THE EFFICACY OF CO-TEACHING GRADE 9 SCIENCE LEARNERS AT AN INTERNATIONAL SCHOOL IN NAIROBI: A CASE STUDY

by

LINDA HENDERSON

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SUPERVISOR: PROF J G FERREIRA

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Student number: 43115284

I declare that '**The efficacy of co-teaching grade 9 science learners at an international school in Nairobi: A case study'** is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

Linda Sharon Henderson 22 November 2011

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Summary

A case study using a phenomenological approach was carried out to determine how effective and enduring learning is for two diverse groups of grade 9 natural science learners when delivered through a collaborative co-teaching approach involving a high school science teacher and a special needs teacher.

Even though the findings of this research indicate that the co-taught sessions did not significantly affect the learners' test results, the majority of the learners reported very positive perceptions of co-teaching. From the findings the main benefits for the learners included an improvement in their understanding of learning styles and associated study skills, increased contact time with the teachers, and the benefit of another teacher's expertise in the classroom. The researcher found the co-teaching approach yielded a clearer focus on the individual learning styles, new strategies for differentiation, and a positive teaching experience.

Key Terms:

Differentiation; Collaboration; Inclusion; Co-teaching; Special needs teacher; Case study; Grade 9 natural science learners; Academic performance.

Dedication

I dedicate this dissertation to my husband Stewart, my sons Michael and Craig, and my parents. I am so blessed to have such an amazing family who love unconditionally and have always encouraged and supported me.

Table of Contents

Chapter 1
Orientation

1.1 Introduction

Teachers at the International School of Kenya (ISK) in Nairobi face the challenge of educating a diverse learner population, and do not always feel equipped to handle all the learner needs in the classroom. The research question guiding this study investigates whether a specific model of teacher collaboration, namely co-teaching, could contribute to academic achievement of learners in a grade 9 natural science class at the ISK in Nairobi.

After World War II, the United States of America established a number of international schools in order to educate their nationals in overseas locations. The children at these schools were mostly from diplomatic, aid development and international business community families. English has been the medium of instruction in these schools and either an American or British curriculum has been followed. While the learners were expected to have a reasonable proficiency in English, most schools did not offer any specific support for children with learning difficulties (Powell & Kusuma-Powell 2007b:14).

However, with increased mobility of non-English speaking parents and their children around the world, international schools adapted by developing “English as a second Language” (ESL) programs to support these learners. In addition, changes in public statutes, such as US Public Law 94-142, guaranteeing an education for children with special learning needs, encouraged parents to expect some form of educational support in international schools (Powell & Kusuma-Powell 2007b:15).

Knowledge in the fields of neuroscience, cognitive psychology, evolutionary biology, curriculum design and learning theory, among other disciplines, have all contributed to re-shaping our view of education, and educators had to rethink the conditions under which children learn most effectively (Powell & Kusuma-Powell 2007b:15). Each

classroom presents remarkable diversity and teachers are required to understand and appreciate the considerable learning differences that enable learners to construct and retain knowledge, and to match the learning preferences of the individual learners with the appropriate instructional strategies (Powell & Kusuma-Powell 2007b:16).

No single instructional strategy has the monopoly on being successful for all the learners in a diverse class, however, it is important to identify those strategies that are effective in improving learner achievement. The instructional strategy that will be examined in this research is that of co-teaching, involving collaboration between a high school science teacher and a special needs teacher at the ISK.

1.2 International School of Kenya

The ISK was established in 1976 under the co-sponsorship of the Canadian High Commission and the United States Embassy. The school, initially known as the Nairobi International School, had pre-existed that date by a few years, but was purchased from its original owner, the United States International University, in 1976. The ISK has been located on the same campus on the outskirts of Nairobi since its establishment.

The hierarchy of the school's governance is as follows: A seven-member Board of Governors of diplomats from both the Canadian High Commission and the United States Embassy is responsible for the school's development. A nine member Board of Directors oversees the running of the school. Six of these board members are ISK parents who are elected at an Annual General Meeting, and the American Ambassador and the Canadian High Commissioner appoint the remaining three members. The Board of Directors delegates the day-to-day management of the school to the school's administration (http://www.isk.ac.ke/).

Nairobi is the African headquarters for the United Nations and as a result there are one hundred and six embassies represented in the capital of Kenya. Learners who attend the ISK come from families of United Nations experts, diplomatic personnel, international business people, residents, missionaries and educators. The school therefore has a diverse community with many different nationalities represented in a

learner body of over seven hundred, with English as the medium of instruction (http://www.isk.ac.ke/).

The school is divided into three sections – the elementary school (Kindergarten to Grade 5), the middle school (Grade 6 to Grade 8) and the high school (Grade 9 to Grade 12). Each division has a principal and counsellors, and there is a Director who oversees the entire school. The high school offers both the International Baccalaureate Diploma and the North American High School Diploma, with learners being prepared for colleges and universities world-wide.

The ISK provides a range of educational opportunities, including appropriate and learner-centred instruction for learners in Kindergarten through grade 12 with mild learning disabilities or learning needs (International School of Kenya, s.a). The school therefore welcomes learners from many backgrounds and in order to provide for learners with mild learning difficulties and learners who are not yet fluent in English, the Student Support Services (SSS) department at the school includes the following services:

- Learning Resource Centre (LRC): This centre offers individualised small-group instruction for learners with identified mild learning needs in reading, writing, mathematics and / or study skills. At least once a year current learners and new referrals are discussed at meetings involving the learner, their parents, their teachers, a school counsellor and the special needs teacher. A learner profile documenting the learner's needs is used to help create an 'individual education program' (IEP) which is a plan of how to support the learning profile and considers the learner's strengths, needs, classroom accommodations and program recommendations.
- English as a Second Language or English for Speakers of other Languages (ESL): This small group instruction assists limited English-speaking learners to help them move successfully into the regular academic program. The English language learners who are at the earlier levels of proficiency - Beginning, Early Intermediate, and Intermediate - are typically placed in one class of ESL comprising learners with similar proficiency levels. The remainder of their day is spent in regular classrooms.

In 2008 the school completed a self-study exercise during the process of accreditation with the Council of International Schools (CIS). As part of the process the school revised their mission statement. The new mission statement of the school states that "...the school prepares learners within a culturally diverse community to become informed, independent thinkers and responsible world citizens" (International School of Kenya, s.a).

The school's philosophy is stated as follows (International School of Kenya, s.a):

- The ISK is a community in which all the teachers, learners, parents, and staff, are teachers and learners.
- The best education is achieved in a caring, learner-centred environment.
- The ISK provides for the realisation of each learner's potential for intellectual, personal and social development, and responsible contribution to our diverse global environment.
- The ISK nurtures learners in critical inquiry, creative expression, ethical behaviour, and cooperative social interaction.
- The acquisition of knowledge, the development of skills, striving for excellence in all endeavours and maintaining a sense of respect for self and others are essential components of an ISK education.
- The ISK develops a sense of responsibility and respect for the environment.
- The ISK values tolerance, appreciation, and respect for human differences among all members of the ISK community.

The major features of the philosophy statements of the school include a view of the school as a 'community of learners' and stress the importance of teaching responsibility and respect for the community and the environment, and the appreciation of human diversity.

1.2.1 Benefits and challenges of heterogeneous classrooms

The benefit of interacting in such a cross-cultural mix of learners, such as those found at the ISK, is that it enables learners to develop an understanding of human differences that will last for a lifetime. By interacting with people from different cultures, learners have a greater understanding of these cultures and hopefully this

knowledge will translate into tolerance of any differences as well as finding commonalities that all cultures share. According to Rothenberg and Fisher (2007:239), diverse learners working together reflect the world outside the classroom and provide a richness of experience for the learners. This diversity, for the most part, strengthens classrooms, schools, and communities (Rothenberg & Fisher 2007:238).

As a teacher, the greatest challenge is accommodating the learner's needs in the classroom. Some learners are newcomers to the English language. Other learners have special learning needs, learning disabilities, attention deficit disorders or special gifts and talents. Sapon-Shevin (2001:35) believes that we must stop talking about diversity as being a problem, but rather consider the differences in the learner body as ways to enrich teaching and learning.

Accrediting agencies, such as the Council of International Schools (CIS) require international schools to deal with the broader range of learner needs. Teachers at the ISK are aware of this and try to implement the curriculum through a range of approaches and teaching strategies that recognise the diverse learning styles and backgrounds of the learners. Teachers vary methods according to the nature of the subject matter, create stimulating learning environments to engage the learners, address individual learner needs and styles, and provide methods that appropriately address learners for whom English is not a first language. It is recognised that the implementation of these methods varies from teacher to teacher. The school has placed emphasis on differentiated instruction for the past three years and there is ESL and LRC support in all three divisions of the school.

As a result of the accreditation self-study, the ISK is committed to have its educational programs, structures and standards in place by 2014 to fulfil the school's mission for *all* the learners. In order to achieve this, all teachers will be required to differentiate instruction for diverse learners, plan collaboratively and use assessment data to drive instruction.

