006 and Oloo, 2006). As revealed in Adoyo (2007), special schools for D/HH learners receive two groups of children. The vast majority (97.9%) are children of hearing parents, who usually arrive at school age with no or very little language skills (in both spoken language or signed language) but may use gestures for basic family communication. The second, much smaller group, are children of deaf parents, who usually have early exposure to an accessible language (Kenyan Sign Language) and thus begin their education with age-appropriate sign language skills and are well adjusted for education.

At an average of age 5, deaf children join pre-primary classes where they spend about 3 years before they move to grade one (Adoyo, 2007; Wilson 2006). During their pre-primary class period, they begin to develop early language skills, learn to communicate with teachers and peers, and begin to recognize signs with pictures and symbols (Adoyo, 2007; Crume, Moran & Shiekh 2001). Teachers for D/HH learners are aware of gaps and delays in language development, however the curriculum is not adapted to meet the language and learning needs for these learners and there is much pressure to cover the curriculum content in a timely manner.

For example, in a study on barriers to effectively educating deaf students in Kenya, Crume, Moran and Shiekh (2001) explained "education officials visit the schools and put pressure on principals to keep pace with the curriculum and syllabus. This presents problems to teachers of the deaf because they are expected to move rapidly at the expense of the students (p.5)." As a result of these pressures, paired with late identification of hearing loss, no early language intervention programs, and an elementary school curriculum that does not included differentiated learner support, D/HH learners often enter secondary school with limited background knowledge to support their learning, large gaps in their language skills and very low literacy levels compared to their hearing counterparts.

Kenyan high schools (secondary schools) are student-centred institutions purposed to help learners discover and develop their individual talents after eight years of primary school education (Sifuna, 1990). Secondary schools offer a wider range of subjects than primary schools do. Students are expected to select and study these subjects based on their career interests (Nugu, 2010). Just like primary schools, all Kenyan high school students, including learners who have disabilities, follow the same standard curriculum without individualized education programmes (IEP) or learner specific curriculum adaptations (Amunga et al., 2011; MOE, 2009). Students are expected to perform competently by the end of four years of secondary education (Grade 12) so they can pursue their talents through existing post secondary institutions in the country (Sifuna, 1990). At the end of four years, all secondary school students sit for the Kenya Certificate of Secondary Education (KCSE) as a final examination that determines their next career alternatives.

During their secondary education, Kenyan students are expected to select two science subjects drawn from a Group 2 cluster, which includes biology, chemistry, and physics

(Wosianju, 2009). In this study, I will use science literacy to refer to education in these three subjects (biology, chemistry, and physics) clustered as Group 2 by the Ministry of Education. Record shows that Kenyan D/HH learners generally score below average on all required subjects in the KCSE examinations (Maina, Adoyo, & Idoshi, 2011). However, their performance in science subjects has been conspicuously lower compared to other subjects (George, Wanjiru, & Nyakwara, 2013). Usually, the KCSE mean scores are calculated by converting subject letter grades into a 12-point numeric scale. For example, a letter grade of A would convert to 12 points whereas a letter grade E would convert to 1 point (see Oketch, 2010). A review of the 2009-2013 KCSE results showed that D/HH learners score well below average demonstrating a mean grade of D and below in Group 2 subjects across these five years of exam data (Kenya National Examination Council [KNEC], 2009; KNEC, 2010; KNEC, 2011; KNEC, 2012; KNEC, 2013). Hence, a trend of failing scores among D/HH students in science subjects has continuously pulled down their overall performance scores, and this has limited their possibilities for using secondary certificates to compete for better career options (Amunga et al., 2011).

2.4. Learning need for D/HH learners

Kinaga (1987) revealed that D/HH students in Kenya lagged behind their hearing counterparts academically. However, Kinaga (1987) also found that the poor performance among D/HH students was due to challenges related to the school-learning environment. Usually, D/HH learners display an inability to grasp information during classroom teaching because the teaching strategies used are not adapted to meet their specific academic needs (Ndurumo, 1993). Teachers focus and struggle to cover the specified curriculum material within expected timeframes means that instruction often occurs at a rapid pace with new material being introduced before ensuring mastery of previous information and without setting up an IEP that would support review and mastery learning among D/HH children (Adoyo, 2007; Crume et al., 2001; MoEST, 2003; Wilson, 2006).

Kenyan D/HH students come to school with delays in their language development yet there are no strategies in place to help them compensate for these delays (Crume et al., 2001). Teachers have limited skills in KSL and hence they give less attention to the language need for these learners. They continue teaching the curriculum using their poor language skills, and poorly adapted teaching and assessment strategies (Nyarangi, 2010). For example, teachers write notes on the black board for learners to copy and read, use combined signs and speech which fails to match signed and spoken content, and train learners to memorise materials for the examination purposes (Crume et al., 2001). As a result of the lack of access to learning that these inefficient practices create, D/HH learners continuously experience challenges in understanding curriculum contents, while teachers assume that the contents are too complex for these learners and therefore need simplification (MoEST, 2003). The process of teachers simplifying what is believed to be complex scientific content has challenged scientific curriculum delivery to D/HH learners (Martin, Compton, & Metzer, 2010; Loughran, 1999; Marschark & Swanwick, 2010). This is because teachers mostly eliminate or avoid teaching complex curriculum content to D/HH learners, instead of scaffolding the content to improve learning (Martin et al., 2010; McQuarrie & McRae, 2010). Therefore, they expose these learners to substandard curriculum content with superficial delivery strategies that limit their cognitive engagement (Kluwin & Stewart, 2001; Molander, Norell, & Pedersen, 2001). D/HH learners may spend eight years in primary school experiencing problems in understanding their teachers, curriculum contents and examinations questions, and hence continuously perform poorly (Crume, et al., 2001). As a result of these gaps these learners join secondary school with very low literacy levels compared to their hearing counterparts (MoEST).

D/HH learners join secondary school with varied skills in different communication modes. This is because of exposure to differing communication modes earlier, when in primary schools (Namukoa, 2012), hence they might not communicate well with each other or understand communication modes used by their secondary school teachers (Nyarangi, 2010). In addition, the class may have learners who are post-lingual deaf, have residual hearing, have lip-reading ability, or may benefit from oral communication with use of various assistive devices like hearing aids (Nyarangi, 2010). To access the curriculum content, each of these groups of learners has different learning needs and requires different adaptations (Nyarangi, 2010; MoEST, 2003).

Because of diversities in learning needs for deaf students, teachers need to have knowledge of multiple strategies, ability in multiple languages, and access to multiple ways to help them fully deliver the curriculum (Easterbrooks et al., 2006; Easterbrooks & Beal-Alvarez, 2013). With this in mind, the Kenya Institute of Education (KIE), which is the sole developer of curriculum and curriculum delivery material in Kenya, recommends a ratio of 1 to 12: one teacher with experience or training in deaf education to a class population of 12 D/HH learners (Makokha, 2013) so as to maximize teacher- learner interaction time. This is because a larger learner population per class and per teacher would result in a significant challenge regarding both the curriculum mediation process and the quality of education (Gongera, Wanjiru, & Nyakwara, 2013). However, contrary to the recommendation by the KIE on teacher to learner ratio, recent studies on education for D/HH learners in Kenya have revealed (a) a scarcity of teachers with relevant training and experience in deaf education and (b) a higher teacher-learner ratio (Adoyo, 2009; Kihingi, 2011; Maina et al., 2011; Kimani, 2012). These situations are primarily due to increased learner enrolment because of subsidised secondary school education costs and failure of government to employ more trained teachers to match the existing learning demands.

2.5. Teaching Practices/Strategies in Science

Teachers' practices have a direct impact on learner performance; a view shared by both learners who are hearing and by those who are D/HH (Brokop & Persall, 2009; Lang, 2005). For example, both groups of learners value a teacher's content knowledge and ability to deliver content explicitly (Lang, 2005). However, teachers' efforts to implement best teaching practices in education for deaf students are profoundly impeded by a lack of evidence-based research that focuses on science literacy instruction (Cooney et al., 2006). In an extensive review of literature, Lang (1994) revealed that only one major survey on the needs and qualifications of science teachers of D/HH learners had been conducted during more than 175 years of the history of deaf education (i.e., Lang & Propp, 1982), only one study on the attitudes of learners who are deaf towards science subjects (i.e., Lang & Meath, 1995), only one major summary on curriculum and teaching (i.e., Lang, 1987), and one journal publication on the priorities in science literacy instruction for D/HH learners (i.e., Lang, Egelston-Dodd, & Sachs, 1983).

In addition, recent studies in science literacy instruction for D/HH learners have mainly focused either on identifying learning challenges or on proposing possible interventions that are seldom supported by empirical evidence (Albertini & Lang, 2000; Geeslin, 2007). Moreover, a review of 964 articles on literacy and deafness by Cooney et al., (2006) revealed that limited research is available for use in the process of identifying and implementing the best teaching practices in education for D/HH learners. This situation has resulted in teachers focusing on deafness as an impediment to learning. For example, they focus their instructions on language, (Marschark & Hauser, 2008) rather than on respective learning areas that need development

(Hyde, Power, & Zevenbergen, 2003; Yore, 2000; Mukhopadhyay & Moswela, 2010). The outcome of these gaps has been a continuous trailing in performance among D/HH learners. However, some teachers have been implementing practices, strategies and innovations that yield optimistic results, even though there has been limited effort to record the results and subject these practices to further research (Albertini & Lang, 2000).

In a research study aimed at identifying the existing best practices in literacy, science, and mathematics instruction for D/HH learners, Easterbrooks and Stephenson (2006) surveyed literature, the websites of professional organizations, and the government education websites of various states in United States. Their survey revealed ten most often cited practices for science and mathematics instruction and another ten for literacy instruction. The researchers reviewed almost 500 articles to establish evidence to support these identified practices (Easterbrooks & Stephenson, 2006). For the purpose of this study, I will consider the ten best practices that Easterbrooks and Stephenson (2006, pp. 391-394) described and grouped under science and mathematics literacy for D/HH learners:

1. The teacher as a skilled communicator
2. Instruction in a primary language
3. The teacher as a content specialist
4. Active learner engagement
5. Visual supports
6. Authentic, problem-based instructions
7. The use of technology
8. Specialized content vocabulary
9. Critical thinking

10. Mediating textbooks

In a follow-up study, Easterbrooks et al. (2006) queried 37 master teachers regarding their perspectives on the practices identified in Easterbrooks and Stephenson's (2006) work. They utilized a Likelihood Impact Analysis (LIA) that involved a 5-point Likert-type scale with a 2-point rating to ask teachers (a) the benefit to learners in using each best practice and (b) the teacher's likelihood to use the practice (Easterbrooks et al., 2006). The next section outlines the ten most cited practices identified by Easterbrooks and Stephenson (2006) to be the best in supporting science literacy for learners who are deaf.

2.5.1. The teacher as a skilled communicator. Skillful communication involves the teacher's ability to use different modes of communication proficiently in response to the diversified language and communication needs of D/HH learners in a classroom (Easterbrooks & Beal-Alvarez, 2013; Roald, 2002; Wilbur, 2000). These needs include signed language (e.g., KSL) or English based sign systems, among other communication modes used by students (Adoyo, 2002; Easterbrooks & Stephenson, 2006; Okombo, 1994). In fact, proficient teacher communication skills are listed as a prerequisite for all beginning teachers of D/HH students (Council for Exceptional Learners, 2003). Additionally, studies propose that teachers' communication skills are significant in science education for D/HH learners (Easterbrooks et al., 2006; Conner, Lang, & Mckee, 1993). With this in mind, teachers of D/HH learners are expected to have good communication skills in a language that is well understood by their learners (Adoyo, 2009). These skills could be in Kenyan Sign Language, an English sign system (e.g., Signed Exact English), written English, or combined signs and speech (Adoyo, 2009).

Some education institutions have considered the use of sign language interpreters in bridging the lack of teacher skill in sign with the need for communication of content to learners who are deaf in the classroom setting. Startlingly, it has been observed that because some teachers who have no sign language skills cannot understand what the interpreter is signing, they assume that the material is being communicated accurately and end up trusting interpreters for content delivery (Enns, 2007). Unfortunately there is wide variation in interpreter qualifications - lack of skill would impact how accessible the curriculum and teaching is for the student. For example, a case study by Russell (2010) on the use of interpreters in a Canadian education setting confirmed that, even though the teachers were satisfied that the needs of D/HH learners were being catered to, the learners themselves were frustrated with the accuracy of the information they received. In fact, one learner routinely understood less than half of the class content due to the interpreter having inadequate skills in interpreting the language used to communicate the content (Russell, 2010). Therefore, it is vital that the classroom teacher has a mastery of the specific curriculum content and understands how to use available resources such as interpreters and teacher aids effectively in developing science literacy. This will facilitate good classroom communication and support leaning (Russell, 2010).

2.5.2. Instruction in a primary language. Scientific instruction delivery in a primary language for D/HH learners described as a process of explaining scientific concepts using the students' first language (i.e., sign language) (Easterbrooks & Stephenson, 2006). It is characterised by using a learner's primary language in teaching scientific concepts before his or her competencies are assessed in English (Easterbrooks & Stephenson, 2006; Easterbrooks et al., 2006; Namukoa, 2012). Due to late identification and exposure to accessible language, D/HH learners experience delay in language acquisition (Crume et al., 2001). These delays among other challenges, greatly affect their capacity to interpret scientific concepts (Anderson, Dowaliby, & Lang, 1994; Hyde et al., 2003). With this reason, current discourse on education for D/HH learners are in favour of early exposure to a natural signed language in order to facilitate age appropriate language and cognitive development (Akach, 2010; Enns & McQuarrie, 2012; Gregory, 1996). Likewise, education for D/HH learners (the Kenyan NSEPF) highlights Kenyan sign language as an official language for D/HH individuals and approves it as mode of instruction in schools with programs that serve learners who are deaf (MOE, 2009).

2.5.3. The teacher as content specialist. In order to be content specialists, teachers need to possess specific training, experience, and certification in their content area in addition to knowledge of the subject they are teaching (Moores, 2001; Binti-maat & Zakaria, 2010). Adoyo (2002) highlighted that subject content mastery in biology, chemistry, and physics among teachers for D/HH learners of utmost significance in fostering scientific literacy. Therefore science teachers for D/HH children need to receive adequate training, experiences and certification in their respective subject area content before engaging them in curriculum delivery (Easterbrooks, et al. 2006). Teachers also need to have skills in using multiple curriculum delivery methods and strategies in order to meet the learning needs of learners or to compensate for limited teaching resources (Croft, & Consortium for Research on Educational Access, 2010; Enns, 2007; Hannary et al., 2010).