1.2.2 Differentiation

Tomlinson (2003:7) writes about the paradigm shift when a teacher accepts the

challenge of teaching all, not some or even most, but all of the learners in the class. So how do teachers design learning environments and learning activities that ensure that each child in the class is an active participant in the learning process? (Carpenter & Ashdown 2001:2).

In 2008, the ISK hosted a teacher-training workshop on differentiation presented by Powell and Kusuma-Powell, who state that differentiation is about recognising the learners' varying background knowledge, readiness, interests, language and preferences for learning and teachers purposefully plan, implement and assess around these differences (Powell & Kusuma-Powell 2007b:12). They also identified seven principles that they believe are at the core of differentiated instruction (Powell & Kusuma-Powell 2007a:7):

1. All children can, do and will learn not always what and when we would like. The challenge for the teacher is how to guide the naturally occurring learning progress into constructive and positive experiences. By teaching in a variety of ways teachers can provide greater access to the curriculum and deepen learners' understanding and retention of concepts (Powell & Kusuma-Powell 2007b:20).

2. Diversity enriches. This 'diversity' does not refer to the cultural, ethnic and linguistic variety in classrooms, but refers to the 'learning diversity' of the individual learners. The children in a classroom differ significantly as learners, and teachers need to understand, respect and utilise these differences. Teachers who are responsive to a range of learning styles and preferences meet the educational needs of more children, than teachers who either teach exclusively to their own learning style or teach the way they were taught at school (Powell & Kusuma-Powell 2007b:21).

3. Children learn most enthusiastically and most efficiently when they are encouraged to use their strengths. Powell and Kusuma-Powell (2007b:23-24) suggest that teachers need to provide learners with the opportunity to show what they have learnt through their individual talents and strengths, and teaching to learners' strengths makes learning success transferable.

4. Effective teachers can teach most children. The traditional approach to teach children who learn differently is to prescribe a number of hours per week in some specialised setting outside the regular classroom where the child receives help from a special education specialist. However, by removing children who learn differently from their classrooms, Powell and Kusuma-Powell (2007b:24) suggest that teachers are being told that education of these children is not the class teacher's responsibility and that they do not have the required skills or knowledge to teach the children with special needs. They are of the opinion that all learners can benefit from good teaching. Ripley (2010:62-63) notes that effective teaching has a great impact on learner achievement and great teachers tended to set big goals for all their learners and constantly re-evaluate what they were doing.

5. The teacher is the most important architect of a child's learning environment. Learning takes place in a social context and the teachers are the prime architects of the social context of the classroom, so the relationship between the teacher and the child is an essential feature of the learning environment (Powell & Kusuma-Powell 2007b:25).

6. Strategies that define and comprise good teaching are applicable to all children. Differentiation makes good teaching more accessible to a larger learner population. There is no formula for good teaching but there are certain principles that we know about teaching and learning. For example, most children find whole to part learning more accessible than part to whole instruction, and learners learn more effectively when they are active participants in their learning (Powell & Kusuma-Powell 2007b:27).

7. A professional partnership is exponentially more effective than the sum of its parts. Teachers usually plan lessons on their own, teach in isolation and access learning without any support or assistance from colleagues. Powell and Kusuma-Powell (2007b:28) believe that this is one of the greatest barriers to learning and teacher professional growth, and that the most effective support a

teacher can get is from professional colleagues through common planning, co-teaching and collaborative assessment of the learner's work.

The teacher is faced with many challenges in a heterogeneous classroom, and these seven principles suggested by Powell and Kusuma-Powell are designed to help teachers on their journey towards achieving differentiated instruction. Kimmelman (1998:53) believes that the quality of teaching is often the single most important factor in the success of learner achievement, and that research on teaching methods that enhance learner achievement should therefore be examined and shared with those who work in the classroom. Tomlinson and McTighe (2006:184) examined research advocating differentiated instruction. While they acknowledge that the results are encouraging, they advise that more studies are needed to determine which elements of differentiation do or do not benefit particular learners. They believe each school and each teacher has not only the capacity but also the responsibility to apply particular models of teaching and to study the results of such implementation on their own learners (Tomlinson & McTighe 2006:184).

1.3 Background to the research question

It is the seventh principle identified by Powell and Kusuma-Powell regarding the effectiveness of a professional partnership, which is the rationale for this research. The professional partnership will involve collaboration between a high school science teacher and a special needs teacher in a heterogeneous grade 9 natural science class. These teachers have different areas of expertise and their diverse skills should help to ensure that the lessons are appropriately differentiated.

In 2007 the administration of the ISK committed the school to follow a more inclusive policy whereby learners with learning difficulties are supported within the classroom, and the mainstream teacher and the special needs teacher plan lessons together, co-teach and assess the learner's work. As in most schools, the ISK experiences shortages of specialist personnel, and the high school have yet to fully adopt this inclusive approach. To date, the mathematics and English departments at the ISK are the only two departments that have worked with special needs teachers in some of their lessons, but their experiences of the effectiveness of the co-teaching

model are vague and purely anecdotal. Many teachers question if the co-teaching model is the most efficient use of the special needs teacher's expertise.

Since there are limits to the number of special needs teachers available to be used in a co-teaching model, organising a special needs teacher to help in the planning, teaching and assessment of learners in a natural science class required considerable planning and approval from the administrators. The grade 9 natural science class chosen for the first trial in this research contained eighteen diverse learners; two were limited English speakers who attended ESL classes, three had 'individual education programs' (IEPs) and were supported by the Learning Resource Centre, and two learners were identified by teachers as having 'learning difficulties' but parent permission was not obtained for further testing with an educational psychologist. The grade 9 natural science class chosen for the second trial in this research had twenty two learners, two of whom had IEPs and were supported by the Learning Resource Centre.

The head of the special needs department, who works in the middle school, agreed to collaborate with this researcher in the first half of 2009 for the first trial, and again in 2010 with the second trial as regards the planning of some grade 9 natural science lessons, the delivery of the instruction and the evaluation of learning. Grade 9 is the first year of the high school and the average age of the learners is fourteen. The natural science program is an integrated approach comprising of four disciplines: biological science, earth science, chemistry and physics. The earth science component was chosen for the research because it is taught in the middle of the year allowing teacher-learner relationships to be well established.

The literature describes the components necessary for successful teacher collaboration, but fails to demonstrate a strong relationship between a specific method of collaboration and learner achievement, or the impact of collaborative efforts on teachers and their instruction. The method of collaboration that will be examined in this research is co-teaching where both the science teacher and the special needs teacher share teaching responsibility.

1.3.1 Research question

The following question will therefore be examined in this research:
How effective and enduring is the learning for a diverse group of grade 9 science learners when delivered through a collaborative co-teaching approach involving a high school science teacher and a special needs teacher?

1.4 Research design

Both qualitative and quantitative research methods were employed in this research in an attempt to investigate the efficacy of a teaching model for all the learners in a grade 9 natural science class. According to Robson (2002:370) the major advantage of using more than one method in an investigation is “the reduction of inappropriate certainty” and can improve the interpretation of the data. Whereas the major disadvantage of combining qualitative and quantitative methods is the possibility that the different methods produce conflicting results (Robson 2002:373).

According to Edwards and Talbot (1999:186) qualitative research methods can be defined as “those which attempt to pick up and convey the ways that the participants in the events under scrutiny make sense to them, and they serve the important function of allowing the voices of participants to be heard when the research is disseminated”. In qualitative research the researcher is the main data collector and the researcher’s role is to establish a relationship with the participants to get their opinions and views. The learners in both experimental groups were interviewed on a one-to-one basis. In contrast, quantitative researchers “collect facts and study the relationships of one set of facts to another, and use techniques that produce quantified and generalizable conclusions” (Bell 1999:7). Quantitative analysis therefore involves the treatment of numerical data and the application of statistical tests (Edwards & Talbot 1999:187). In order to examine if the co-teaching approach had an impact on the learner’s test results, a t-test was used to examine whether the test results differed significantly from one another.

The research design used in this project is of a phenomenological approach. Robson (2002:550) defines phenomenology as “a theoretical perspective advocating the study

of direct experience taken at face value". Phenomenology attempts to understand the meaning of a lived experience. In this research the experience of the learners in a science class without collaboration or support of a special needs teacher and then with the collaboration of a special needs teacher, is sought. The core of phenomenological research is the attempt to understand a particular experience and Robson (2002:196) warns that there are considerable barriers in the way a novice researcher uses this approach. Nevertheless, it is an approach that has been useful in answering research questions about subjective experiences.

In this research the focus is a case study. A case study is suitable for this investigation since it focuses on an in-depth investigation in a real life situation. Robson (2002:545) defines a case study as "a research strategy focusing on the study of single cases. The case can be an individual person, an institution, a situation, etc." The distinguishing feature of case study research is that it concentrates solely upon a specific case in its context (Grosvenor & Rose 2001b:72). Case studies therefore examine a bounded system or a case in detail over time and employ multiple data sources. A case study using a phenomenological approach is appropriate for this research since it focuses on grade 9 natural science learners with a range of educational needs. In other words, there is maximum variation from 'information rich participants' where one aspect of a problem is studied in some depth within a limited time scale (Bell 1999:10).