2.5.4. Active learner engagement in science literacy. Active learning strategy involves the use of approaches that maximize lively student engagement in learning process such as hands-on activities, discovery learning, inquiry learning, experiential learning, and other approaches (Richardson, Marschark, Sarchet, & Sapere, 2010). Pedagogical strategies that promote passive, rote-oriented learning and that focus on basic skills and the memorization of disconnected facts have never been successful among D/HH learners (Pohl, 2000). Also, Bransford, Brown, & Cocking (2000) highlight that learning is enhanced when (a) the teacher pays attention to the knowledge and beliefs that learners bring to a learning task, (b) this knowledge is used as a starting point for new construction, and (c) learners concept development monitored as instruction proceeds. Similarly, Darling-Hammond and Richardson (2009) explain that learning that enables critical thinking, elastic problem solving, the transference of skills, and the use of knowledge in new situations is paramount in scientific literacy. Therefore, teachers are urged to facilitate concept mastery among D/HH learners by using hands-on activities and materials that focus on active learning principles and that cognitively engage learners (Albertini & Lang, 2001; Smith & Remsey, 2004; Roald, 2002).

2.5.5. Visual supports. Visual supports include strategies that are used to represent thoughts, ideas, or concepts graphically (Easterbrooks & Stoner, 2006). These strategies are also known as visual tools, visual organisers, cognitive maps, or cognitive organisers (Easterbrooks & Stoner, 2006; Kluwin & Stewart, 2001). The use of visual supports in teaching involves representing information visually to learners as an alternative way of looking at the same information (Easterbrooks et al., 2006).

Scientific content can be well delivered to D/HH learners if it is available in in a visual format rather than a format that requires auditory abilities to hear (Easterbrooks & Stephenson, 2006). Kluwin and Stewart (2001) argue that the use of visual supports such as concept maps, graphs, charts, and visual maps in explaining scientific concepts have been successful in enhancing the understanding of scientific content among D/HH learners (Kluwin & Stewart, 2001). More so, deaf learners' ability for the construction of meaning and the development of scientific content vocabularies has been observed to increase when visual supports are combined with reading, writing, or specific content explanations (Albertini & Lang, 2000). Also, a study by Easterbrooks et al. (2006) revealed that teachers for D/HH learners ranked the use of visual supports highest among other teaching practices and strategies for teaching science to D/HH learners.

2.5.6. Authentic problem solving. Authentic problem solving is a teaching strategy that involves challenging students to learn through engagement in real world problem solving and projects that allow them to explore and discuss these problems (Evans, 2004; Brown et al., 2002). This strategy develops learners' problem solving skills and disciplinary knowledge by placing students in the active role of problem-solvers confronted with situations that simulate the kind of problems they are likely to face in the real world (Brown et al., 2002; Malloy, 2003; Kluwin & Stewart, 2001). Authentic problem solving usually consists of a problem that challenges learners' prior knowledge and motivates them to research, discuss, analyze, and produce a solution (Wiske, 1998; Komesaroff & McLean, 2006). It has been suggested that learners who are deaf experience delay in their language development and have challenges in understanding the language used to explain complex scientific concepts (Roald, 2002; Wang, 2011). However, the integration of authentic problem solving strategies with the general science school curriculum show promising gains in cognitive development (Kluwin & Stewart, 2001). This is because, authentic problem solving strategies supports learning through exploration and participation in problem solving rather than depending on reading texts as the only source of content knowledge.

2.5.7. The use of technology. The use of technology in teaching involves creating, integrating, and managing technological resources with the aim of facilitating learning and improving performance (Januszewski & Molenda, 2008). A good technological fit between the learning needs of specific students and the capacities of teachers provides exposure and diversity that supports curriculum delivery (Lopez, 2007). It has been suggested that, when well mediated by teachers, technology may provides learners with increased learning experiences that facilitate content mastery, decreases learning time, and increases chances to learn by discovery (Lopez, 2007).

The implementation of evidence-based practices has been negatively affected by the scarcity of curriculum resources that enhance content delivery by diversifying learning experiences in science literacy for D/HH learners (Egelston-Dodd & Ting, 2007). Educators have been answering this challenge by integrating technology in the delivery of scientific content for D/HH learners (Marschark, Lang & Albertini, 2002). Assistive devices for enhancing access to classroom lectures in mainstream classes, multimedia approaches, and technologies for teacher networking during preparation have been implemented (Lang, McKee, & Conner, 1993) Therefore, teachers should embrace the fluidity and innovation that exists in the current world of technology by integrating these qualities into their teaching in all areas of science, especially for D/HH learners (Xue & Li, 2009).

2.5.8. Specialized content vocabulary. These are subject specific content signs that are agreed upon by teachers with their students and presented consistently to show the contexts for abstract concepts (Vesel & Robillard, 2013). Each subject area has specialized spoken language content vocabularies, which need an equivalent translation in sign. Therefore, having students participate in the development of specialized subject content signs in science subjects, results in ownership and the increased comprehension of abstract scientific concepts (Easterbrooks & Stephenson, 2006). Teacher' mastery of the content vocabulary used in science subjects is central in determining the quality of the curriculum delivery process to D/HH learners (National Board for Professional Teaching Standards [NBPT], 2000). A good understanding of the content vocabulary also helps the teacher be more effective in planning, gather the required teaching aids, and adjust the classroom environment to meet learners' needs (Smith & Allman, 2010). Additionally, with a good mastery of scientific vocabulary in sign language, a teacher is able to engage the learners maximally in discussing abstract scientific concepts, and hence, helps to develop learners' inquiry and problem solving skills (NBPT, 2000). However, the use of sign language in teaching science to D/HH learners faces some challenges. For example, a study by Lang et al. (2006) confirmed that about 60% of the words that are considered fundamental in science curriculum have no sign representation. It is therefore paramount that teachers of D/HH learners work hand-in-hand with their learners in exploring possible signs that could be used to communicate these scientific concepts without compromising the content quality (Roald, 2002).

Teachers need to understand that scientific concepts are mostly abstract, hence regardless of the nature of the learners' needs; the subject content needs to be precisely delivered (Kluwin & Stewart, 2001). Therefore, teachers for D/HH learners are required not only to be content specialists, but also to have a plausible mastery of scientific content vocabulary in sign language (Adoyo, 2002). However, a report by the Global Deaf Connection (GDC, 2010) reveals that most teachers in schools for D/HH learners use pointing to introduce new vocabularies to their students due to either a lack of knowledge for equivalent KSL signs or the absence of signs for abstract scientific content vocabulary. They expect learners to read the printed word regardless of literacy levels, understand it, and relate it to the content being taught (Nkolola-Wakumelo & Manyando, 2013). Moreover, due to limited sign language skills in content specific vocabularies, most teachers prefer writing notes on the classroom blackboard (GDC, 2010). In addition, they offer minimum explanations (GDC, 2010). Students then copy all the notes in their notebooks and are expected to read them during free time (Nkolola-Wakumelo & Manyando, 2013). This approach of giving reading notes to learners who are deaf/HH and offering limited explanation of content vocabularies seldom supports the understanding of scientific contents (Kluwin & Stewart, 2001). Moreover, D/HH learners often experience challenges in science literacy because of the language used to deliver the content rather than the nature of the content itself (Kluwin & Stewart, 2001). Therefore teachers need to clearly explain content vocabularies and work with their students in deciding on which sign to use for content words that have no equivalent signs (Easterbrooks & Stephenson, 2006). Additionally, teacher mastery of the signed content vocabulary assists the learners in the comprehension of material and in the assessment and evaluation of the material (Roald, 2002).

2.5.9. Critical thinking. Critical thinking, as it pertains to teaching and learning, can be considered an open-minded process of discovery, understanding, analysis, application, synthesis, and evaluation of information gathered from observation or experiences (Easterbrooks & Scheetz, 2004; Snyder & Snyder, 2008). Developing learners' critical thinking skills is an essential strategy that supports learning among D/HH students (Easterbrooks & Scheetz, 2004) and encourages learners to use their background knowledge and skills as they discover and learn new concepts (Boucher, 2010).

Researchers have observed that D/HH learners are mostly subjected to curriculum content that rarely engages them cognitively due to perceptions that they are either low performers or that they are unable to understand "complex" curriculum content (Kluwin & Stewart, 2001; Yore, 2000; Marschark & Spencer, 2010). Additionally, curriculum contents are superficially delivered due to poor sign language skills among some teachers of D/HH learners (GDC, 2010). Because of this exposure to simplified curriculum content, D/HH learners have recurrently displayed challenges in solving problems that require the critical thinking strategies required in the sciences and mathematics (Kluwin & Stewart, 2001). In relation to this view, Kelly, Lang and Pagliaro (2003) asked 33 teachers of learners who were deaf to answer a survey on word problem solving practices in mathematics among their learners. Half of those who responded were teachers from general (centre) schools while the other half were from self-contained classes (Kelly, et al., 2003). The findings from this study revealed that learners who are deaf are not sufficiently engaged in challenging problems, regardless of their instructional setting. Moreover, it revealed that teachers focus more on practice exercises rather than on true problem solving through word problems (Kelly, et al., 2003). This study reveals the need to ensure that D/HH learners are provided with opportunities to develop the independent reasoning skills needed to facilitate both inquiry-based learning and diversity in problem solving approaches (Kluwin & Stewart, 2001). Additionally, practices that support learners to use available scientific resource materials to explore the world of science and apply these skills across all other areas of curriculum prove most helpful to all learners (Yore, 2000).

2.5.10. Mediating textbooks. In deaf education, textbook mediation involves using teaching approaches that scaffold learning from text with an aim of bridging the gap between deaf student reading levels and the language demands of the text (Biser, Rubel, & Tascano, 1998; Easterbrooks & Stephenson, 2006). Studies reveal a big gap between the reading levels for D/HH learners and the demands of textbooks in science and related subjects (Easterbrooks & Stephenson, 2006). In Kenya, the gap in reading levels among D/HH learners due to delayed exposure to accessible language is compounded by ineffective instructional strategies used by teachers to teach reading. Often teachers blame the learner for having poor reading abilities instead of creating opportunities that would allow learning by scaffolding from text (GDC, 2010). Examples of approaches that scaffold learning from texts include adding visual prompts, graphic organizers, breaking down content and teaching step by step (Easterbrooks & Stephenson, 2006).

Discourse with teachers of D/HH learners and their students have revealed that the complex written language used in textbooks to explain scientific content often challenges D/HH learners (Roald, 2002). It is also observed that most scientific curriculum content either exists in print form or requires the learner to use written English (Albertini & Lang, 2001; KIE, 2009). In the process of curriculum delivery, teachers as mediators need to understand challenges that text can present to all learners including D/HH learners. In addition, they need to support these learners with strategies that facilitate learning from texts without simplifying or substituting the expected content (Kluwin & Stewart, 2001).

As previously discussed, the outcomes from the study by Dowaliby and Lang (1999) confirm that teachers need to be as flexible as possible in integrating all options that could maximize learning science among D/HH learners. In fact, implementing one of the ten discussed practices will seldom produce significant positive results if it is implemented in isolation from the other practices. It is critical that teachers understand the academic needs of their learners and the specific learning areas that need to be developed to mediate the curriculum effectively to D/HH learners (Kluwin & Stewart, 2001).

2.6. Causes for poor performance among D/HH learners in Kenya

Even though it is clear that D/HH learners in Kenya perform poorly in science literacy, there are no specific studies that have examined Kenyan teachers practices in developing scientific literacy for D/HH learners. However, some studies have attempted to explain possible causes for general poor academic performance among D/HH learners. For example, some of these studies have highlighted the teacher factors or the learning factors. The most influential factors include learner motivation, teacher preparation and staffing, adaptation of curriculum or assessment strategies, and teaching resources.

Studies indicate that D/HH learners often are less motivated to study because they continuously perform poorly on the national exams compared to their hearing counterparts (Kimani, 2012; Kihighi, 2011). In addition, existence of teachers with insufficient experience or no training in deaf education has also been highlighted. Science teachers of D/HH students have either a diploma or degree in special education while some have training in general education without special education (Adoyo, 2007). None of these teachers receives comprehensive training, experience, or certification that equips them well to specifically work with D/HH learners (Crume, et al .2001). This is because, special education teacher training programmes in Kenya equips teachers with general knowledge on working with a wider category of learners with special needs and offer limited exposure, experience and opportunities for specialization (Crume, et al. 2001). When hired to teach in schools for D/HH learners, these teachers may either: a) have some skills on teaching D/HH learners but lack the required content mastery on scientific subjects or b) have good content knowledge in science subject but lack the language skills to communicate the content to their students (Crume et al. 20001; Adoyo, 2007; Kihingi 2011). As a result of inadequate teacher preparation, when employed to work in school for D/HH learners, teachers spend some time learning skills (such as communication skills, KSL and classroom management) that was missed during their training, at the expense of curriculum content delivery (Kihingi, 2011).

Poor communication skills among teachers working with D/HH learners have been observed to negatively impact teaching and learning in all subjects (Crume et al., 2001). A study conducted in Kenya by Kihingi (2011), employed a descriptive design in assessing views of 148 students and 46 teachers on factors hindering teaching and learning activities for D/HH learners. This study revealed that even though D/HH learners prefer using KSL in learning and communication, only 7.7% of teachers working in schools for the deaf had the required skills in using KSL to teach their respective subjects. Additionally only 15.4% of teachers had received the required training in education for D/HH learners. The study also reported that 78.3% of D/HH learners had no knowledge of English based sign systems used in school. Finally, the study showed that 68.7% of the students were frustrated with poor communication strategies used in school. This study by Kihingi, urged the government to employ teachers who have specific training in deaf education, integrate sign language training in teacher preparation, encourage learners to use available assistive technologies, and urged KIE to initiate studies that would support the harmonization of sign language to facilitate consistency in curriculum delivery. The findings in Kihingi (2011) are consistent with observations made by other researchers on teachers' qualifications in education for D/HH learners in Kenya (Crume et al., 2001; Adoyo, 2007).