According to Bell (1999:11) a major advantage of a case study is that it "allows the researcher to concentrate on a specific example or situation and to identify the various interactive processes at work which may remain hidden in a large-scale survey but may be vital to the success or failure of systems or organisations". The advantages of case study research according to Edwards and Talbot (1999:56) are as follows:

- It allows in-depth focus on shifting relationships,
- It captures complexities,
- It allows a focus on the local understandings of participants and affords an opportunity for the voices of the participants to be heard,
- It provides readable data that brings research to life and is true to the concerns and meanings under investigation.

The case study research is appropriate to this study as it involves interviewing the learners in the grade 9 natural science classes in an attempt to understand their perceptions of the two teaching approaches. The learner's grades for both short term and long-term learning (four months later) were also analysed. Combined, this information should provide evidence to determine if a collaborative co-teaching approach, involving a special needs teacher and a high school science teacher, meets the educational needs of all the learners.

However Edwards and Talbot (1999:57) also raise the disadvantages of case study research:

- It can be an unwarranted intrusion into the lives of others,
- It is situation and time bound,
- It requires carefully collected, high-quality data,
- Appropriate data collection takes time,
- The researcher can become so immersed in the case that data analysis becomes difficult.

These disadvantages need to be negated as much as possible while conducting the research. In order to remove potential researcher bias, another teacher conducted the interviews and encouraged the learners to be as honest as possible. All the interviews were audio taped and recorded for data analysis.

This research also incorporates action research. Action research often starts with case studies (Edwards & Talbot 1999:33). Action research is not a method or technique but an approach to research that is directed at problem solving (Bell 1999:10). Action research has been extensively discussed in the literature, and it works in any context where "specific knowledge is required for a specific problem in a specific situation or when a new approach is to be grafted on to an existing system" (Bell 1999:10). Edwards and Talbot (1999:63) stress that action research demands systematic monitoring of the action being taken, for example, observable changes, personal feelings and measurable outcomes. In this research both objective and subjective data (quantitative and qualitative) was recorded; the learner's grades for short term and long-term understanding (after four months), and their views regarding the two

teaching strategies. Edwards and Talbot (1999:67) differentiate action researchers from other researchers through their centrality to the research, pointing out that objectivity is less of an issue, and the researcher's perceptions are important in the evaluation process.

Action research gives one the opportunity to try out an intervention, assess how it is received or how effective it is, and adjust and introduce the proposed changes. This cycle of action can be continuous and repeated until the desired result is achieved. In this research, the efficacy of the co-teaching approach involving a high school science teacher and a special needs teacher was evaluated for one class of eighteen grade 9 learners in a natural science class in 2009. After the research, the process was assessed and the knowledge gained from the experience was used again to evaluate the efficacy of the co-teaching approach using the same high school science teacher and special needs teacher for another class of twenty two grade 9 learners in a natural science class in 2010.

Critics of action research are concerned that there is a lack of scientific rigor and the action researcher has little control over variables and can therefore not expect to achieve results that are easily generalised. However, supporters suggest action research can focus on a specific situation and is able to examine the atypical and unrepresentative events (Rose & Grosvenor 2001a:15). As this research is a study into the efficacy of a collaborative co-teaching approach for grade 9 natural science learners at the ISK in Nairobi, it is unlikely to provide information that can be generalised beyond this school. However, Bassey (cited in Grosvener & Rose 2001b:72) propose that some form of "fuzzy generalisation" might be possible from such a study that may encourage further research in other institutions. Even though research might be small in scale and conducted in one school, Grosvenor and Rose (2001b:72) remind us that if research provides important information that confirms beliefs, identifies issues or may result in improved performances within the school, this is justification for doing the research.

1.5 Aims of the research

The three main aims of the research are:

1. To identify the methods of instruction and assessment to be used in those lessons taught in a grade 9 natural science class without collaboration or support of a special needs teacher, and in the lessons where there is collaborative co-teaching with a special needs teacher.

2. To determine the views of the learners by asking them open-ended questions about four main themes:

- Are the lessons differentiated for the learners' individual needs?
- What study skills do the learners use?
- Do learners have an understanding of their individual learning styles and do they recognise different learning styles?
- What is the effect of having another teacher in the classroom?

3. To determine the effectiveness of learning without collaboration or support of a special needs teacher, and then with the collaboration of a special needs teacher by analysing the learner grades for short and long-term understanding (after four months) of the concepts.

Five lessons on 'Soil formation' were planned and taught by the researcher, who is a high school science teacher. The special needs teacher was not present and had no influence on the planning stage, instruction or assessment phase of the lessons. This was followed by six lessons on 'Soil productivity and nutrient content', which were planned, co-taught and assessed with the special needs teacher. After each set of lessons, the learners wrote a test to demonstrate their understanding. Four months later, the learners wrote a multiple choice test on both of these topics and these grades were then compared with their previous grades to determine if the collaborative teaching strategies had influenced their ability to effectively recall information.

1.6 Outline of the dissertation

Chapter One provides an overview of the challenges facing the teachers at the International School of Kenya in Nairobi, the call for a more differentiated and inclusive approach in teaching, the purpose of the proposed research, the research question, the research design and research aims.

Chapter Two provides a review of the relevant academic literature on differentiation, collaboration, inclusion and co-teaching, and explains how these teaching strategies inform the project.

Chapter Three provides an overview of the methodology of the study and a critique of the research design.

Chapter Four includes the findings, and discussion of these findings.

Chapter Five includes the critique and summary of the research findings, as well as limitations of this research and future research considerations.

Chapter 2
Literature Review

2.1 Introduction

This chapter provides a review of practices that can be used to teach diverse learners within a classroom, and focuses on differentiated instruction, collaboration with the special needs teacher, the inclusive classroom and co-teaching approaches. The chapter concludes with a discussion of whether or not the co-teaching strategy is an effective approach for helping learners with and without learning difficulties in a heterogeneous classroom.

So how do teachers deal with learner populations that are academically diverse? Tomlinson (2008:26) suggests three ways to deal with learner differences. One is to ignore differences; however, there is no evidence that pretending that all children are alike and teaching them the same things in the same way over the same time period is successful. A second way to deal with the differences is to separate the children, such as removing the learners who have a learning disability or do not speak English very well. This method is currently practiced in the high school at the International School of Kenya (ISK) in Nairobi, where learners with special needs requirements or learners not yet proficient in English attend a session once or twice a week with a special needs teacher or with an "English as a second language" specialist. Tomlinson (2008:26) believes that when children are separated, we are telling them that they are not 'normal' and that they cannot do the work, which is detrimental to their self esteem. A third method Tomlinson (2008:27) suggests to deal with learner differences is to keep the children together in the context of a high quality curriculum but attend to their readiness needs, their interests, and their preferred ways of learning. Tomlinson (2008:27) believes that this differentiated approach not only assumes a more positive mind-set, but has also shown impressive results.

2.2 Differentiation

There is an assumption that learners work with the same raw resources, all in the same conditions, all with the same needs, and all growing at the same rate (Wormeli 2007:10). However, learners do vary in so many ways and every learner has special needs at some time, or many times, in a school day, a school year, and a school life. According to Carolan and Guinn (2009:12) the diversity in classrooms offers multiple ideas, perspectives and solutions to problems, and teachers can encourage this diversity by practicing differentiated instruction.

2.2.1 What is differentiation?

Differentiated instruction is defined in the literature in similar ways. According to Tomlinson (2001:103) differentiation is a way of thinking about teaching and learning that recognises and addresses the particular learning needs of each learner. Teachers use varied approaches to curriculum, instruction and assessment. In other words differentiation means starting where the learners are. This idea is echoed by Nunley (2006:xvii) who states that "differentiated instruction is simply providing instruction in a variety of ways to meet the needs of a variety of learners". Wormeli (2006:3) defines differentiated instruction, as "doing what is fair for learners, and it's a collection of best practices strategically employed to maximise learning at every turn".

Tomlinson (2009:3) believes that differentiated instruction not only helps the learners to master content, but also to form their own identities as learners. Differentiation is a refinement, but it is not a substitute for a quality curriculum and good instruction (Tomlinson 2000:6). Differentiation is not just an instructional strategy, nor is it a recipe for teaching; rather it is an innovative way of thinking about teaching and learning (Tomlinson 2000:6).

Powell and Kusuma-Powell (2007b:17) state that differentiation is not simply a larger toolbox of teaching strategies. It is about being able to match learning preferences to instructional strategies. They list the characteristics of differentiation as follows (Powell and Kusuma-Powell 2007a:9):

- Clearly articulating the knowledge that learners will be learning and recognising that the different learners may be learning different knowledge.
- Allowing learners to identify their own learning goals relative to this knowledge and assisting them in determining the degree to which they are mastering it.
- Using on-going assessment as a diagnostic activity that can be used to shape instruction.
- Changing the way groups are organised for activities (for example, whole group, pairs, small groups, individual) based on varying criteria (such as readiness, or interest).
- Engaging learners in meaningful, challenging learning experiences that help them become more self-directed in their learning (for example, performance tasks that involve the use of complex reasoning).
- Varying the level of teacher support from one learner to another.
- Varying the complexity and pace of learning experiences.
- Keeping records that show where learners began in their learning and where they have ended up.

Planning around the learners in the classroom is therefore an important feature of successful differentiation. Differentiated instruction requires that teachers stop thinking about the learners as a class and start seeing them as individuals all with unique learning needs.

In order to clearly understand what differentiation is, it will help to point out what it is not. According to Powell and Kusuma-Powell (2007a:9) differentiation is **not**:

- Teaching to the average ability of learners in the classroom.
- Using a 'one-size fits all' approach.
- Watering down the curriculum or differentiating the outcomes.
- Requiring all learners to learn the same knowledge at the same time, the same way and at the same pace.
- Creating a teacher-directed classroom where learners have relatively little input into what they are learning and how they would best be able to learn it.

- Providing all learners with the same resources and requiring them all to complete the same activities and work at the same pace.
- Providing the bright learners with the interesting activities.
- Masking learner differences or pretending they don't exist.
- Asking learners who finish the assignment early to play games for enrichment, or tutor other learners, or to do extra work that is meaningless to them.
- Using assessments at the end of the learning to "see who got it".
- A mechanistic recipe.

In summary, a differentiated classroom is a place where teaching and learning are *flexible, purposeful and respectful* (Powell & Kusuma-Powell 2007b:12-14). Differentiation assumes that there is enough flexibility of instruction, activities and assessment that a diverse group of learners will find a good fit most of the time. Everything in the learning environment of the differentiated classroom is purposeful with the teacher identifying precise learning goals and clear success indicators. Respectful pedagogy implies that every learner in the classroom is presented with tasks, activities and challenges that are equally interesting and engaging, and is provided equal opportunity for the development of conceptual understanding. Differentiated instruction therefore provides the appropriate challenges that enable learners to thrive (Wormeli 2006:4).

Wormeli (2006:8) states that what we teach is irrelevant; it is what our learners learn after their time with us that is important. Learners for whom teachers have a differentiated approach are far more competent learners, and they also understand themselves as learners and are therefore better equipped to advocate for themselves (Wormeli 2006:4). Tomlinson and Kalbfleisch (1998:52) warn that a one-size-fits-all approach to classroom teaching is ineffective for most learners, and harmful to some according to recent brain research.

2.2.2 Brain research and differentiation

Tomlinson and Kalbfleisch (1998:52) suggest that three aspects of brain research that point clearly to the need for differentiated classrooms are emotional safety, appropriate challenge and self-constructed meaning. Learning environments must be

emotionally safe for learning to take place. To learn, learners must experience appropriate levels of challenge, and each brain needs to make its own meaning of ideas and skills (Tomlinson & Kalbfleisch 1998:53-54).

Because learners in a classroom have diverse backgrounds, interests and experiences they take in information through different channels, process ideas at different rates and have varied preferences of how to show what they have learnt (Tomlinson & Kalbfleisch 1998:54). Brain research suggests the following two guidelines for academically diverse learners to make sense of essential understandings and skills: The first is teaching based on concepts and the principles that govern them as opposed to teaching that is based largely in facts. The second is that the brain learns best when it 'does' rather than when it 'absorbs'. This means that learners must think at a high level to solve problems and then alter the ideas and information they come across (Tomlinson & Kalbfleisch 1998:54).

This information on brain research helped Tomlinson and Kalbfleisch (1998:54-55) to sketch what a differentiated classroom might look like:

- Learners and teachers continually work to accept and appreciate each other's similarities and differences and to respect one another.
- Teachers find out all they can about the learners' current readiness, interests and learning profiles.
- Teachers use what they learn about the learners to provide varied learning options and build learning experiences around the important concepts of the content.
- All learners take part in respectful learning experiences that are equally interesting, equally important, and equally powerful.
- Learners use essential skills to address open-ended problems designed to help them make sense of key concepts and principles.
- Teachers often present several learning options at different degrees of difficulty to ensure there are appropriate challenges for learners at varied readiness levels.
- Teachers often give learners choices about ways of learning, modes of expression and working conditions.

- Teachers present information in varied ways, for example, orally, visually, through demonstration, part to whole, and whole to part.
- Learners work as collaborators with their classmates and teacher.
- Teachers serve as coaches who attend to individuals as well as to the whole class. The goals of teachers are to meet all learners at their starting points and to move each one along a continuum of growth as far and as quickly as possible.
- Teachers may assign learners to groups on a random basis or on the basis of readiness, mixed readiness, similar interests, mixed interests, similar learning profile, or mixed learning profile.
- Teachers design homework to extend the individual's understanding and skill level.
- Varied assessment options are common.
- Grades or reports are based on individual growth.

Many authors in the literature consider the preceding aspects when discussing a differentiated classroom. The purpose of differentiation is therefore making schools fit better for all the learners so that learning can be an interesting and meaningful experience. Whether learners show signs of gifted behaviours, or have attention deficits, or are learning English as a new language, teachers want to make sure that they find ways to engage each learner in the learning process.

2.2.3 Implementing differentiated instruction in the classroom

Tomlinson (1999a:9-15) states that when differentiating instruction the teacher makes consistent efforts to respond to the learning needs of the children in the class and is guided by the general principles of differentiation of *respectful tasks, flexible grouping, on-going assessment and adjustment*. Considering learner interests helps to ensure that tasks are meaningful. This principle suggests that every learner should be required to think at a high level and everybody's work needs to be equally engaging, equally appealing and equally important (Tomlinson 2003:9). Knowing the learners' proficiency levels in English, their knowledge related to the lesson, and reading levels (in other words the learner readiness) as well as the learner interests and learning profiles, helps the teacher determine appropriate grouping configurations. When

flexible groupings are used in a classroom, it ensures consistently fluid working arrangements. The teacher who differentiates instruction continually auditions learners in different settings and the learners get to see how they can contribute in a variety of contexts (Tomlinson 2003:9). On-going assessment provides information for planning and helps the teacher know how to adjust his or her lessons accordingly.

According to Tomlinson (1999a:11) the teacher can modify three things – the *content* (what the learners are to learn), the *process* (the strategies and structures used to teach the content) or the *product* (the ways in which learners demonstrate their learning). Teachers do not need to differentiate all the elements (content, process, product) all the time in every way. They can choose their moments when they feel the modification may help the learner understand better.

Learners show what they have learned based on the *readiness levels* (a learner's entry point relative to a particular interest or skill), *interests* (a learner's affinity, curiosity or passion for a particular topic), and their preferred *learning profile* (how they learn). The teacher should employ a range of instructional and management strategies (such as learning centres, interest centres, compacting, contracts, independent study, collegial partnerships, tiered assignments, etc.) to help target instruction to individual learner needs (Tomlinson 1999a:15). A teacher in a differentiated classroom should therefore respect the readiness level of each learner, expect all learners to grow and support their continual growth, and all tasks should be challenging and engaging (Tomlinson 1999a:12).

Both the principles of differentiation suggested by Tomlinson and the explanation of what differentiation means to Kusuma-Powell and Powell, have similar underlying ideas. The key to differentiated instruction appears to be the *flexible* use by teachers of a wide range of activities and lesson organisations.

For the purposes of this research, differentiation is recognising the learner's varying background knowledge, readiness, interests, language and preferences for learning. Teachers plan, implement and assess around these differences, and the process is purposeful, respectful and flexible.

2.2.4 Planning differentiated lessons

Powell and Kusuma-Powell (2007b:163) warn that differentiation can appear to be daunting when we think of diversity in culture, languages, educational background and experiences of the learners together with their differences in readiness levels, differences in style and learner preferences. Tomlinson (1999a:14) advises that as teachers cannot differentiate everything for everyone every lesson, teachers should choose moments when they feel the modification would help understanding.

There are many publications that give reasons for a differentiated approach but give little advice on what it involves or how teachers might implement it in a classroom (Clare 2004). Carolan and Guinn (2009:12) suggest that many teachers hesitate to implement differentiated practices into their classroom methods because of a perceived lack of time, training, and support from administrators. They propose that differentiation does not actually require teachers to make dramatic changes in their approach. Many expert teachers were successful differentiators long before the term 'differentiation' was popularised and have learnt which strategies to use and when to use them (Carolan & Guinn 2009:13).

From Carolan and Guinn's (2009:13) observations of five successful differentiators who taught a broad range of learners in their classrooms, they recognize four strategies that identified individual needs: One is to offer personalized scaffolding. Scaffolds are temporary supports that help a learner bridge the gap between what they can do and what they need to do to succeed at a task (Carolan & Guinn 2009:14).