The implementation of a generalised curriculum and use of poorly adapted teaching and curriculum evaluation strategies (exams), have also been highlighted to cause poor performance among D/HH learners in Kenya. A study by Maina et al. (2011) engaged 3 head teachers, 10 mathematics teachers and 112 D/HH students in examining curriculum factors that influenced performance in mathematics. This study utilized questionnaires, interviews and observation in collecting data from the participants. The study revealed content coverage, time on task and medium of instruction as curriculum factors affecting learner performance. The study recommended the need for in-service training of teachers on teaching methods and employment of trained teachers with deaf education backgrounds. Additionally, other studies have highlighted use of textbooks with poor text mediation strategies as a contributing factor to poor performance among D/HH learners. For example, a study on teaching deaf students in Kenya, by Kimani (2012), revealed that D/HH learners did not understand content being taught due to teachers having poor KSL skills, and use of only textbooks as teaching resources. The study revealed that learners experienced difficulties in understanding the language used in textbooks due to lack of relevant teaching strategies to scaffold the understanding of text to support learning among D/HH learners. Additionally, it was revealed that lack of adaptations in exams and assessment strategies contributed to poor performance among deaf learners.

Kenya just like other African countries has been challenged to consider diversifying the educational learning environment by integrating technological alternatives in their curriculum and respective teaching strategies (UNESCO, 2002). In response to this call, Kenya, through the national educational policy, has strongly supported the use of technology in pedagogical practices at all levels of educational institutions (IIomaki, 2008). Additionally, the NSEPF has highlighted the use of technology in curriculum mediation as a key consideration for inclusive education and education for children who have special needs in Kenya (MOE, 2009). Conversely, a current report by the MoEST revealed that the emphasis in learners' performance on examinations has compelled teachers to focus on improving learners' scores rather than on specific learning needs. Therefore, many teachers prioritize exposing their students to exam answering strategies rather than developing capacity on the use of technology to meet specific learning needs for each student (Nyarangi, 2010). This has created an unfavorable learning environment for children with special needs by limiting their strategic access to educational technology (MoEST, 2012).

Advocates in education for D/HH children in Kenya have incessantly lobbied the MoEST to consider prioritizing the support for the use of technology in all schools for D/HH learners (Kakiri, 2012). Studies on use of technology in teaching reveal positive results in supporting both language and cognitive development among D/HH learners. For example, Nyarangi (2010) conducted a descriptive research study on the effect of caption TV programming on learning with 204 participants from the Karen Technical Training Institute for the Deaf in Kenya. In this study, learners' opinions were collected using interviews, questionnaires, and observations. The results revealed that use of captioning helped to increased accessibility to content and support learning among D/HH learners (Nyarangi, 2010). With evidence of positive results from the use of technology in teaching Kenyan D/HH learners, it is paramount to develop teachers' capacities on the use of technology in teaching and equip schools with sufficient technological resources (Kakiri, 2012). Additionally, the use of the Internet combined with sign language and classroom adoptive technologies like FM systems and hearing aids has been confirmed to support and improved delivery of scientific content to D/HH learners (Egelston-Dodd & Ting, 2007). High internet accessibility can also provided multiple channels through which D/HH learners are exposed to scientific content online (i.e., video, print, signed content, pictures, and other options) that are plausible to the visual learning strengths and needs of D/HH learners (Egelston-Dodd & Ting, 2007).

Considering some of the issue that have been highlighted as general causes for poor performance among D/HH learners in Kenya (e.g., Adoyo, 2007; Nyarangi, 2010; Kiningi, 2011; Maina et al., 2011; Kimani, 2012), it is apparent that the quality of education for these learners is affected by numerous challenges. While policy makers propose the implementation of best practices in education for D/HH learners (MOE, 2009; MoEST, 2003), these learners still perform poorly in national examinations. Teachers are entrusted with the responsibilities of delivering the curriculum, yet there are no studies that have focused on assessing the current teaching strategies and practices in schools for D/HH learners in Kenya. Similarly, there are no studies that have been conducted to explore teachers' (the implementers) views on teaching practices or even assess how these practices are implemented.

2.7. Research Questions

The three research questions for this study are:

1. What are the views of science teachers of D/HH learners concerning the ten practices cited by Easterbrooks and Stephenson (2006) as best in teaching science to D/HH learners?
    i) To what extent do teachers implement any of these practices in their science classroom with D/HH learners?
    ii) Which of these practices are perceived as more beneficial in supporting science literacy for D/HH learners in secondary school?
2. What other teacher practices and innovations in developing science literacy are currently being implemented by teachers for D/HH learners?
3. What issues or recommendations need to be considered in order to improve scientific curriculum delivery and performance for D/HH learners?

2.8. Significance of the study.

The findings from this study will contribute to a better understanding of teacher practices that support teaching science to D/HH learners. The identified teaching strategies/practices and analysis of teachers' views on proposed practices in science education for D/HH children will provide Kenyan teachers and policy makers with information on teaching strategies and practices in science literacy for D/HH learners. Also, the finding will provide a foundation for further studies that support science literacy for learners who are deaf/HH in Kenya, Africa, and the world.

Chapter 3: Methodology

3.0. Introduction

In this chapter, I discuss the methodology employed in the study including the study design, data collection instruments, data collection procedure, reliability and validity. The ethical considerations and data analysis methods are also described.

3.1. Study Design

A descriptive survey research design was employed in this study. This design is used in studies that need to establish an accurate portrayal or account of participants' characteristics in terms of behaviour, opinions, abilities, beliefs, and knowledge without manipulating the outcomes (Burns & Grove, 1993; Neuman, 2000). The descriptive survey research design was considered an appropriate method for the current research for two reasons:

1. Original data is used in the study. The aim of the study is to collect information and views from secondary school science teachers of D/HH learners based on their experiences in the classroom without changing, altering, or affecting their current teaching practices.
2. A description of practices is a goal of the study. The study also seeks to collect information that describes the practices and opinions of secondary school teachers for D/HH learners regarding issues and recommendations that would further support science literacy for these learners.

The descriptive survey research design has been successfully used in investigating views on issues that relate to education for D/HH learners. For example, Schick and Moeller (1992) used the descriptive survey design to study the ability of D/HH children in acquiring English from manual code English input. Another example is a recent study by Maina et al. (2011) that employed the descriptive research design in investigating views on curriculum factors influencing the performance of Kenyan secondary school deaf children in mathematics.

3.1.1. Sampling procedures. The current study employed a convenience-sampling method in the participants' selection. Convenience sampling is defined as a non-probabilistic participant selection method, which involves selecting participants based on their availability at the right place and right time (Jackson, 2009). Considering the nature of the current study, the participants were selected through a convenience sampling technique for four reasons:

1. At the time of data collection, Kenyan teachers were on a national strike, which meant their availability in schools was unpredictable.
2. Public secondary schools for D/HH learners in Kenya have a small number of trained science teachers per subject. This number is too small to permit randomized sampling. Therefore, the use of convenience sampling made it possible to ensure that all three science subjects were represented.
3. The schools are located far away from each other so it would be both expensive and time consuming to have teachers travel and meet in one favourable place to participate in the study. Therefore, convenient sampling made it possible for the researcher to travel and meet teachers in schools.
4. The study was aimed at collecting teachers' views within their respective environment (schools). The use of convenience sampling made it more realistic for the researcher to travel and collect data from the teachers in each school. It also enabled the teachers to participate in the study without taking much time out of their teaching roles.

3.1.2. Research setting. The study was conducted in five secondary schools for learners who are deaf located in five different counties of Kenya. These schools are all special public secondary schools for learners who are deaf and have a history of their students sitting for the KCSE.

3.1.3. Description of the target population. As mentioned earlier, chemistry, biology, and physics are secondary school subjects in Kenya that are clustered under the Group 2 option (Kinuthia, 2009). Science teachers are trained to teach two science subject options and are expected to teach any of the subjects from the two options (Mulkeen, Chapman, DeJaeghere, & Leu, 2007). In some cases, teachers are trained to teach mathematics and any of the science subjects mentioned above even though mathematics is classified under Group 1 together with English and Kiswahili (Ogwel, Odhiambo, & Kibe, 2008; Kinuthia, 2009).

In the current study, the target population was secondary school teachers for D/HH learners who teach any of the science subjects under Group 2. In addition, the participants were science teachers with a diploma, bachelor's degree, or higher training in teaching biology, chemistry, or physics.

A convenience sample of 26 secondary school science teachers of D/HH learners was involved in the study. A range of between four to six teachers was selected from each school based on their availability. From the selected sample, 15 participants were selected to participate in focus group interviews. The participant selection for the focus group interviews was voluntary (based on availability and willingness to participate).

3.2. Data Collection Instruments

The study used data collection tools employed in the descriptive research design as described by Jackson (2009) (i.e., a survey and an interview). I elected to use both a survey and a focus group interview because research confirms that information collected from both survey questions and interviews provides sufficient data to permit triangulation during analysis (Polit & Hungler, 1993).

First, an online survey was developed using an on-line survey tool called SurveyGizmo. The questionnaire contained questions regarding demographic information and teaching practices. The questions were evaluated and approved by the research supervisory committee and a web link to the survey was generated for the purpose of distribution to the participants. A copy of the survey was printed as a backup measure just in case the respondents did not have access to a computer. The survey included open-ended questions, which allowed the collection of diversified responses. It also contained multiple-choice questions that included a rating scale (see Appendix A).

Second, focus group interview questions were developed. The interview questions focused on identifying success stories from the teachers' experiences, highlighting the best practices that contributed to the success, and identifying factors that would motivate teachers to implement the identified best practices (Appendix B). The research supervisory committee approved the interview questions and a hard copy printed to be used by the researcher for data collection. Focus group interviews were conducted to allow an in-depth discussion of the views and opinions of the participants regarding their practices.

3.3. Data Collection Procedure

The researcher visited each school and administered the data collection tools in person over a period of four months. First, the selected participants responded to the online survey questionnaire that was accessed through the approved survey link. The link was opened using school, individual, or investigator computers stationed in a staffroom, science laboratory, or science department's office. The participants spent between 30 to 35 minutes responding to the survey questions. A hard copy of the survey was given to respondents who preferred to complete a manual survey. The manual responses were entered into the online survey by the investigator and the copies stored for reference. All responses were collected anonymously in the report section within SurveyGizmo's password protected account.

Second, after responding to the survey, participants were selected to participate in a focus group interview, which lasted for an average of 30 minutes depending on the size of the group. The focus group interviews were video recorded for the purpose of data transcription and analysis.

3.4. Reliability

Reliability is defined as the degree of consistency with which an instrument measures the attribute it is designed to measure (Jackson, 2009). To ensure reliability of the instruments, the entire survey and focus group interviews was administered by the researcher. In addition, the two forms of data (the survey and focus group interviews) provided an opportunity to test reliability by assessing consistency in the participants' responses. Also, Cronbach's Alpha formula was used to determine reliability for the Likert scales employed in the study. All of the Likert scales used in the study yielded a Cronbach's Alpha reliability coefficient between 0.757 and 0.820. Additionally, each secondary school for learners who are deaf was located in a different county and the schools were situated far away from each other geographically. Hence, a consistency in the responses from teachers would confirm the reliability of the instruments.

3.5. Validity

Validity is defined as the degree to which an instrument measures what it is intended to measure (Jackson, 2009). First, the questions used in this study were developed based on information gathered during the literature review to ensure that they represented recommended teacher practices in science literacy for learners who are deaf. Second, after the data collection tools (survey and interview questions) were developed, they were assessed by a research committee that included, professionals with experience in education for D/HH learners and in secondary school science education. Third, the researcher conducted a pilot study using one school, which was not part of the study.

3.6. Ethical Considerations

A written approval to conduct the study was obtained from the University of Alberta's Ethics Review Board prior to implementation of the study. Also, an application for a research permit together with copies of the research proposal and data collection tools was submitted to the National Council for Science and Technology (NCST) in Kenya. The council approved the study and issued written consent together with a research permit (see Appendix C) that allowed the researcher to collect data from science teachers teaching in secondary schools for learners who are deaf in the selected five counties.

As directed by the Kenyan NCST, an information letter (with copies of all of the research tools, approvals, and permit) was submitted to the respective county commissioner's office, the county director of education, and the school principals before the researcher visited the schools. Details about the study were provided in the information letters that were given to the teachers prior to the data collection. The information letter together with an introductory note on the questionnaires informed the respondents that participation in the study was voluntary and was consented through the completion of the questionnaires and participation in an interview.

3.7. Data Analysis

The study collected both qualitative and quantitative data. The quantitative data was collected from closed-ended and rating scale survey questions and was analysed using descriptive statistics (i.e., frequency distribution tables, mean, mode, range, and standard deviation among others). The qualitative data was collected from open-ended survey questions and focus group interview questions. The qualitative data was organised thematically based on categories that emerged from analysing the teachers' views.

Chapter 4: Results

4.0. Introduction

In this chapter, I will present the results from the survey questions and the focus group interviews. In addition, I will discuss the demographic information of the science teachers for D/HH learners that participated in this study.

4.1. Demography

The first part of the survey questions asked for information regarding the teachers' qualifications, training, years of teaching experience in schools for learners who are deaf, specific science subjects taught, and the preferred language used by science teachers for general interactions with their students and for teaching specific science subjects. Information regarding the average number of students (class size) taught by each teacher was also requested. Ten of the selected participants mainly taught biology. Eight of the 26 participants were chemistry teachers while the remaining eight were physics teachers. On average, the participants had 6 years of experience teaching their respective science subjects to learners who are deaf with a minimum of 2 years and a maximum of 16 years.

The results regarding the participants' qualifications revealed that 4 (15.4%) of the teachers had a Diploma in Special Education (with science subjects), 4 (15.4%) had a Diploma in Education Science, 12 (46.2%) had a Bachelors of Education degree in special education (science subjects), 5 (19.2%) had a Bachelor of Education degree in science, and 1(4%) had a general Bachelor of Science degree and a Post Graduate Diploma in Education (PGDE).

The teachers were asked about the modes of communication they prefer to use (a) in general interaction with their students and (b) in teaching their respective subjects. In general, 53.9% of the science teachers responded that they use combined sign and speech (simultaneous communication) in their general interactions with students, 34.6% use Kenyan Sign Language (KSL), 11.5% use Signed Exact English (or Manual Coded English). However, regarding the preferred language used for teaching science, 80% of the participants use Signed Exact English or Combined Sign and Speech while 20% use KSL. While teaching science to their students, most teachers did not prefer to use either spoken or written English alone. Table 1 illustrates the teachers' preferred language.