A second strategy is to use flexible means to reach a defined end. After teachers establish curricular direction and content, they should offer multiple ways for the learners to demonstrate what they know. Carolan and Guinn (2009:15) believe one of the characteristics of successful differentiation is designing and facilitating "multiple paths" to reach defined learning goals. Tomlinson (1999b:12) also mentions that even though learners may learn in many ways, the essential skills and content they learn can be the same, and the learners could take different roads to the same destination. In differentiated instruction the core of what the learners learn remains relatively the same, but how the learner learns, including the degree of difficulty, styles of

expression, working arrangements and the types of scaffolding, may differ greatly (Tomlinson 1999b:16).

A third strategy suggested by Carolan and Guinn (2009:17) is to create a caring classroom in which differences are seen as assets. Teachers should see the differences in learner ability, culture, language or interests as assets, not as hurdles, and learners should recognise and value the unique qualities of their peers.

The final strategy suggested by Carolan and Guinn (2009:16) concerns the expertise of the subject area. Teachers should not only know their subject matter but they should also show several ways to explain it. Successful differentiators understand how learners come to know their subject, where learners might struggle, what preconceptions learners might have, and how to match content with instructional method in a way that connects to differing learning styles and levels.

Based on classroom work over the last thirty years, Powell and Kusuma-Powell (2007b:35) have also identified strategies that serve as a foundation for differentiated instruction. One of their strategies is ‘knowing your curriculum’, which echoes that suggested by Carolan and Guinn regarding expertise of the subject area. Powell and Kusuma-Powell (2007b:42) believe that an in-depth knowledge of the curriculum allows the teacher to identify the primary concepts and to distinguish between enduring understandings.

Another strategy suggested by Powell and Kusuma-Powell (2007b:36-39) is “knowing your learners (and yourself as a teacher)”. This strategy is based on knowing the children in your class particularly as learners in the specific areas of readiness, interests and learning profile. Understanding learning profiles means knowing their preferred learning modalities (visual, auditory, tactile or kinesthetic) and having an understanding of their intelligence preferences.

The challenges and demands of differentiating a rigorous academic curriculum can be overwhelming. Powell and Kusuma-Powell (2007b:43) acknowledge that differentiation is complex and challenging work and suggest that teachers should set a realistic and reasonable differentiation goal and move slowly but surely.

Tomlinson (1999a:24) proposes that lessons grounded in best practice and modified to be responsive to learner differences, benefit all the learners. Wormeli (2006:8) suggests that most teachers who incorporate differentiation practices experience learning at a level otherwise not achievable through non-differentiated practices. However, despite all this information on the benefits of differentiation, teachers still base their practices upon identical content, process and products. Why do teachers tend to be habitual and standardised in their practices?

2.2.5 Challenges with implementing differentiated instruction

Tomlinson (2000:11) suggests that teaching is difficult and that teachers seldom have time to question why they do what they do. They also find change uncomfortable. However the teaching profession cannot progress and the increasing diverse learner body cannot succeed if teachers do not adapt to a more differentiated approach.

Carolan and Guinn (2009:18) recognise the complexity of addressing the needs of all the learners in a classroom, and suggest two practical ways to help teachers master a strategy as complex as differentiation. Firstly they suggest that teachers should be given opportunities to view examples of differentiation. They believe that teachers need concrete examples and a common analytic vocabulary. Secondly Carolan and Guinn (2009:18) suggest mentoring relationships where a novice teacher is paired with an expert teacher in the same subject area. This relationship should be beneficial to both teachers, with the novice teacher learning ways in which the expert teacher differentiates curriculum and instruction, and the expert teacher being given an opportunity to reflect on their knowledge and practice.

Powell and Kusuma-Powell (2007b:44) also believe it is essential that professional colleagues are included on the journey towards differentiation and argue that one of the most important messages that any teacher can receive about differentiation is that "no teacher needs to go it alone". Delisle (1999:83) also notes that teachers must realise that "within the constraints of a single day, or a single career, they will face intellectual or emotional issues that would be better addressed by someone whose skills, training and personality differ from their own". As mentioned in the

introduction, one of the principles identified by Powell and Kusuma-Powell (2007b:27) at the core of differentiated instruction is that "a professional partnership is exponentially more effective than the sum of its parts". This is the underlying principle that will drive this research: Are our professional colleagues, especially the special needs teachers, a source of knowledge and inspiration to help high school teachers embark on a more differentiated approach?

2.3 Collaboration

It appears from the literature that in order to improve learning, the focus must be on what adults do in the classroom, because without changing the behaviour of teachers, the outcomes for learners will not change. Barth (2006:12) suggests that the adult relationships in a school have a greater influence on learner achievement than anything else. Schmoker (1999:ix-x) believes that the key to continuous school improvement is to set goals, work collaboratively and to keep track of learner achievement from many sources. All the elements of effective instruction that Schmoker describes relate to what the adults do in the school.

Working with a colleague is the basis of the collaborative experience and there are many examples in the literature where collaboration is regarded as an essential feature of the differentiation model. For example, Villa and Thousand (1995:153) are of the opinion that a teaching team is needed to meet the diverse needs of a heterogeneous learner body. Pettig (2000:14) and Wormeli (2007:140) also acknowledge that teaching colleagues are probably the most powerful professional resource available to teachers. Wormeli (2007:18) indicates that one of the steps while designing and implementing differentiated learning experiences is to review plans with a colleague. Nunley (2006:113) also emphasises the idea of having a colleague on board when designing and implementing differentiated lessons because without support many teachers are afraid to change their traditional teacher-centred classroom into learner-centred instruction. According to Nunley (2006:19) teachers tend to teach with the teaching style in which they were taught and collegial cooperation is one way to enhance the range of instructional approaches.

2.3.1 Characteristics of successful collaboration

It is important to distinguish between collegiality and collaboration and according to Schmoker (1999:15) much of what we call teamwork or collegiality is ineffective or counterproductive because it is not task orientated. Friend and Cook (1992:6- 28) list the defining characteristics of successful collaboration as follows:

Collaboration:

- is voluntary,
- requires parity among participants,
- is based on mutual goals, and
- depends on shared responsibility for participation and decision making.

In addition to these characteristics, individuals who collaborate share resources and accountability for outcomes.

DuFour (2003b:18) also believes that collaborative teams are most effective when the team members have specific goals. Simply providing teachers with time to collaborate will not necessarily lead to improvements in learner achievements. Powell and Kusuma-Powell (2007b:141) suggest that the highest level of collaboration is achieved when there are *co-equal* teaching partnerships, and the trust in the relationship allows for self-criticism, good humour and spontaneity. Collaboration is therefore based upon mutual goals and shared responsibility for participation and decision-making, and teachers who collaborate share accountability for the outcomes (Powell & Kusuma-Powell 2007b:135-6).

According to DuFour's (2004:11) "Professional Learning Community Model", it is necessary to focus on learning rather than teaching, work collaboratively on matters related to learning, and focus on results. In order to create a culture of collaboration, DuFour (2004:11) suggests that the most important element in the improvement in any school is the commitment and persistence of the teachers.

For the purposes of this research, the term collaboration combines the talents and experiences of the high school science teacher and the special needs teacher in

creating a new approach to a unit of study or an aspect of the curriculum, and there is a shared goal and shared responsibility.

2.3.2 Obstacles that prevent collaboration

If effective teamwork in teaching is now being recognised as a key ingredient to successful teaching, why do many teachers still tend to work in isolation from each other? DuFour and Burnette (2002) point out that "teachers decide what to do based on their own knowledge of content, instruction, assessment and classroom management, and isolation is alive and well due to lack of time, incompatible schedules, personal routines and deeply rooted traditions". DuFour and Burnette (2002) correctly recognise that teachers cannot develop professionally when isolated from their colleagues and denied access to fresh insights and ideas. They suggest that a collaborative culture results from a systematic effort to engage the teachers in an environment designed to improve collaboration.

Schmoker (1999:10-11) also highlights the negative effects of teacher isolation, and suggests that schools would perform better if teachers worked in focused, supportive teams. Isolation prevents teachers from reflecting collaboratively to find common solutions to problems, and day-to-day concerns stop teachers reflecting on what the most important goals should be. If there is a lack of clear-cut specific goals, there is an absence of a common focus and solutions. These goals can only be obtained when teachers regularly collaborate and communicate in an effort to define and reach such goals (Schmoker 1999:11).

The intention of this research is to focus on the collaboration between a high school science teacher and a special needs teacher but Siders (2008:5-6) lists the following concerns that may hinder successful collaboration between these two teachers:

- Unclear roles and responsibilities of the special needs teacher and the subject teacher in the classroom.
- Lack of common planning time.
- Lack of content knowledge by the special needs teacher.
- Lack of trust between the two teachers.

DuFour and Burnette (2002) also identify the problem of territorialism where teachers view each other as competitors, and Siders (2008:5) reports that many special needs teachers in high school classes are treated as “glorified paraprofessionals” and typically suffer from no advance notice of instructional planning.