Table 1

Teachers' Preferred Modes of Communication

Mode of Communication	Teachers	%
General Interactions		
KSL (Kenyan Sign Language)	9	34.6%
Signed Exact English (Manual Coded English)	3	11.5%
Spoken English	0	0.0%
Written English	0	0.0%
Combined Sign Language and speech (simultaneous communication)	14	53.9%
Total response	26	
Teaching Science		
KSL (Kenyan Sign Language)	5	20.0%
Spoken English	0	0.0%
Written English	0	0.0%
Combined sign and speech/ Signed Exact English	21	80.0%
Total Responses	26	

In addition, the teachers classified and described their skills in using KSL to communicate with and teach D/HH students. They classified their skills as follows: 7.7% beginner, 50% intermediate, and 42% advanced.

The survey responses show that each teacher teaches an average of three classes. These classes are either one class with three streams (for example Form 1A, B, and C) or three different classes. Additionally, the average student population per class is 28.

4.2. Research Question 1

The first research question was, “What are the views of science teachers of D/HH learners concerning the ten practices cited by Easterbrooks and Stephenson (2006) as best in teaching science to D/HH learners?

i) To what extent do teachers implement any of these practices in their science classroom with D/HH learners?

ii) Which of these practices are considered as more beneficial in supporting science literacy for D/HH learners in secondary school?”

Participants in this study reported employing the ten teaching practices proposed in studies by Easterbrooks and Stephenson (2006) with a variation in the percentages of teachers using each of the practices (see Table 2). For example, 92% of the participants reported to using visual supports in teaching science subjects (biology, physics, or chemistry) to D/HH learners while use of textbook mediation was reported by 50% of teachers. Table 2 provides the details of the numbers and percentages of participating secondary school teachers responses on the use of each of the ten proposed practices and strategies for teaching science to D/HH learners.

Table 2

Number and Percentage of Teachers Responses on the Use of Proposed Teaching Practices and Strategies for Science

Practices/Strategies	No. of Teachers/Practice	% of Teachers/Practice
Teacher as a skilled communicator	23	89%
Instruction in primary language	20	77%
Teacher as a content specialist	20	77%
Active learning	21	81%
Visual supports	24	92%
Authentic, problem-based instructions	20	80%
The use of technology	09	35%
Specialized content vocabulary	19	73%
Critical thinking	19	73%
Mediating textbooks	13	50%

The teachers also responded to views that related to teaching practices and strategies for sciences. The responses were on a 5-point agreement scale with 1 representing *strongly disagree* and 5 represented *strongly agree*. In the analysis, the five categories were combined into three categories as recommended by research to optimize effectiveness of the rating scale (Linacre, 2002): *agree*, neutral and *disagree*. Table 3 shows the teachers' responses to views about teaching practices and the strategies they used in teaching.

Table 3

Teachers' Responses to Views about Teaching Practices/Strategies

Practice	Agree %	Neutral %	Disagree %	M	*SD*
1. My communication skill helps to facilitate learning in my class.	84.6	11.6	3.8	1.19	.49
2. My subject contents are well understood when delivered in KSL (the learner's primary language).	69.2	26.9	3.9	1.35	.56
3. The use of KSL to teach my subject may lead to poor performance among my students.	42.3	15.4	42.3	2.00	.94
4. Knowledge of my subject area content is important in facilitating learning in my class.	96.2	3.8	0	1.04	.20
5. Learner participation in class helps to facilitate understanding.	96.2	3.8	0	1.04	.20
6. Using visual supports or other visual teaching resources (e.g., charts, concept maps, or models) facilitates content delivery.	96.2	0	3.8	1.08	.39
7. Conducting frequent experiments and other laboratory exercises in my subject helps learners to understand the subject contents.	92.3	0	7.7	1.15	.54
8. Use of technology (e.g., ICT) in teaching my subject helps to facilitate content delivery and understanding.	69.2	26.9	3.9	1.35	.56
9. My knowledge of content vocabularies (in Kenyan Sign Language) supports content delivery and understanding.	84.6	7.7	7.7	1.23	.59
10. Allowing the learner to argue for or against ideas in my class supports both content delivery and critical thinking among learners.	92.3	7.7	0	1.08	.27
11. Language used in explaining scientific concepts in textbooks impedes conceptual understanding among learners in my class.	65.4	26.9	7.7	1.42	.64
12. Lots of content vocabularies in my subject area do not have equivalent signs.	73.1	11.5	15.4	1.38	.70
13. I need continuous professional development, experiences, and/or certification in content area knowledge.	76.9	19.2	3.9	1.31	.68

As displayed in Table 3 above, teachers provided varying responses regarding their views of each practice and strategy used in teaching science subjects to D/HH learners in their schools. For example, 96.2% of the teachers felt that knowledge of subject area content was important in facilitating learning in class, learner participation in class helped to facilitate understanding, and using visual supports or other visual teaching resources (e.g., charts, concept maps, or models) facilitated content delivery. However, 42.3% of the respondents felt that the use of KSL to teach their subjects could lead to poor performance among D/HH students, while 42.3% indicated they believed that the use of KSL would support performance. Equal percentages for teachers' views that agreed or disagreed on the use of KSL in teaching could have resulted from some factors outlined below.

The participants highlighted that some teachers lack the required competencies in KSL, and this affects their effectiveness when using it to deliver science content to students. For example, one of the respondents stated, ". . . there is a need to have classroom interpreters to facilitate and bridge communication in my class."

Also highlighted was the lack of relevant accommodations in science curriculum and assessment strategies. For example, one teacher responded:

> . . . when marking exams, scores are given based on the English grammar used other than the concept mastery. Deaf students score lower because they use KSL grammar in responding to questions. However, we are using combined Sign and English to teach so as to improve learners' grammar.

The teachers also called for the standardization of sign language because learners come to secondary school with different modes of signing, which causes a delay in communication adaptation and learning.

Of the teachers, 76.9% felt that they need continuous professional development, experience, and/or certification in content area knowledge. The results from comments revealed that the professional development options that were accessed by teachers included seminars organized by the association for science teachers, science teacher mentorship programs, exchange programs with teachers from other schools, and distance learning courses offered by the Kenya Institute of Special Education (KISE) or by universities. Figure 2 illustrates the percentage of teachers per professional development option accessed.

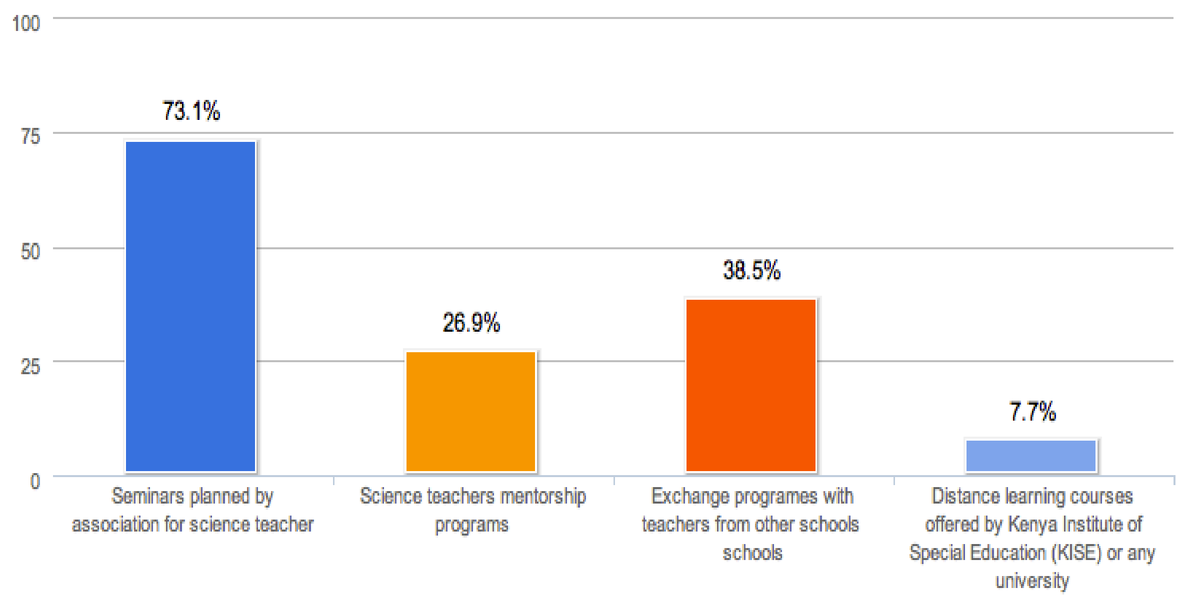

Figure 2. Bar graph showing the percentages of teachers who accessed specific professional development options.

The teachers discussed the need for funding to support more in-service courses for science teachers who are teaching learners who are deaf, more school visits by professionals, and better communication with content experts. For example, a teacher stated that teachers ". . . need visits by experts to observe, advise, and share experiences with teachers on teaching strategies." The majority of the teachers indicated they prefer to have professionals in deaf education visit their classes and offer specific capacity development to support their teaching. The participants stated that having professional development done within the schools provides solutions to immediate teaching challenges and helps them maximize their time on content delivery.

The comments also revealed that teachers actively engage their learners by allowing them to work in groups, giving them sufficient discussion time, and encourage peer tutoring amongst D/HH learners. Additionally, they offer classroom demonstrations related to the respective science content being taught to the students. One example given was "... acting/demonstration provides learners with the opportunity to master concepts. For example, learners acting as parts of a cell *organelle* would help them understand the functions of each organelle in the cell."

Other comments regarding learner active engagement revealed the participants' feelings that a need exists to increase secondary school learning time as a curriculum adaption for D/HH learners. The teachers proposed that it would be helpful if D/HH learners take 5 years of secondary school rather than the regular 4 years required by the curriculum. The extra year would allow teachers to cover the required curriculum content extensively and facilitate individualized reading among learners.

In the following section, the teachers' responses to Research Question 1(a) and (b) are discussed. Table 4 displays the teachers' responses to teaching practices/strategies that they feel are beneficial in supporting science literacy for D/HH learners in secondary school. The practices and strategies were rated on a 5-point scale with 1 representing *not at all* and 5 representing *very beneficial.* The teachers were asked to indicate how often they used each of the teaching practice or strategies on a 5-point scale (with 1 representing *never use the practice* and 5 representing *always use the practice*). They were also asked to indicate how likely they would start using or continue using each of the teaching practices in science education for D/HH learners (on a 5 point scale with 1 representing *not at all* and 5 representing *very likely*).

Table 4

Teachers' Views on Teaching Practices/Strategies Considered Beneficial, the Extent They Implemented the Practices/Strategies, and Their Likelihood to Start or Continue Using the Teaching Practices/Strategies (N = 26)

	Beneficial to Students		Extent Implemented		Likelihood to Use	
	M	SD	M	SD	M	SD
Teacher as a skilled communicator - engaging in skilful communication using KSL, Spoken Language, English Based Systems, or other languages and modes used by students	4.62	0.70	3.81	1.23	4.35	0.94
Instruction in primary language - explaining science concepts using students' first language before competencies are assessed in English	4.26	1.08	3.69	1.26	4.08	1.20
Teacher as a content specialist - receiving content relevant professional/capacity development	4.35	1.20	3.00	1.57	4.38	1.02
Active learning - using hands-on activities and materials - allowing sufficient discussion time	4.50	0.95	3.46	1.36	4.18	1.11
Visual supports - using visual supports such as graphs, chart, or visual maps	4.65	0.67	4.00	1.17	4.58	0.70
Authentic, problem-based instructions - teaching science by incorporating a collaborative, case-based, problem solving approach to real world	4.27	1.08	3.31	1.38	4.15	1.05
The use of technology - using CDs, captioned materials, and interest-based Internet sites	4.38	0.94	2.31	1.54	3.46	1.33
Specialized content vocabulary - pre-teaching vocabulary and agreeing on signs for specialized content - teaching specialized content by signing or fingerspelling	4.21	0.96	3.62	1.46	4.14	1.27
Critical thinking - teaching step-by-step strategies for problem solving and processes that require high order thinking skills	4.50	0.86	3.88	1.48	4.04	0.97
Mediating textbooks - providing scaffolding between the student reading levels and the language demands	3.96	1.15	2.65	1.50	3.85	1.27

As shown in Table 4, the teachers believed that the use of visual supports was the most beneficial practice (mean = 4.65; SD = 0.67) in science literacy for D/HH learners. The next three most beneficial practices/strategies were teacher as a skilled communicator (M = 4.62; SD = 0.70), active learning (M = 4.50; SD = 0.95), and critical thinking (M = 4.50; SD = 0.86). The mediation of textbooks ranked lowest on the list of most beneficial practices (M= 3.96; SD = 1.15). However, regarding the extent to which each of the practices were being implemented, visual supports was the most frequently used practice by teachers (M = 4.00; SD = 1.17) followed by critical thinking strategy (M = 3.88; SD = 1.48) and teacher as a skilled communicator (M = 3.81; SD = 1.23). In contrast, the mediation of textbooks and the use of technology ranked lowest among the mostly used practices with means of 2.65 and 2.31, respectively. The results also show that teachers are very likely to start or continue using visual supports (M = 4.58; SD = 0.70) in teaching science to their D/HH students. However, the teachers ranked the likelihood to start or continue mediating textbooks lowest on the likelihood scale with M = 3.85; SD = 1.27.

The most cited examples of the types of visual supports used by science teachers are charts, graphs, pictures, and concepts maps. In comments, the teachers emphasized that visual supports facilitate scientific content mastery among learners who are deaf. For example, one teacher commented, ". . . the use of visual supports like charts is very important to deaf students since they understand better and faster if contents are explained in a way that they can see." Another teacher said, "When teaching a topic like blood circulation, on my chart I use the color red to represent oxygenated blood and dark red to represent deoxygenated blood."

The other often-used practice or strategy indicated by the teachers involves supporting critical thinking skills among D/HH learners. For example, teachers break concepts down into stages and teach the concepts based on how they relate to each other. This critical thinking support includes asking students to use the learned concepts to solve or explore new ideas. The teachers also provide end-of-chapter questions to motivate learners to use the learned concepts.

The use of technology ranked last among the practices and strategies used by participants in this study. Technology also ranked last regarding the likelihood that teachers would start or continue implementing it in class. Examples of the kinds of technology used include videos, Power Point presentations downloaded from the Internet, and YouTube clips. In comments, however, the teachers expressed concern regarding the limited access to information and communications technology (ICT) facilities and the capacity to enable frequent use. For example, in the view of one teacher, ". . . we have no ICT options. Hence, it is hard to expose students to diversified sources with information on scientific concepts."

In the mediation of textbooks, the teachers break tasks into small units, simplify them, give summaries, or explain the same content in a simplified language to the level of the learner (scaffolding). Also, learners are given short notes to copy in their books, read, and discuss in groups prior to discussion with teachers in class. The respondents highlighted that a learners' background from primary school affects their reading and understanding of text material, and hence, the learners' background affects their performance. Also teachers expressed concerns that high number of students per class and per teacher affected effective text mediation. In addition, according to the teachers, the learners who have residual hearing have been observed to have a better understanding of text compared to those who are totally deaf. However, some teachers also expressed that the language expectations in the curriculum are set too high for D/HH learners. The teachers explained that learners are over-dependant on teachers for content mediation, yet due to the class size, the teachers find it impossible to meet the learners' needs.

4.3. Research Question 2

The second research question asks, “What other teacher practices and innovations in developing science literacy are currently being implemented by teachers for D/HH learners?” This study collected teachers’ views on other teaching practices and strategies from focus group interviews. In the interviews, the teachers were asked to think, visualize, and discuss moments when their students had their best performance in subjects. The teachers cited some examples of students who achieved good grades in their KCSE exams. The grades ranged between C- and B+. The teachers then discussed the practices that they believe contribute to the peak students’ performance. An analysis of themes revealed 6 major categories and 19 related concepts describing the teaching practices and strategies used by science teachers of D/HH learners. The major categories comprised learner motivation, active participation, curriculum/syllabus coverage, language of instruction, scaffolding, and visual supports. Out of 90 clauses referring to one of the six major categories, 14 were allocated to learner motivation, 17 to active participation, 14 to curriculum and syllabus coverage, 14 to language of instruction, 12 to scaffolding, and 19 to visual supports. Table 5 contains a summary of the major themes and associated concepts that emerged from focus group interviews.

Table 5

Emerging Themes on Other Teaching Practices and Strategies

Major Categories	Associated Concepts
Learner motivation	- Appreciating the learner for trying - Building confidence in the student - Changing the attitude about the teacher - Setting achievable goals
Active participation	- Frequent practical classes - Group work - Demonstration - Supervised individualized studies
Curriculum/syllabus	- Curriculum/syllabus coverage on time - Reviewing missed concepts - Teacher collaboration
Language of instruction	- Learners' language - Harmonization of signs
Scaffolding	- End of chapter questions - Simplify tasks - Content related question answering skills
Visual supports	- Diversification of visual teaching aids - Context related colors - Bridge visual to written

Generally, the teachers explained how they used the ten practices proposed in Easterbrooks and Stephenson (2006) by providing approving comments or examples that emphasize the value of the teaching strategies and practice to science education for D/HH learners. However, two new themes emerged from the focus group discussions with respondents in this study: (a) learner's motivation and (b) curriculum/syllabus coverage.

4.3.1. Learners' motivation. The teachers felt that there is a need to motivate D/HH learners to learn science subjects since their poor scores compared to their hearing counterparts discourage them. The teachers observed that options like contractual learning, in which D/HH students makes an agreement with their teachers regarding how they will meet specific learning objectives, is not only an active learning practice but also a motivation strategy for the student to learn science subjects. Additionally, the teachers gave motivating feedback to their students. For example, in the words of one teacher, “Congratulating learners who are weak when they make attempts in class and encouraging those who score better to aim higher” also supports learning science among D/HH learners in Kenya. In addition, regarding motivation, it was observed that setting achievable objectives for learners and changing teachers’ attitudes towards D/HH learners would encourage learners to work harder in science subjects.

4.3.2. Curriculum/syllabus coverage. The teachers observed that learner performance could be improved when they cover the science curriculum in good time. This is because, when the contents are covered earlier, it gives the science learners time to review areas that they missed, and have more consultations with their teacher before sitting for the final exams. Early coverage of the curriculum also gives confidence to the students and more time to revise and practice question-answering strategies as they prepare for the final exams. One of the proposed curriculum coverage strategies was teacher collaboration when teaching specific content. For example, one teacher commented “. . . encourage teachers to work collaboratively, i.e., maths is key in sciences also biology, physics and chemistry have some relationships. If this is done, [the] syllabus can easily be covered.”

4.4. Research Question 3

The third research question is, “What issues or recommendations need to be considered in order to improve scientific curriculum delivery and performance for D/HH learners?” Through a focus group interview, this study collected science teachers’ views on the issues and recommendation that need to be considered to support scientific curriculum delivery and performance for D/HH learners. The views were thematically analysed based on the major categories and related concepts that emerged. In Table 6, the major themes and related concepts are summarized.

Table 6

Major Categories and Concepts on Issues and Recommendations for Science Teachers

Major Categories	Associated Concepts
The size of class population	- Large number of students per class - Teacher workload
Teacher qualifications and experience	- Teacher knowledge of KSL - Scarcity of science teachers - Teacher turnover - Teacher training background - Continuous professional development
Learners' background	- Knowledge of sign language - Learners' exposure to English - Entry grade from primary school
Teaching resources	- Equipping school laboratories - Building larger school laboratories - Scarcity of ICT resources - Capacity development on ICT
Curriculum adaptations	- Content simplified to learners' levels - Increased secondary school time for learners
Content vocabulary	- Signs for scientific words
Evaluation strategies	- Adaptation of exams - Exam set in KSL
Teacher motivation	- Teacher reception, student performance, and enumeration

4.4.1. Class population size. The participants highlighted the large number of students per class as an issue that affected the effectiveness of their teaching practices. They observed that the teachers work with an average of between 28 to 35 D/HH learners per class. The teachers felt that this number is too big to allow them to offer maximum individualized support to each student, and hence, it can lead to poor performance among D/HH learners. It was clear that the teachers who have a smaller number of students give more time to each learner. This practice improves student performance in respective science subjects. For example, one teacher commented, ". . . in 2003 I had a class of 7, they all performed very well in my subject. But now I have 35 students in my class and it is hard to offer individualized support." The teachers proposed that the government, through the Ministry of Education (MOE), consider constructing more classes and hiring more teachers to accommodate a manageable number of students per teacher.

The teachers also stated that they are currently teaching an average of three classes each containing between 28 to 35 students. This situation poses a challenge for teachers to implement the best teaching practices effectively in their classes. For example, a response that related to teacher workload stated, ". . . considering the class size. Now one teacher handles from form 1 to form 4 and has between 28 to 35. We have no time to talk, sign and write same notes for 4 form one classes, then repeat the same all along to form 4…"

4.4.2. Teacher qualifications and experiences. Teacher qualifications and experience was another theme that emerged from the focus group interviews. The respondents raised issues that they feel impact scientific curriculum delivery to D/HH learners. The issues are teacher knowledge of KSL, scarcity of science teachers, teacher turnover, teacher training, and continuous professional development.

Respondents observed that many science teachers who are employed to teach in special schools for deaf students come with no experience in KSL or deaf education. The respondents revealed that trained teachers with no experience in deaf education spend a considerable amount of time learning KSL and changing their attitudes towards learners who are deaf at the expense of curriculum delivery. For example, one teacher commented ". . . The government should employ teachers who have mastered KSL. Many teachers start to learn KSL after being posted to schools: this wastes time that could be used for content delivery." The teachers felt that this situation contributes to poor performance in science subjects among D/HH learners. The teachers felt that the Ministry of Education Science and Technology (MoEST) could support scientific curriculum development by employing teachers who have relevant experience in not only science literacy, but also in deaf education.

The teachers observed that a shortage of science teachers exists in schools for D/HH learners. Because of this shortage, some schools are tempted to hire untrained teachers (for example, former students who are assigned to teach science subjects to D/HH learners). In addition, these untrained teachers are paid by funds from the respective school board instead of the Ministry of Education, and hence, their hire affects school budgets.

According to the teachers, some schools for D/HH learners experience a high rate of staff turnover. This is because some teachers are transferred to a regular school after working with D/HH learners for about 5 years. For example, this is evident in the comment "…teachers come here, spent time to learn signs, then they are transferred to hearing schools after maybe 5 years and be replaced by new inexperienced teacher, it's just like a cycle sometimes." These transfers lead to schools losing teachers who have already spent time gathering valuable experience in teaching science to D/HH learners. Additionally, after transferring teachers, schools for D/HH learners end up either not getting a replacement or receiving new teachers with no experience in deaf education.

The respondent views from interviews revealed that teachers believe that the performance of D/HH learners in science subjects would improve if the MoEST employed and/or posted science teachers with deaf education or special education training to schools for D/HH learners. The respondents felt that the employment of experienced teachers in schools for the deaf would save time and would improve the quality of scientific curriculum delivery to D/HH learners.

The participants also observed that the MoEST needs to work with schools for D/HH learners in establishing a structure for continuous teacher professional development with specific preference given to science literacy curriculum delivery. In addition, it was proposed that the government should allocate funding that would support schoolteacher skill development sessions with experts in deaf education. On respondent suggested that the "…government needs to sponsor in-school trainings for teachers. For example, experienced professionals may visit our classes, assess our teaching and offer relevant capacity development. This is good because it meets both teachers' and learners' needs." The teachers felt that involving experts who have experience in deaf education in observing and sharing their skills with teachers at their schools would maximize the teachers' time for curriculum delivery and would not require the teachers to take time out of school to attend related professional development.

4.4.3. Learners' background. In some sessions, the teachers disclosed issues that relate to the learners' backgrounds. The teachers believed that these issues significantly impact secondary school performance for D/HH learners in science subjects. The issues highlighted were knowledge of sign language, learners' exposure to English, and learners' entry grade from primary school.

The teachers explained that some students come to secondary school without any knowledge of sign language or that the students use sign languages that are different from the preferred mode of communication in the specific secondary school. As in the response,

> Schools for the deaf should try to harmonize signs. Sometimes it is confusing because we receive students from different primary schools. Some primary schools use ASL, others use KSL, while some use manual coded English. Imagine all these students meeting in one class and expected to be taught by one new teacher.

From this response, it is clear that secondary schools receive learners from different primary schools who have varied sign language backgrounds. These students then need to take time to learn the new communication system, and at the same time, they struggle to understand the curriculum content being taught in class.

The participants observed that some learners who have residual hearing or become deaf after exposure to spoken language earlier in their life tend to perform better than those with no such exposure. For example, some learners who are post-lingual deaf perform better in science subjects because they understand the spoken language used in both the textbooks and exams.

Teachers also observed that learners who join secondary school with good grades from primary schools end up performing well. Therefore, the teachers recommended that the MoEST set up a detailed monitoring and evaluation structure that will support and monitor the quality of curriculum delivery to D/HH learners in primary school, starting as early as the beginning of primary school.

4.4.4. Teaching resources. The participants explained that availability of sufficient teaching resources would support scientific curriculum delivery. For example, continuous exposure of students to practical and experimental classes supports scientific curriculum delivery and the learners' performance. Also, teachers considered the use of ICT resources helpful in delivering scientific curriculum to D/HH learners. They observed that ICT is very helpful in exposing D/HH learners to diversified experiences that support the learning and understanding of abstract content in science literacy. For example in a comment "…. a YouTube video showing the movement of food from mouth to the stomach would easily explain *peristalsis* process of digestion than when the same process is explained using text or signed exact English." The teachers mentioned several issues related to teaching resources that affect the delivery of science curriculum to D/HH learners. These included, equipping school laboratories, building larger school laboratories, scarcity of ICT resources, and capacity development on ICT.

The participants observed that some schools have scientific laboratories but lack the relevant chemicals and equipment for teachers to hold frequent practical classes with their science D/HH learners. In addition, it was observed that most schools for D/HH learners have few or no trained fulltime school laboratory technicians. Hence, these schools shift the whole curriculum delivery burden onto the respective science teachers. Consequently, teachers are tempted to reduce the number of practical classes in their courses and focus on curriculum content instead without exposing the learners to related experiments. Also the respondents observed that some schools have very small laboratories to accommodate the large numbers of students in their class. For example, "We have small labs not enough to serve all my students and at the same time the labs are not even well equipped." Additionally, the teachers expressed that it was difficult to give experimental instruction and monitor learners who are deaf in a crowded laboratory. They proposed that the county governments should invest in building and equipping larger school laboratories to accommodate not only the high student population, but also the needs of D/HH learners.

The responses from the teachers also revealed that schools for D/HH learners are either not equipped with ICT or have out-dated or insufficient equipment to meet both learning and teaching needs. In some cases, the teachers use their personal funds to access ICT resources from external sources like commercial cyber cafes. Accordingly, these situations limit the extent to which science teachers integrate ICT in their teaching practices. In the comment, “The area of information technology is very important in teaching deaf students. The government needs to equip school with technological resources that would help both students and their teachers to diversify learning. As they interact with the world,” a teacher urged the MoEST to prioritize the process of equipping schools for D/HH learners with enough ICT facilities to improve the quality of scientific curriculum delivery. Additionally, they urged the government to work with the MoEST in facilitating relevant training for science teachers regarding the use of ICT in delivering scientific curriculum to D/HH learners. For example, in the comment, “. . . we need ICT facilities and training or exposure on how to use them in teaching science.”

4.4.5. Curriculum adaptation. The respondents expressed concerns regarding the current science curriculum/syllabus. Participants proposed that relevant adaptations need to be made in the curriculum to meet the needs for science D/HH learners. The proposed considerations for curriculum adaptation include simplifying the content to the learner’s levels, and increasing secondary school time for D/HH learners.

The teachers observed that the current scientific curriculum has content that is well suited for hearing learners in regular schools but is more complex for D/HH learners. For example, this is evident in the comment, “…the curriculum should allow teachers to make relevant adaptations to fit the learning need of these learners. If it remains complex it makes them to give up.” The teachers noted that the current curriculum is more exam-oriented and that teachers focus more on scores than on developing the learners' scientific experience. This is because teacher performance is evaluated based on how the students score on exams. The teachers proposed breaking down and adapting curriculum objectives to meet the needs of D/HH learners. Additionally, due to broad curriculum expectations and the diversity in students background knowledge, teachers urged the MoEST to consider increasing the time allotted for secondary school D/HH learners to complete high school so that they can gain enough exposure to the concepts before sitting for national exams. For example, a teacher commented, ". . . the content taught to the deaf is too much to cover within 4 years. There is need to add more time to allow more exposure and content coverage; at least more than 4 years maybe 5."