Another obstacle that may prevent collaboration is the absence of training in the skills of collaboration. If colleagues are a teacher’s greatest resource, they need to be taught the skills for successful collaboration.

2.3.3 Collaboration skills

According to Powell and Kusuma-Powell (2007b:44) high quality professional relationships are made, not born, and schools need to provide support to teachers as they develop their collaborative skills. Garmston and Wellman (1998:32) recognise the difficulties in creating collaborative work environments, and suggest the following seven norms that are basically collaboration skills needed when working together:

1) *Promoting a spirit of inquiry*. The development of understanding is promoted when exploring perceptions, assumptions, beliefs and interpretations; so inquiring into the ideas of others before advocating one’s own ideas are important for productive dialogue and discussion.
2) *Pausing*. Pausing before responding or asking a question allows time for thinking and enhances dialogue, discussion and decision-making.
3) *Paraphrasing*. To paraphrase is to translate into one’s own words the comments or thoughts of another person. Paraphrasing helps team members understand each other as they analyse and evaluate data and formulate decisions.
4) *Probing.* Probing seeks to clarify something that is not yet fully understood. Clarifying questions can increase the clarity and precision of the group’s thinking and can contribute to trust building. It is often useful to precede a probing question with a paraphrase.
5) *Putting forward ideas.* Ideas are the heart of a meaningful dialogue, however, it takes self-confidence and a degree of courage to offer an idea for a group’s consideration. It is vital that collaborative groups nurture such self-confidence and courage.

6) *Paying attention to self and others*. Meaningful dialogue and discussion are facilitated when each group member is conscious of self and of others, and is aware of what he/she is saying and how it is said as well as how others are responding. This includes paying attention to learning styles when planning, facilitating and participating in group meetings and conversations.
7) *Presuming positive intentions*. Assuming that others' intentions are positive promotes and facilitates meaningful dialogue and discussion and prevents unintentional put-downs. This norm builds trust, promotes healthy cognitive disagreement and reduces the likelihood of misunderstanding.

These norms require focus, mindfulness and perseverance, and Garmston and Wellman (1998:30) suggest that when faculties are meaningful of these norms, their adult relationships result in more effective collaboration and a willingness to participate in professional coaching relationships. According to Powell and Kusuma-Powell (2007b:144) professional coaching is the highest forms of collaboration.

2.3.4 Benefits of collaboration

The literature contains many positive comments about collaboration benefiting both the learners and teachers. For example, Powell and Kusuma-Powell (2007b:140) believe that when two or more teachers plan together, execute instruction together and then reflect on the experience together, there are *dramatic* improvements in learning and increased teacher professional fulfilment. They are of the opinion that there is little in education that holds as much promise for improved learning as teachers working together to plan, implement instruction and then critically reflecting together.

Lipsky (2003:34) reports that the benefits of collaboration for teaching include: reducing the isolation of being a solo-practitioner, sharing the responsibility for teaching a diverse group of learners, learning new skills and methods, reflecting upon different practices with colleagues, and adding enjoyment to teaching. Lipsky (2003:34) is of the opinion that collaboration is a powerful means of both personal and professional development.

In spite of obstacles that may prevent collaboration, Doll (2005:26) assures us that collaboration is worth the effort because the learners benefit from exposure to the skills, ideas and energy of two or more people and multiple inputs can result in more variety in teaching methods. According to Lipsky (2003:35) the traditional classroom practice of having an individual teacher in a classroom needs to change to teachers working together to address the needs of all the learners in an inclusive classroom.

2.4 Inclusion

Inclusive education is defined by Sapon-Shevin (2007:xii) as a "set of practices that support the belief that *all* learners in a school, regardless of their strengths, weaknesses, or labels, should be full members of the general school community, with their individual needs met within the general education context". Mittler (2000:2) states that the aim of inclusion is to ensure that all learners have access to the whole range of educational and social opportunities. Inclusion therefore celebrates diversity arising from gender, nationality, race, language, level of educational achievement, social background or disability (Mittler 2000:10). According to Villa and Thousand (1995:11), inclusion is based on the belief that each individual learner is valued and belongs in a regular classroom.

Mittler (2000:vii) states that inclusion is not about placing children in mainstream schools, but is about changing schools to make them more responsive to the needs of *all* the learners. "Inclusion is not a goal that can be reached but a journey with a purpose and during the course of that journey, teachers will build on their experience and increase their skills in teaching *all* children" (Mittler 2000:133). Sapon-Shevin (2007:xiii) discusses the moral and educational case for creating classrooms in which *all* learners are full and valued members. She argues that inclusion when implemented thoroughly and conscientiously can create learning environments that are better for all the learners.

The term inclusion implies that all learners are accommodated in the same classroom. However, for the purposes of this research the focus is going to be on those learners who have special needs. As mentioned in the introduction, the learners with special needs at the ISK in Nairobi are those with mild learning difficulties and those learners

who are not yet fluent in English. The school does not have severely physically handicapped or learning disabled children, so the school might be perceived as not being a model of a **fully** inclusive school. However, the learners have a wide range of characteristics and differences such as race, ethnicity, language, family composition, gender, religion and socioeconomic status.

For the purposes of this research study, inclusion involves bringing the support services to a learner in a regular classroom and providing effective learning opportunities for all the learners. The special needs teacher and class teacher therefore work together in the same classroom to address the needs of all the learners.

2.4.1 Role of the special needs teacher

To create a true community of learning, Tomlinson (1999a:31) believes that the teacher must appreciate each child as an individual, and should teach the whole child. As mentioned earlier, when planning differentiated lessons, individual learning styles need to be considered. One of the strategies for differentiated instruction according to Powell and Kusuma-Powell (2007b:35) is “knowing the learners in your class”. This means knowing how they learn best and knowing their strengths and talents as well as their deficits. McNamara (1999:56) suggests that if a teacher is not meeting the needs of a particular learner, the teacher should interview the learner and find out their preferred learning style and then check if different forms of differentiation have taken place that incorporate the learner’s learning style. The assumption here is that all teachers can identify individual learning preferences and then modify instructional practices to create a match with those preferences. This is not always the case and is possibly where the special needs teacher can play an invaluable role in a differentiated classroom, because it is one of their areas of expertise.

Everyone learns in different ways, and learners all have unique learning profiles and strengths. When learning, individual learners use visual, auditory, kinaesthetic/ tactile learner styles, but in different combinations of preference. Generally the largest proportion of the population tends to be visual learners, with the smallest proportion preferring auditory learning (Powell & Kusuma-Powell 2007b:69). Learners often need to use their auditory skills in most classrooms, and for English language

learners, even those with strong auditory skills, listening in an unfamiliar language can be a challenging way for them to learn. Each style of learning may have particular academic difficulties that can be challenging to overcome. Powell and Kusuma-Powell (2007b:70-71) discuss some of these difficulties and suggested activities that appeal to the various learning styles.

Tomlinson and Jarvis (2006:21) believe that when teachers genuinely recognise the strengths of the learners in their classroom and nourish their strengths, learner success is generated. They acknowledge that when teachers teach to learner strengths it helps learners see themselves positively, see learning positively, see strengths in one another and help learners overcome weaknesses.

The needs, intelligences and learning styles of learners differ and the knowledge of the special needs teacher about individual learning profiles and strengths is therefore invaluable in helping the subject teacher accommodate each learner's learning style during the course of the lesson. Tomlinson (2003:11) suggests that one special needs teacher can positively touch hundreds of learners through successful collaboration with a single teacher.

2.4.2 Can inclusion be achieved in diverse classrooms?

The norm in most schools (as at the ISK) is to remove learners that need remediation from the classrooms and this often leads to a decline in teacher expectations for the learners and the teaching materials are usually simplified. Tomlinson (1999a:21) suggests that remedial classes keep remedial learners remedial, and that all learners are entitled to have teachers who help them realise their potential. Tomlinson (1999a:22) believes that diverse classrooms should be able to address all learners' needs. However, one of the problems of placing remedial learners in a heterogeneous class is that the struggling learners are sometimes left to their own devices to 'catch up', and the advanced learners become tutors for the struggling learners, which can hinder the growth of the advanced learners (Tomlinson 1999a:22).

When learners that need remediation are removed from a class, the general education teachers are concerned about discipline issues that may arise when these learners are

returned to the classroom. Lipsky (2003:35) suggests that this problem can be overcome by the implementation of positive behaviour support programs that act as a preventative measure and address inappropriate behaviour.

Another concern of inclusive models is that it could limit the achievement of learners and diminish the quality of the schools. However, Sapon-Shevin (2007:93-94) notes that academic performance of learners in inclusive classrooms has been shown to be equal to or better than that of general education learners in non-inclusive classrooms She believes that "inclusive classrooms can teach us important lessons that go far beyond individual learners and specific settings and can help create the inclusive, democratic society that we envision for our learners and society" (Sapon-Shevin 2003:26).