4.4.6. Content vocabulary. The teachers noted that knowledge of scientific content in sign language helps to facilitate teaching and improves content mastery among D/HH learners. The issue of teachers' knowledge of scientific vocabularies in sign language was highlighted as significant in teaching science to D/HH learners. It was clear that due to lack of signs for science words, limited skills among teachers to facilitate expression of complex scientific concepts and poor signing skills among teachers, both teachers and students often become confused as they deliver and learn science, respectively. One teacher commented, ". . . we need signs that are related to science, for example in Physics it is hard to explain some concepts in KSL, i.e., the concept '*work and done*' I signed it as 'DO' and 'DO,' it is even confusing to students." When translated directly to KSL, scientific concepts like this can either cause confusion or mislead D/HH learners and hence affect understanding.

4.4.7. Evaluation strategies. The teachers highlighted that D/HH learners perform poorly in science subjects because the evaluation strategies are not adapted to meet the needs of these learners. Regarding evaluation, the teachers proposed the following considerations.

The teachers observed that D/HH learners fail in exams because they have difficulty understanding the exam questions. For example, as stated in a teacher's comment, "The MOE should try to adapt the exams/assessments, especially the language used in asking questions. Usually they (deaf/HH students) fail because they don't understand the long sentences used." Questions with long sentences tend to confuse or even discourage learners from reading a question through to the end. Additionally, D/HH learners use KSL grammar in responding to questions on exams. Consequently, they are often marked wrong based on the grammar they used (usually called "broken English") without the marker considering the concepts being communicated. It was observed that D/HH learners get discouraged when they are marked wrong based on the grammar used instead of considering the validity of the content in their responses to exams. Also the participants proposed that the MoEST should consider setting questions in KSL or in the learners' primary language as an adaptation for D/HH learners. Additionally, the ministry should consider training teachers who mark exams for D/HH learners on skills to understand and evaluate the learners based on the KSL grammar used. Also, to ensure impartiality in scoring and assessment, independent teachers who have training in KSL or deaf education could be assigned to review the marked exams.

4.4.8. Teacher motivation. The participants explained that teacher motivation has an impact on scientific curriculum delivery to D/HH learners. The teachers raised issues that require consideration in support of curriculum delivery to D/HH learners. The issues are teacher reception, student performance, and remuneration.

The participants observed the need for school administration to appreciate, welcome, and encourage creativity or innovativeness from all teachers who teach science to D/HH learners. Creativity and innovativeness could be supported through funding or through other school resource allocation. For example, some teachers wish to combine teaching with field trips to help D/HH learners experience how concepts work in the real world. Another example of resource allocation could be a teacher using a school garden for a scientific project like aquaculture or deciding to prepare students to compete on a science congress exhibition.

The teachers also explained that student performance motivates them to implement strategies that support science literacy. The teachers who would like to have their learners score higher in exams spend more time with learners who are good performers than with those who are poor performers. Curriculum evaluation strategies that focus more on exam scores instead of on knowledge development have contributed to this situation. In fact some teachers end up seeking transfer from schools for the deaf to schools for hearing learners with an expectation of teaching a group of students who will perform better on national exams. Participants proposed that the teachers who work with D/HH learners need to be paid more in consideration of the greater workload that they have compared to teachers who work with hearing students. Additionally, it was highlighted that salaries for teachers working with D/HH learners should be based on the levels and relevance of their training instead of the current mode that determines job groups based on generalised qualifications. One teacher commented,

> …as it is now, B.Ed. science teacher teaching in schools for the deaf are paid same salaries as those with B.Ed. special/deaf education (science). Because of this, teachers are less encouraged to enrol for further trainings that are relevant to deaf learners.

Chapter 5: Discussion

In this final chapter, the study results in response to the research questions will be discussed. The discussion will focus on the results from the views of Kenyan science teachers of D/HH learners concerning the ten most cited best practices in teaching science to D/HH learners (Easterbrooks & Stephenson, 2006). In addition, the issues or recommendations that needs to be considered in order to improve science curriculum delivery and performance for D/HH learners in Kenya will be discussed.

The themes that emerged from the focus group interviews revealed a pattern that was consistent with the results from the teachers' responses to the survey questions. With an exception of two categories (learner motivation and curriculum/syllabus), a response to a question on other practices implemented by teachers (See Table 5) revealed major categories and related concepts that emphasised the practices that had been highlighted by Easterbrooks and Stephenson (2006) and Easterbrooks et al. (2006). Additionally, themes that emerged from focus group discussion question (see Tables 6 and 7) provided information that could be attributed to the gaps between the knowledge of teaching practices/strategies and the extent to which they are implemented in the classroom.

5.1. Implementing best practices

As shown in Table 2, the teachers' responses to Research Question 1 indicated that the participants reported to use some of the ten best practices proposed by Easterbrooks and Stephenson (2006). The teachers also expressed their perceptions regarding different views about each teaching practice in supporting science literacy for D/HH learners (see Table 3). It is evident that participants implement each of the practices or strategies to some extent. Surprisingly, however, the teachers' responses on the benefits of these teaching practices/strategies to science learners who are deaf/HH showed all practices were perceived as beneficial with higher mean scores (see Table 4) compared to the extent to which they were implemented. Additionally, a higher mean regarding the likelihood that science teacher would start using or continue using each teaching practice and strategy was reported.

In this study, best teacher practices/strategies in science literacy are considered as those practices and innovations that efficiently mediate high school science curriculum, engage learners in the classroom, and positively contribute to performance of D/HH learners in science education. However, the analysis of the study results revealed existing gaps between extent or depth of teachers knowledge of the teaching practice/strategies (how well the teachers understood the practices) and factors that facilitate smooth implementation of the practices or strategies (how well teachers implemented the practices) in science literacy for D/HH learners.

5.1.1. Teaching in learner's primary language. From the demographic information, it was observed that teachers both in teaching and general interaction with D/HH learners mostly used combined sign and speech rather than KSL. However, on assessment of their KSL skills, teachers classified their KSL skills as good, or excellent. Moreover, there was a small gap between the means for teachers view on the benefits of primary language to D/HH learners, to that of the extent to which they used primary language to teach and likelihood to start/continue using the practices (See Table 4). This narrow gap between means would elicit a perception that indeed teachers used KSL in teaching their science subjects. Ironically, however, there was an equal mean of 42.3% each (see Table 3) for teachers who agreed and those who disagreed with a view that the use of KSL to teach science subject would lead to poor performance among D/HH learners. Additionally, the participants in this study reported that they are reluctant to use KSL in teaching because D/HH students tend to transfer the KSL grammar to exams, and hence, fail these exams due to incorrect grammar used. As a result of these perceptions over 80% of teachers used combined speech and signs, in teaching science subjects to D/HH learners. The uncertainty in teachers' perception regarding the best language to use in teaching shows a potential gap in teachers' knowledge and skills on the use of KSL.

There is overwhelming evidence supporting the use of the primary language (i.e., KSL) in teaching all subjects, including science subjects to D/HH learners (see e.g., Easterbrooks & Stephenson, 2006; Enns, 2007; Kluwin & Stewart, 2001; MOE, 2009). Therefore teachers' observation that D/HH learners performed poorly in science subjects because they transferred the KSL grammar to their answers on exams is very likely a misconception. Additionally, teachers feel compelled to use combined signs and speech (simultaneous communication) in class because they assume this will lead to improving the learners' English grammar and performance on exams. Kenyan secondary schools for D/HH learners receive learners from diverse backgrounds (Adoyo, 2007; Crume et al., 2001) and these learners have different language learning needs. The use of only one mode of communication in teaching (e.g., simultaneous communication) may not meet the language needs for all learners in a classroom (Wilbur, 2000). Therefore this method could not be generalized to meeting the language learning needs of all D/HH students in class. Additionally, studies conducted in Kenya have revealed negative outcomes regarding the use of simultaneous communication to develop deaf learners' English language (Ndurumo, 1993; Okombo, 1994; MoEST, 2009). Likewise, key studies in bilingual education have recommended the use of a learner's first language to support learning a second language (see e.g., Enns, 2007; Enns & McQuarrie, 2012; McQuarrie & Abbott, 2013; McQuarrie & Parrila, 2009). Moreover D/HH learners have been confirmed to understand concepts well when these concepts were delivered in their primary language (Anderson et al., 1994). However, as proposed by science teachers, there is a need for curriculum evaluation strategies (exams) to shift the focus from scores and emphasize strategies that support scientific knowledge development and application. The Kenyan MoEST and special education policy makers need to consider teachers' views as they process the adaptation of scientific curriculum evaluation strategies to meet the learning needs for D/HH learners.

Study results also suggest existence of some teachers with limited communication skills teaching learners who are deaf are HH. This outcome is consistent with the finding by previous studies done in Kenya, (e.g., Adoyo 2009; Kihingi, 2011) that have highlighted a scarcity of trained teachers with required competencies to teach D/HH learners as a major challenge to deaf education in Kenya. Effective teacher communication skills have been recommended as a prerequisite for all beginning teachers (Council for Exceptional Learners, 2003). Also, Kenyan Ministry of Education recognizes and approves the use of KSL as a mode of instruction for D/HH learners (MOE, 2009). Moreover, Adoyo (2009) emphasized the need for teachers to have good communication skills in KSL in order to facilitate learning among D/HH learners. The majority of teachers who participated in this study had training in either special education (with science subject) or in science education. However, results in this study show gaps in teachers' communication skills and knowledge of KSL. Similarly to the outcome of a study conducted in Kenya by Kihingi (2011), the implementation of best practice or strategy has been inconsistent due to the limited number of teachers with required language skills and experience to effectively use teaching practices and strategies in teaching D/HH learners. As reported in the results, under teacher qualification and experiences (see Table 6), many teachers start teaching in schools for learners who are deaf with limited or no experience in deaf education and limited or no skills in a signed language. Thus they will have to spend their time learning on the job at the expense of curriculum delivery.

5.1.2. Retaining experienced teachers. Teachers reported that schools for D/HH learners experience a high staff turnover, which means they regularly lose experienced teachers who are either not replaced or replaced by a new, inexperienced teacher. According to teachers, this trend of replacing teachers who have gained relevant experience in teaching D/HH learners with new inexperienced teachers has further limited the possibilities of having teachers with good signed language skills and science content expertise teaching science to these learners. Therefore, the Kenyan MoEST and special education policy makers urgently need to facilitate the employment of teachers with relevant training in teaching science to D/HH learners and to consider retaining already-experienced teachers in schools for the Deaf.

5.1.3. Equipping teachers with relevant skills. In this study teachers reported that even though an increasing number of deaf students have enrolled in Kenyan secondary schools, minimum efforts have been made to (a) employ trained and certified teachers to work with these learners and (b) to support continuous professional development to equip these teachers with relevant skills pertinent to the learning needs of the students. For example, the absence of KSL certification training has potentially contributed to lack of qualified teachers in schools. According to teachers in this study, some schools have opted to either hire untrained teachers or former students to teach science in attempt to fill the gaps of under staffing. Similar findings were also reported in a study by Kihingi (2011) that highlighted the lack of qualified teachers as one of the contributing factors to poor performance among D/HH learners in Kenya.

Teachers in this study also reported that they required continuous professional development to support their work with D/HH learners. Consistent with this view, Maina et al.

(2011) proposed the need for in-service training to develop teachers' capacity on effective teaching strategies. Therefore, schools administrations should consider engaging the Ministry of Education, and special education policy makers in exploring required professional development options to support teaching D/HH learners. Continuous professional development will constantly equip and update teachers with skills to facilitate scientific content delivery to D/HH learners. For example, there is a need to assess a proposal by teachers to have professionals in deaf education visit schools, observe teaching, and mentor teachers regarding specific areas that require development.

5.1.4. Engaging learners' to increase their science literacy. In this study, even though science teachers agreed on the benefits of active learners' participation in science literacy, they indicated that this strategy/practice is implemented less often. The teachers highlighted a number of issues that prevent the frequent use of active learner participation as a strategy/practice for teaching science to D/HH learners. These issues are class population size, teachers' workload, and poor resourcing such as lack of science labs or ICT facilities, and evaluations that focus on score. Due to large student population sizes of about 28 learners per class/teacher, teachers are unable to give each learner time to actively participate in the learning process. Additionally, teachers observed that to counter the student population, they are currently expected to teach about three classes each with an average of 28 D/HH students from different backgrounds and with diverse learning needs (Adoyo, 2007; Crume et al., 2001; Namukoa, 2012). Moreover this current class population size is in fact more than double the size recommended by KIE (Makokha, 2013). Hence teachers reported finding it hard to differentiate instruction to meet individual learner needs as they deliver scientific curriculum that is also poorly adapted to suit learning needs for D/HH learners.

Teachers pointed out that broad curriculum expectations and poor curriculum evaluation strategies are also barriers to equal learner involvement in learning science. For example, it was observed that teachers tend to spend more time with D/HH learners who perform well while giving less support to those who perform poorly. This occurs because the teachers feel there is not enough time to meet the needs of all of the learners before they sit for the KCSE exams. Hence, they find it better to work with a few learners who are likely to perform better rather than spending time with the whole population. However, this approach where education is driven by tests other that content mastery, contradicts the key recommendations for special education in Kenya as highlighted by the MOE (2009) and by Kochung (2011), and it has been reported to negatively affect the performance of D/HH learners by obstructing active learner participation. Scientific concept mastery is enhanced when learners are fully involved in the learning process (Bransford et al., 2000). Additionally, when teaching science to D/HH learners, there is a critical need for active learner involvement and manipulation of the learning environment to provide the required exposure that would allow both the learning and application of learned abstract concepts (Albertini & Lang, 2001; Roald, 2002). In order to support science literacy among D/HH learners, the government needs to support the establishment of enough learning facilities and personnel to serve the learning needs of the growing population of D/HH learners.