The paper on achieving inclusion by Causton-Theoharis and Kasa-Hendrickson explains how all learners can be educated in the general education setting with appropriate strategies in place. Causton-Theoharis and Kasa-Hendrickson (2010:6) discuss a common misconception about inclusion that learners have to keep up with the class in order to be included. Research has shown that when learners with disabilities are included into the general education classroom, learning opportunities are strengthened because teachers increase learner access to resources and technology, implement differentiation, and teach skills of collaboration and interdependence (Causton-Theoharis & Kasa-Hendrickson 2010:7).

Advocates for full inclusion are concerned that if the option of separation or pull-out from the regular classroom is available, it will be chosen. (Vaughn, Bos & Schumm 1997:29). However other researchers, such as Holloway (2001:86) have asked whether it is educationally reasonable to place learners with learning difficulties in an inclusive classroom? Vaughn et al (1997:29) believe that the progress of all the learners should be monitored and adjustments provided if progress is not adequate. This supports Holloway's findings that suggest that "any criteria for judging the effectiveness of inclusion programs must include the entire scope and quality of services available to learners with learning difficulties, and a shared commitment by the general and special needs teachers to ensure that all learners receive a variety of learning opportunities in all education settings" (Holloway 2001:88).

The International School of Brussels (ISB) is an example of an international school that practices inclusion. The director of the ISB Kevin Bartlett (2011:8) defines inclusion as offering a planned, balanced program of differentiated learning to a diverse learner body, reflecting the full range of aptitudes and abilities. The ISB found that the best way to balance their learner intake was to match society, and one per cent of their learner body have severe disabilities; three per cent have moderate disabilities and between eleven and thirteen per cent have mild learning needs. Their learner body therefore reflects the diversity of real life, not some ideal. They have had occasions when the school could not serve the needs of a particular child, but Bartlett (2011:8) emphasises that these "failures" are not for want of trying and are usually as a result of a child's unpredictable behaviour. The school has broad guidelines for different levels of need (http://www.isb.be/learning-support), however this is supplemented with case-by-case flexibility. Their inclusive program has evolved over the last twenty years and they have learnt that they can organise learning for learners with different levels of need, that co-teaching is a most valuable strategy, and that they can mainstream learners or offer them specialized separate support when it makes sense.

There is a belief among educators that too many learners are identified with 'special needs' and one approach that has been used to determine learners' eligibility for special education services is the Response to Intervention (RTI) program. According to Brown-Chidsey (2007:45) RTI is a data-based, systematic procedure that supports equitable educational access for all learners. It provides mechanisms by which learners can receive supplementary instruction without the stigmatising effects of a disability label. Basically the approach is divided into three tiers (Brown-Chidsey 2007:42): The first tier includes instruction and assessment for all the learners, and success at this tier demonstrates the levels of knowledge and skills expected for the learners at that particular grade level. The second tier is selected instructional activities and assessments for those learners who have not achieved at the expected level while participating in tier 1. These learners are monitored closely to see whether their skills are improving. If their assessment data indicate progress, the learners gradually receive less support until they are able to succeed within the general education program. If they do not make progress after a specified period of tier 2 instruction, the school either adjusts the learners' tier 2 instruction or refers them to

tier 3. Only at tier 3 does the school conduct a comprehensive evaluation of a learner's skills to determine why his/her performance is significantly different from that of other learners of the same age and grade and to decide what additional instructional supports the learner needs. The RTI approach requires the active participation of all general educators and the most effective solutions include collaborative work by the general and special educators to provide effective instruction for learners as soon as they need it. According to Brown-Chidsey (2007:45) the RTI program has shown greater success for all the learners and fewer learners are placed in special education. This program has enabled schools to identify the kinds of support that struggling learners need in an inclusive classroom, and provide that support when it is needed.

Achievement in inclusive education therefore assumes that no one person has all the expertise required to meet the needs of all the learners in a classroom. Greater collaboration among education professionals has resulted from an increased awareness that learners with disabilities are more likely to succeed in general education classrooms if they receive targeted support services in the classroom (Vaughn et al 1997:26). Villa and Thousand (2003:22) suggest that for inclusive education to be successful, educators must become effective and efficient collaborative team members and develop skills in creativity, co-teaching and interpersonal communication. In a study of more than six hundred educators, collaboration emerged as the only variable that predicted positive attitudes towards inclusion among general and special needs teachers (Villa & Thousand 2003:22).

Unfortunately the separate teaching roles - special needs teachers for special children, and classroom teachers for the other children - has created a very simplistic way of looking at learners. It has supported the development of separate systems of education that are complementary at best, but rarely collaborative (Sapon-Shevin 2007:97). Teaching in isolation is not possible in inclusive models, so teachers need to learn extensive repertoires of collaboration, co-teaching and communication to plan and teach effectively with others. Inclusive models require teachers to work together, and teachers with more specialised skills are critical to the inclusion process (Sapon-Shevin 2007:99).

2.4.3 Inclusion in a high school science classroom

The mathematics and English departments at the ISK are the only two departments that have worked with special needs teachers in some of their lessons. Science is also one of the core subjects and grade 9 natural science learners will be used as a sample in this research. Ritchie (2001:64) suggests that one way to alleviate the challenges of teaching science to a class of diverse learners is to make use of other adults in the classroom. It is the aspect of a shared commitment by a specialist high school science teacher and a special needs teacher that will be examined in this research. It is evident from the research that has been conducted into children's learning in science that learners approach new experiences in science with existing ideas about the world and these ideas will significantly affect their future learning (Ritchie 2001:54). The special needs teacher can help elicit the learner's existing skills, knowledge and understanding and use these to make decisions about appropriate interventions. Ritchie (2001:55) also suggests that because each science learner actively constructs a unique understanding of the world, learning should be differentiated.

Traditionally special needs teachers are trained to provide individual education programs based on the learner's needs, they routinely differentiate instruction, but rarely is there an opportunity for the special needs teachers to teach large groups of learners. On the other hand, traditional classroom teachers are trained in teaching methods and content area subjects. They teach large groups of learners and rarely have time for individualised instruction. Classroom teachers are now expected to design materials and activities that can meet the needs of *all* the learners in a heterogeneous classroom but this is usually difficult to achieve unless the classroom teachers and the special needs teachers combine their skills and knowledge.

As discussed earlier in the literature review research on teacher collaboration, the reasons for collaboration and the components necessary for successful teacher collaboration are clear, however, the literature fails to demonstrate a strong relationship between a specific type of collaboration and learner achievement. This research will examine the effectiveness of learning in a heterogeneous grade 9 natural science classroom when there is collaboration between a specialist science teacher and a special needs teacher using a co-teaching approach.

2.5 Co-teaching

Co-teaching was initially practiced as team teaching by general educators, and gained popularity in the 1950s in the United States when, due to teacher shortages, teams of teachers shared the responsibility for large group presentations and follow-up activities. By the early 1980s, team teaching became an approach borrowed from general education and applied to special education as a way of mainstreaming learners with learning difficulties into the general classroom (Friend 1993:7).

2.5.1 What is co-teaching?

Co-teaching according to Gartner and Lipsky (1997:9) is when the general education and special education teachers work together to teach all the learners in a classroom. Both groups of teachers are responsible for the planning and delivery of the lesson, learner achievement, assessment, and discipline. As a result of this collaboration, the two teachers should be capable of developing a more comprehensive program that could adapt to the needs of all the learners. This definition is similar to that of Friend (1993:8) who describes co-teaching as "a delivery approach when a classroom teacher and a special education teacher share responsibility for planning, delivering, and evaluating instruction for a group of learners".

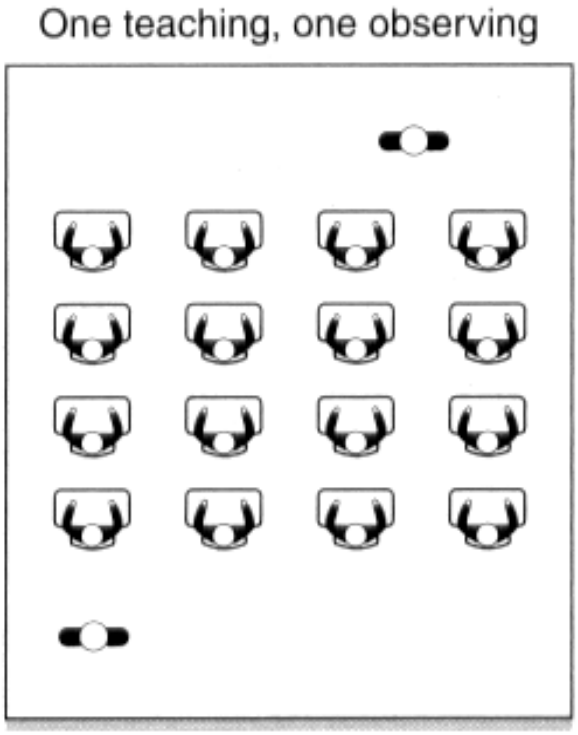
Bauwens (1991:23) suggests that co-teaching, where the general and special educators work together, could allow teachers to best serve the diverse populations that exist in general education classrooms, and help avoid the labelling and stigmatisation of particular learners. Instructional time is also sustained because learners are not leaving the classroom for special help. To do so Murawski and Dieker (2004:56) suggest that before the planning meeting, the general educator should provide a general overview of content, curriculum and standards to be addressed, and the special educator should provide individualised education program (IEP) goals, lesson objectives, and possible modifications for the learners in the shared classroom. They believe that this type of information sharing is critical at the high school level where subject teachers tend to be content specialists and special needs teachers tend to focus on individual learning needs.