5.1.5. Creating appropriate instructional materials. Respondents ranked the use of visual supports highly among the teaching strategies/practices assessed in this study. This strategy/practice scored high on the often-used practices, the practices teachers are likely to start or continue using, and the practices that they see as beneficial to students. Master teachers in a previous study by Easterbrooks et al. (2006) also ranked visual supports highest according to the same parameters. In the current study, however, the teachers highlighted that most curriculum content was available and accessed in text and there was limited time to allow for the development and use of visual supports in teaching science. Additionally, most schools had limited resources to support the use of visual supports in teaching D/HH learners.

Although the KIE, a major producer of curriculum resources and teaching materials, confirms that most teaching materials are in print form (KIE, 2009), there are no clear guidelines regarding how teachers could integrate visual supports to supplement text and support understanding among D/HH learners (Maina et al., 2011). Due to these conditions, teachers reported that they have been compelled to concentrate on teaching without visual aids. They give written notes to students and continuously encourage students to read these notes as they prepare for the exams even though these D/HH learners likely have low reading abilities. Largely due to delayed exposure to an accessible language and poor language development earlier in their life (Adoyo, 2007; Crume, et al., 2001; Roald, 2002), D/HH learners struggle with reading and thus have difficulties in understanding text (Roald, 2002). As a result, International studies have consistently revealed that teaching strategies that solely focus on the use of text have not yielded positive outcomes among D/HH learners (see review in Kluwin & Stewart, 2001). Moreover, since deaf students are visual learners (Kluwin &Stewart, 2001), scientific concepts remain unclear and abstract when they are solely delivered in print (Roald, 2002). The Kenyan Ministry of Education and the KIE need to work collaboratively with science teachers of D/HH to develop scientific literacy instruction materials that could allow easy adaptation for D/HH learners. Additionally assessment strategies should allow assessment that focuses on concepts rather than faulting the language used by students to explain the same concepts.

5.1.6. Facilitating practical science learning experiences. Participants in this study considered presenting authentic problem scenarios to learners important in teaching science and beneficial to D/HH learners. Consistent with this view, studies have proposed that the integration of strategies that expose learners to real world experience support learning science among D/HH learners (Brown et al., 2002; Kluwin & Stewart, 2001). However, teachers reported that this practice was implemented less often in comparison to how beneficial it was perceived to be. For example, the teachers observed that school field trips, use of a school garden, and laboratory experiments were the most authentic learning options that they used in their teaching. However, according to teachers, the frequent use of these strategies was impeded by the lack of sufficient resources at the schools. To illustrate, small-sized school laboratories with limited equipment often mean that teachers who have a larger student population need to conduct experiments in their classes. Teachers end up starting their classes late and finish early as they prepare for experiments and clean up the class for the next teacher respectively. The time wasted as they prepare and clean up the classroom after the experiment can affects scientific curriculum delivery negatively. Therefore, to facilitate the learning of science through experience, the teachers of D/HH learners urge the government to support schools both financially and with laboratory related resources that would increase learning by experience.

5.1.7. Providing access to ICT. Kenyan Ministry of Education has encouraged teachers to integrate ICT alternatives in their teaching (Nyarangi, 2010). However, the results from the current study indicate that only a few teachers used ICT in teaching science to D/HH learners. Consistent with the report by the MOE (MoEST, 2012), teachers observed that, the curriculum focus on performance of students in exams, limited the use of ICT to diversify learning opportunities for D/HH learners. In the current study, teachers favourably welcomed ICT and appreciated the fact that using it would supplement and diversify teaching and learning experiences. However according to teachers, the biggest concern was that most schools have no access to ICT options such as computers and the internet. Additionally, although some schools have a few computers, the machines are used specifically for administration purposes. In fact, many teachers who have used ICT have had to use their own money to access Internet resources. Considering the importance of ICT in deaf education, it is imperative for the government to consider working with education departments at county levels in investing ICT options that would foster education within respective schools for D/HH learners. Also, the use of ICT needs to be incorporated into professional development so that more teachers will acquire basic knowledge on the use of ICT in curriculum delivery. Curriculum developers also need to avail enough resources online to limit the cost of them and increase accessibility within the education systems.

5.1.8. Developing standardized signed scientific language. Most scientific concepts are abstract and require that teachers have a good knowledge of related vocabularies in a language well understood by D/HH learners (Kluwin & Stewart, 2001). In the current study, it was reported that the teachers mostly finger spelled scientific words, or invented signs with the help of their learners. As observed by the teachers, the invention of signs or the fingerspelling of scientific words increased chances for either misleading learners or making the understanding of the concepts too difficult for D/HH learners. For example, as illustrated in results on content vocabularies, a teacher mentioned the confusion regarding the physics concept of “work done” that was signed DO and DO. Therefore, in this study, the teachers highlighted the need for sign harmonization and the development of standardized signs for scientific words in KSL/sign language. In this view, the MoEST needs to facilitate and encourage special education policy makers and the KIE (as a curriculum content developer) to work collaboratively with teachers and D/HH learners on a comprehensive program that would lead to developing and availing KSL/sign language vocabularies for scientific words and related resources.

5.1.9. Adapting science curriculum and evaluation strategies. D/HH learners are mostly perceived as low performers. Due to this perception, many teachers have been tempted to lower the quality of curriculum content with an expectation of meeting learners' needs (Yore, 2000; Kluwin & Stewart, 2001; Marschark & Spencer, 2010). Nonetheless, D/HH learners need to be helped in developing their critical thinking skills as they go through scientific curriculum (Kluwin & Stewart, 2001). In this study, the teachers mentioned that they break down curriculum content and teach step-by-step to support understanding among D/HH learners. The teachers also mentioned that they avoid teaching complicated content, and instead, focus on equipping learners with specific skills to answer questions from the complicated parts of the curriculum. Similar finding, were revealed in a study by Kelly and Lang (2003), which emphasised that teachers focused on helping learners learn how to answer exam questions instead of on developing the learners' critical problem solving skills. Even though teaching step-by-step is a best practice, the quality of knowledge being taught need not compromise curriculum expectations. Currently, no clear guidelines exist for curriculum or content adaptation to better suit learners' needs (Adoyo, 2009) and D/HH learners receive the same generalised curriculum as their hearing counterparts without differentiating instruction to ensure that the curriculum is actually accessible to these D/HH learners. Moreover, the national exams have not been adapted well enough to consider language accessibility and specific learning need for D/HH learners. Therefore, since D/HH learners are expected, like other learners, to fulfill the Vision 2030 initiative, it is paramount that the Ministry of Education consider ways to make the curriculum accessible and equitable evaluation strategies in order to foster critical thinking skills equally among D/HH learners.

5.1.10. Textbook mediation. According to participants, textbook mediation is among the practices that were used the least by participants in this study. The use of this practice also scored the lowest regarding the likelihood for teachers to start or continue implementing it in future as they teach science to D/HH learners. Once again, issues related to curriculum, teacher's workload, student population size, and evaluation strategies were highlighted as major barriers to frequent textbook mediation. Also highlighted was the influence of low learners 'reading levels and that Kenyan curriculum resources are mostly produced in print form (KIE, 2009) without any adaptations for learners with low reading levels (MoEST, 2003). Ironically in this study it was revealed that, despite poor reading levels of the students, many teachers give written notes to students to copy and read on their own with an expectation that this practice allows them to cover curriculum content along expected timelines. The teachers observed that the learners who had better English than other learners or who had a spoken language background often performed better due to their ability to read independently and understand the language used in the text. Contrary to this view on learners' English language backgrounds, results emerging from studies on reading, writing, and academic achievement (e.g., Adoyo, 2007; Gregory, 1996) have indicated that the deaf children of deaf parents are more successful academically than deaf children with hearing parents because early exposure to an accessible language (e.g., KSL) forms a strong foundation for learning other languages (e.g., English). Therefore, academic achievement could not necessarily be limited to learners' English background, but rather to early exposure to an accessible language. Given the complexity of the scientific concepts to be explained and student's difficulties in reading and understanding the textbook language used to explain these scientific concepts, the role of the teacher in text mediation cannot be underestimated and based on teachers' views, the current situation where text mediation is less implemented would create a critical dilemma in science education for D/HH learners.

5.1.11. Supporting teachers who teach science to D/HH learners. Participants in the current study also reported the need to motivate teachers. It was observed that teachers for D/HH learners have a hard task in bridging the curriculum and facilitating learning. The teachers proposed that school management should consider giving science teachers equal support as given to other teachers (e.g., language and arts teachers get funding for drama and creative arts). For example, science teachers who wish to use school resources for creative and innovative projects need to be supported since such approaches support learning by experience. Also, as highlighted in Chapter 4, giving teachers of D/HH learners use of the school farm or other facilities would support the teachers' efforts to deliver science content to D/HH learners.

5.2. Limitations and Directions for Future Study

Several limitations moderate the effectiveness of this study. First, the scarcity of other studies conducted in Kenya or Africa with a focus on science literacy for D/HH learners was a major challenge in this study. Second, the study was limited to views of science teachers teaching in public schools for D/HH learners. This limitation led to a small sample size. Kenya has various private secondary schools for D/HH learners that offer the same curriculum as public schools. Therefore, future research should consider including all teachers to gain a broader view regarding science literacy for D/HH learners in Kenya. Third, the focus solely on teachers could provide a biased perspective in terms of views and recommendations. This is because this study did not assess or consider views from science D/HH learners in Kenya. Hence, future studies should consider integrating or correlating student views to facilitate and document a more balanced perspective in support of best practices in science education for learners who are deaf/HH in Kenya. Finally, further research can also be sought out to examine possible approaches that could be employed by teachers, special education policy makers, curriculum developers and the MoEST to address the issues and considerations raised by the teachers in this study. This will help to support evaluation and implementation of best teaching strategies and practices in science education for D/HH learners in Kenya.

5.3. Conclusions

In Kenya, although science teachers of D/HH learners do implement the most cited best teaching strategies/practices, implementation appears to be inconsistent with these teaching strategies often being implemented only superficially. Teachers in the current study reported that they struggle through several issues that impede the consistent implementation of these best teaching practices/strategies. The bitter reality is that D/HH learners are still trailing in Group 2 subjects. Consequently, they are placed far from both contributing to and realizing the country's (Kenya) Vision 2030 initiative.

As the government prepares to achieve the Vision 2030 initiative, necessary curriculum adaptation needs to be made through a process that considers and incorporates teachers' views. A need also exists to have personnel with experience in deaf education involved in monitoring and evaluating the special education system in the country. This would involve bringing services down to county levels, using existing structures to assess specific teaching and learning needs, and offering relevant support to teachers as they implement the curriculum. With this approach, ownership and accountability would be appreciated at all levels while education for D/HH learners receives the attention it deserves.

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Appendix: A

Survey for science teachers, teaching D/HH learner in Kenya

This survey is designed for secondary school Science teachers, teaching learners who are deaf in Kenya. The survey is intended to gather teachers' views/opinions regarding teaching practices and strategies used in science literacy instructions for learners who are deaf.

By filling this questionnaire you will be consenting to participate in the study. Thank you for participating in this survey. The information you provide will be invaluable as we continue to improve education for learners who are deaf in Kenya.

Part 1 - Demographic Information

What is your gender?

○ Male

○ Female

What is/are your qualification(s)?.

☐ Diploma (special/ deaf education +Science subject)

☐ Diploma in education science

☐ BEd special education (Science subjects)

☐ BEd Science

☐ Other (Please specify):

Which other trainings have you received?

How many years of teaching experience do you have?

○ 0-2 years

○ 3-5 years

○ 6-9 years

○ 10 -15years

○ 16 +years

○ Other (Please specify):

How many years of experience working as a science teacher for learners who are Deaf or Hard of Hearing do you have?

- 0-2 years
- 3-5 years
- 6-9 years
- 10 -15years
- 16 +years
- Other (Please specify):

Which mode(s) of communication do you mostly use in your interactions with learners who are deaf?

- ASL (American Sign Language)
- KSL (Kenyan Sign Language)
- Signed Exact English (Manual Coded English)
- Spoken English
- Written English
- Combined sign and speech (Simultaneous communication)
- Other Please specify):

How would you classify your skills in using KSL(Kenyan Sign Language) to communicate with learners who are Deaf or Hard of Hearing?

- Beginner
- Intermediate
- Advanced
- Other (Please specify):

What science subject(s) area do you teach? (please select all that apply).

- [ ] Biology
- [ ] Chemistry
- [ ] Physics
- [ ] Other (please specify):

Which mode of communication do you use in teaching your subject area?

- ○ ASL (American Sign Language)
- ○ KSL (Kenyan Sign Language)
- ○ Signed Exact English (Manual Coded English)
- ○ Spoken English
- ○ Written English
- ○ Combined sign and speech
- ○ Other Please specify):

How would you describe your skills in using KSL to teach your subject (s) area to learners who are Deaf or Hard of Hearing?

- ○ Excellent
- ○ Good
- ○ Satisfactory
- ○ Fair
- ○ Not sure
- ○ Other (please specify):

Which class do you teach?(please select all that apply).

- [ ] Form 1
- [ ] Form 2
- [ ] Form 3
- [ ] Form 4

What is your class population size? (if you teach more than one class please mention the class and number or students)

Please select the statement that best describe your VIEW(s) on content delivery in your subject area: How often do you feel that;

	Never	Occasi onally	Fairly Many Times	Very Often	Always
I prefer using KSL to teach my subject (eg., Biology, chemistry or Physics).					
I feel that subject content(s)(Biology, Chemistry or physics) have been understood by the learners at the end of my lesson.					
I feel that subject contents have been well delivered, by the end of the specified time.					
My teaching resources (aids) helped to meet the learning objectives for my lessons.					

Part 2- This section contains questions about teaching strategies, benefits of each teaching strategies to D/HH learner and the liklihood to continue using the strategies.

1. Considering your experience and practices in teaching science subject (s) to learners who are deaf:

a) To what extent do you agree with the following statements?

	Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**Not sure**
My communication skill helps to facilitate learning in my class						
My subject contents(e.g. Biology, Chemistry or Physics) are well understood when delivered in KSL (learner's primary language)						
Use of KSL to teach my subject may lead to poor performance among my students.						
knowledge of my subject area content is important in facilitating learning in my class						
Learner participation in class helps to facilitate understanding						
Using visual organizers or other visual teaching resources (eg. charts, concept maps or models) facilitates content delivery						
Conducting frequent experiments and other laboratory exercises in my subject helps learners to understand the subject contents.						
Use of technology (eg ICT) in teaching my subject helps to facilitate content delivery and understanding						
My knowledge of content vocabularies (in Kenyan Sign Language) supports content delivery and understanding						
Allowing the learner to argue for or against ideas in my class supports both content delivery and critical thinking among learners						

Language used in explaining scientific concepts in textbooks impedes conceptual understanding among learners in my class						
Lots of content vocabularies in my subject area does not have equivalent signs						
I need continuous professional development, experiences and/or certification in content area knowledge						

b) Please feel free to provide any other comment, view or observations in the space below.

2. As a science teacher for learners who are deaf:

a) Which teaching strategies and practices do you use? (Please select all that apply).

☐ Skillful communication using KSL, Spoken language, English based systems or other languages and modes used by students

☐ Explaining science concepts using the students first language before competencies are assessed in English

☐ Use of hands-on activities and materials

☐ Use of visual organizers such as 'graphs, charts or visual maps.

☐ Teach science concepts by incorporating a collaborative, case-based, problem-solving approach to real-world problems

☐ Allowing sufficient discussion time.

☐ Use technology such as CDs, captioned materials, and interest-based internet sites

☐ Teach science using 'specialized content vocabulary" either by signs or fingerspelling.

☐ Pre-teach the vocabulary and agree on signs for specialized content.

☐ Teach Step by step strategies for problem solving

☐ Teach step by step conceptual processes that require higher-order critical thinking and problem-solving skills.

☐ Provide scaffolding between the students' reading levels and the language demands.

b) Please list any other teaching strategies/practices that you use, or comment on those listed in 2 a).

c) **What professional development option(that relates to your subject area) do you have access to?**

- ☐ Seminars planned by association for science teacher
- ☐ Science teachers mentorship programs
- ☐ Exchange programes with teachers from other schools schools
- ☐ Distance learning courses offered by Kenya Institute of Special Education (KISE) or any university

d) **Others please? (specify)**

e) **What examples of technology options do you use in teaching your subject to learners who are deaf?**

3. Considering your experience and practices in teaching science subject (s) to D/HH learner:

a) On a scale of 1-5, how often do you use the following teaching strategies/practices? (1 being never use the practice and 5 being always use the practice)

	1 (Never use the Practice)	2	3	4	5 (Always use the practice)
Skilfully communicating using KSL, Spoken language, English based systems or other languages and modes used by students					
Explaining science concepts using the students first language before competencies are assessed in English					
Use of hands-on activities and materials					
Use of visual organizers such as 'graphs, charts or visual maps.					
Teach science concepts by incorporating a collaborative, case-based, problem-solving approach to real-world problems					
Allowing sufficient discussion time.					
Use technology such as CDs, captioned materials, and interest-based internet sites					
Teach science using 'specialized content vocabulary" either by signs or fingerspelling.					
Pre-teach the vocabulary and agree on signs for specialized content.					
Teach Step by step strategies for problem solving					
Teach step by step conceptual processes that require higher-order critical thinking and problem-solving skills.					
Provide scaffolding between the students' reading levels and the language demands.					
Receiving content relevant professional/ capacity development(to support teaching)					

b) Others comments (Please specify)

c) Please rate the following in terms of "how beneficial you think they are," in supporting learning and performance? On a scale of 1 to 5 (1- not beneficial and 5 very beneficial)

	1 (Not beneficial)	**2**	**3**	**4**	**5 (Very beneficial)**
Skilfully communicating using KSL, Spoken language, English based systems or other languages and modes used by students					
Explaining science concepts using the students first language before competencies are assessed in English					
Use of hands-on activities and materials					
Use of visual organizers such as 'graphs, charts or visual maps.					
Teach science concepts by incorporating a collaborative, case-based, problem-solving approach to real-world problems					
Allowing sufficient discussion time.					
Use technology such as CDs, captioned materials, and interest-based internet sites					
Teach science using 'specialized content vocabulary" either by signs or fingerspelling.					
Pre-teach the vocabulary and agree on signs for specialized content.					
Teach Step by step strategies for problem solving					
Teach step by step conceptual processes that require higher-order critical thinking and problem-solving skills.					
Provide scaffolding between the students' reading levels and the language demands.					
Receiving content relevant professional/ capacity development(to support teaching)					

d) What are other teaching practices/strategies (that you use) in science education that you think they are most beneficial to your students?

4. From your experience in teaching science:

a) On a scale of 1 to 5 (1- not at al and 5 very likely). How likely are you to start/continue using the following practices in teaching your science subjects to D/HH learner?

	1 (Not at all)	2	3	4	5(Very Likely)
Skilfully communicating using KSL, Spoken language, English based systems or other languages and modes used by students					
Explaining science concepts using the students first language before competencies are assessed in English					
Use of hands-on activities and materials					
Use of visual organizers such as 'graphs, charts or visual maps.					
Teach science concepts by incorporating a collaborative, case-based, problem-solving approach to real-world problems					
Allowing sufficient discussion time.					
Use technology such as CDs, captioned materials, and interest-based internet sites					
Teach science using 'specialized content vocabulary" either by signs or fingerspelling.					
Pre-teach the vocabulary and agree on signs for specialized content.					
Teach Step by step strategies for problem solving					
Teach step by step conceptual processes that require higher-order critical thinking and problem-solving skills.					
Provide scaffolding between the students' reading levels and the language demands.					
Receiving content relevant professional/ capacity development(to support teaching)					

b) What would motivate you or make it more possible (if any) for you to start or continue implementing the above 10 practices

c) Any other comment?

Thank You!

Appendix: B

Focus group discussion Interview question for science teachers for learners who are deaf and hard of hearing in Kenya

1) a) Think about moments when your students performed well in their science exams or understood the topic that you were teaching, please share examples of this good performance?

b. What do you think contributed to this performance/success described in 1a?

d) In your opinion, what would it take for you to have your students perform well in science subjects

2) Please feel free to add any other comment,

Thank you for taking our survey. Your response is very important to us.

Apendix: C

Consent and research permit

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telephone: 254-020-2213471, 2241349, 254-020-2673550
Mobile: 0713 788 787 , 0735 404 245
Fax: 254-020-2213215
When replying please quote
secretary@ncst.go.ke

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: **NCST/RCD/14/013/977**

Date: **10th June, 2013**

Abraham Wafula Namukoa
University of Alberta
CANADA.

RE: RESEARCH AUTHORIZATION

Following your application dated ***31st May, 2013*** for authority to carry out research on "***Teacher Practices in Science Literacy Instruction for Learners who are Deaf or Hard of Hearing,***" I am pleased to inform you that you have been authorized to undertake research in **selected Counties** for a period ending **31st December, *2013.***

You are advised to report to **the County Commissioners and the County Directors of Education, Selected Counties** before embarking on the research project.

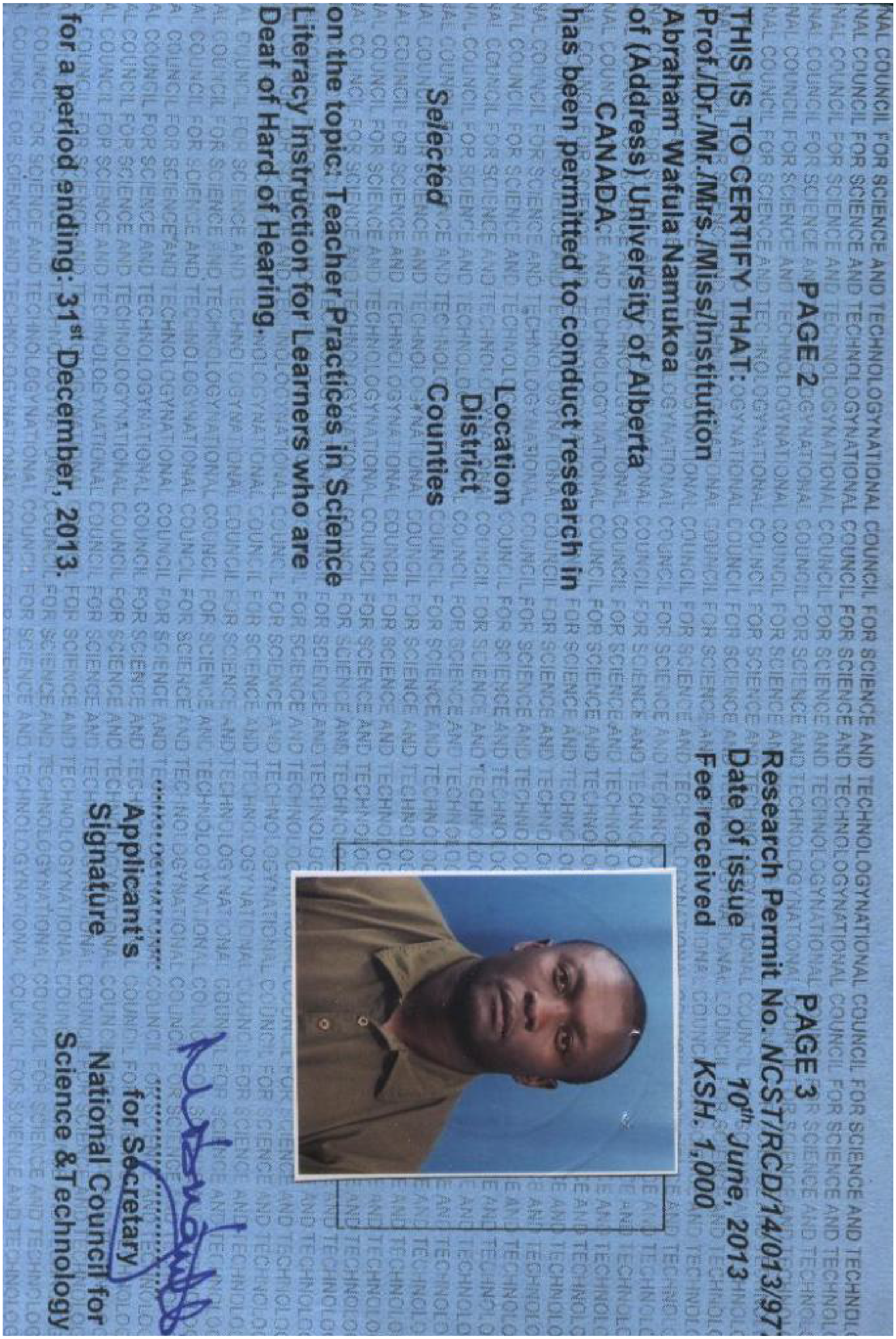
On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. M. K. RUGUTT, PhD, HSC.
DEPUTY COUNCIL SECRETARY

Copy to:

The County Commissioners
The County Directors of Education
Selected Counties.

"The National Council for Science and Technology is Committed to the Promotion of Science and Technology for National Development".



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THIS IS TO CERTIFY THAT:
Prof./Dr./Mr./Mrs./Miss/Institution
Abraham Wafula Namukoa
of (Address) University of Alberta
CANADA.
has been permitted to conduct research in
Location
District
Selected Counties

on the topic: Teacher Practices in Science Literacy Instruction for Learners who are Deaf of Hard of Hearing.

for a period ending: 31st December, 2013.

PAGE 3

Research Permit No. NCST/RCD/14/013/97
Date of issue 10th June, 2013
Fee received KSH. 1,000

Applicant's Signature

for Secretary
National Council for
Science &Technology

Appendix: D

Information letter for Secondary Science teachers in Kenya.

Project Tittle: Science Literacy Instruction for Learners Who are Deaf
Investigators: Abraham Wafula Namukoa, Graduate Student, Education Psychology
University of Alberta, Canada
Lynn McQuarrie, Associate Professor, University of Alberta

About the study

Kenyan Vision 2030 initiative, aims at improving the quality of life for all citizens. The initiative intents to utilize individual's, scientific knowledge in management and in solving the community's challenges regarding economic development. Even though the Kenyan secondary school curriculum is prepared to accomplish this initiative, learners who are deaf perform poorly in required science subjects (group 2 subjects) on their Kenya Certificate of Secondary School Examination (KCSE).

My research project, *Science Literacy Instruction for Learners Who are Deaf,* will collect teachers' views on teaching practices and strategies in science education. I will investigate teachers' view on practices and strategies that are currently being used and there impacts on science education for secondary school learners who are deaf. Also, I will collect teachers' views and recommendations that need to be considered to support scientific literacy for learners who are deaf.

I am a graduate student in Education Psychology (Special Education) at the University of Alberta. This project has been reviewed and approved by the University of Alberta's Research Ethics Board (REB).

Procedures

I am inviting you to participate in this study. The knowledge, views/opinions that you will share regarding teaching practices and strategies used in science literacy instructions for learners who are deaf will provide much insight and will have potential to better inform researchers, policy makers and teachers in the field of deaf education.

Your involvement in this study includes completing an online survey questionnaire about science literacy practices and, if possible, participation in a focus group interview that I will be conducting in your respective school. All focus group interviews will be video recorded for the purpose of data analysis. I would like to inform you that participation in this research is voluntarily.

Confidentiality

- Your privacy will be respected. All results will be kept confidential.
- Your participation is voluntarily and you can decide to stop at any time without consequence.
- No names will be used in the data or any published work resulting from this study. All data will be assigned either numerical value or thematic codes, and only this value or codes will appear in the computer files.
- By filling the questionnaire or participating in focus group interview, you will be consenting to participate in the study.
- You are not obligated to answer any question you find objectionable or that makes you

uncomfortable.

- Results from this study will be used for research thesis, scientific publication and presentation to professionals and educators.
- You can obtain documentation resulting from this study by contacting Abraham W Namukoa.

Risk and Benefit:

- There are no risks or discomfort involved with this study
- The result from this study will be beneficial to you and other future science teachers for secondary school learners who are deaf.
- There is no cost to you

Freedom to Withdraw

If you decline to continue or you wish to withdraw from the study, your information will be removed from the study upon your request.

Further information

If you have any further questions regarding this study please contact.

Abraham W Namukoa
Email: namukoa@ualberta.ca
Phone: 7802006614

Dr. Lynn McQuarrie (Supervisor)
Associate Professor, Educational Psychology
University of Alberta
Telephone: 780 492-1146
Email: lynn.mcquarrie@ualberta.ca

For any questions regarding participant rights, or concerns regarding how this study is being conducted, please contact the University of Alberta's Research Ethics Office at 780-492-2615. This office has no affiliation with the study investigators.