DeLuca, Borman, Jump, Ratzlaff and Nystrom (2010) suggest that co-teaching is one way to help learners with special needs in an inclusive classroom. They believe that co-teaching leads to an increased understanding and respect for learners with special needs on the part of other learners, and reduces the stigma for learners with special needs.

2.5.2 Co-teaching in practice

According to Gartner and Lipsky (1997:26-28) co-teaching can be organised in a number of ways. The diagrams below are from a PowerPoint presentation by DeLuca et al (2010) and illustrate the different types of co-teaching arrangements:

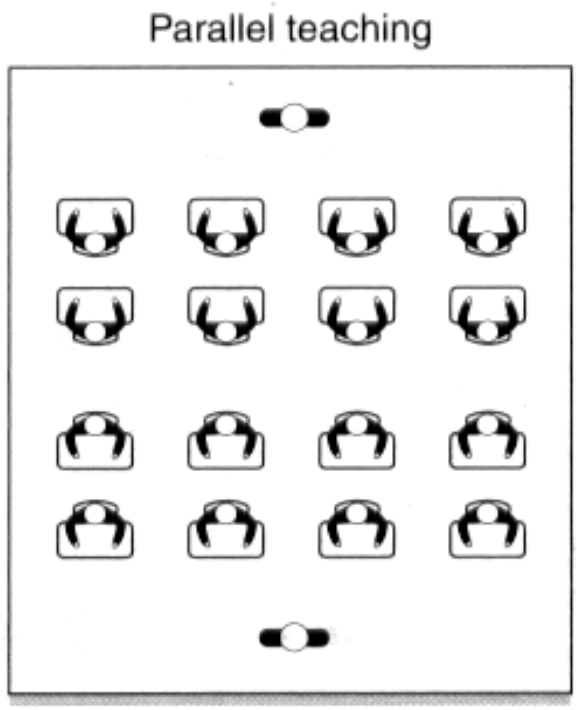
* *One teacher, one support:*
In this arrangement, one teacher leads the lesson while the other teacher observes and walks around the room and assists individual learners making sure they understand the lesson.



(DeLuca et al 2010:Slide 10)

This organisation works well for teaching a unit where one teacher is more of an expert than the other. Learners still have two teachers to ask questions and get help, and this approach requires very little joint planning. The major disadvantage of this arrangement is that if it is used exclusively, the support teacher can be seen as the "assistant" and the learners may question the support teacher's authority. This format provides only basic support to learners with diverse needs.

* *Parallel teaching*:
In this arrangement, the class is divided in half with diversity in both groups and both teachers plan instruction jointly and teach the same lesson at the same time.

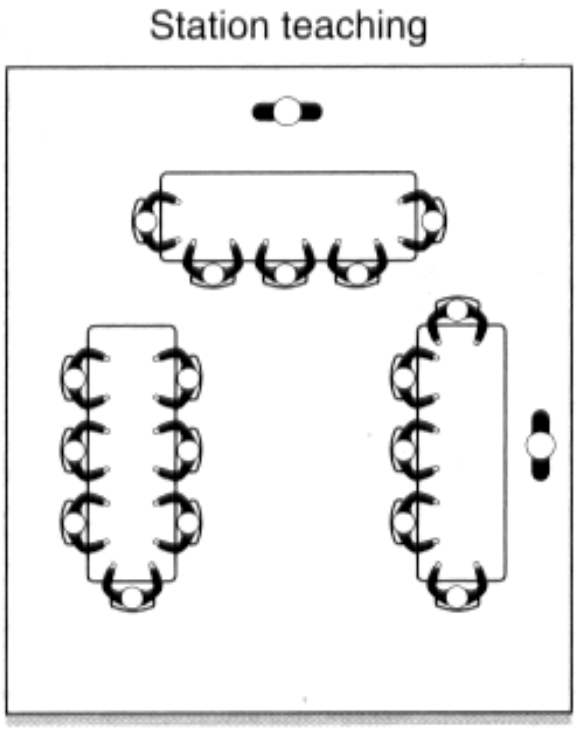


(DeLuca et al 2010:Slide 7)

In this approach, the learner to teacher ratio is low, more time is devoted to learning versus learners waiting for help, opportunities for re-teaching are immediate, communication is constant, and behaviour problems can be minimised. The content covered is the same, but methods of delivery may differ. After teaching the class in two groups, the learners can all be brought together for a joint discussion. A disadvantage of this approach is that it requires a lot of joint planning and the pacing of the individual lessons needs to be similar. Both teachers need to be proficient in the

content being taught and the teachers also need to aware of the noise generated by two lessons being taught at the same time.

* *Station teaching*:
This teaching arrangement divides up content and learners, so that teachers or learners rotate at the end of a unit. This arrangement is ideal for subject matter taught in units with no particular sequence.

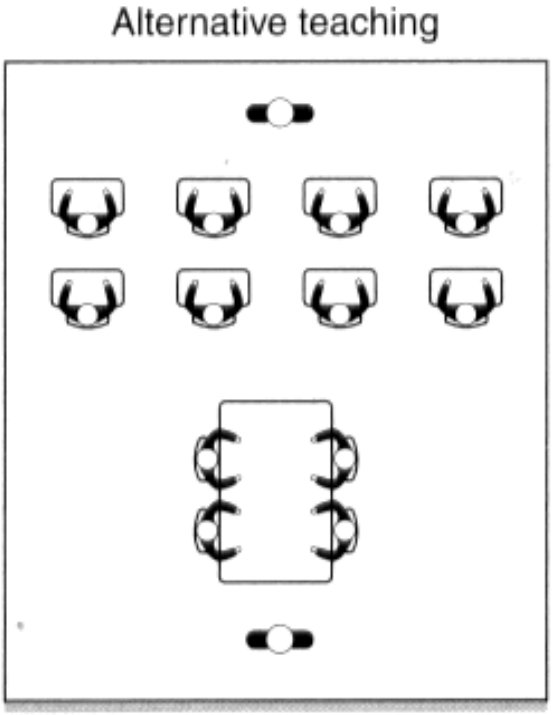


(DeLuca et al 2010:Slide 4)

Benefits include the opportunities for immediate re-teaching, the learner to teacher ratio is low, and teachers become experts with their material. Both teachers are active and equal, have separate responsibilities and each teacher instructs every learner. This model can be used even if teachers have very different pedagogical approaches. The disadvantages of this model are that the noise level can be high as a result of a lot of movement around the classroom, and the pacing of the lesson can also be a problem because it might be difficult to ensure that the learners spend sufficient time at all the stations.

* *Alternative teaching*:

With alternative teaching, one teacher works with a large group while the other teacher works with a small group of learners. Small groups can be pulled for pre-teaching, re-teaching, enrichment, interest groups, special projects, make-up work or assessment groups.



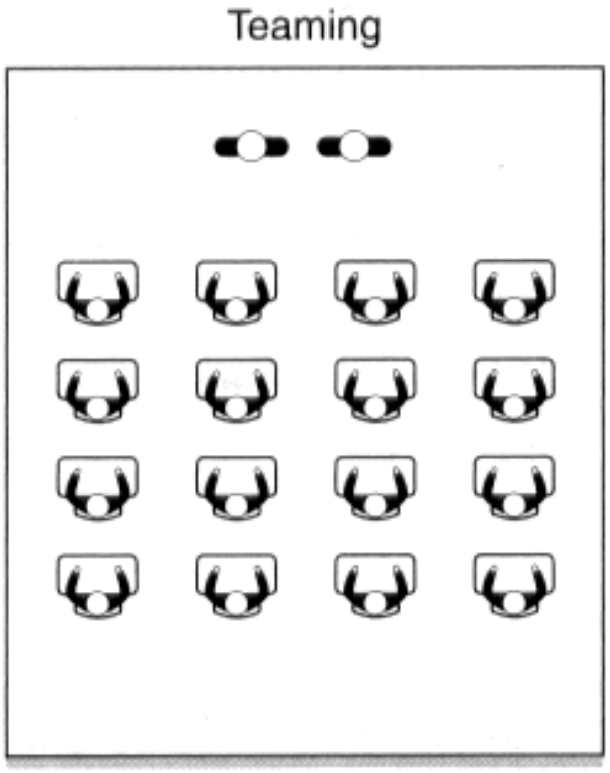
(DeLuca et al 2010:Slide 13)

The advantage of this arrangement is that all learners benefit from small group instruction. If the classroom teacher and a special education teacher alternate roles, equal status should be maintained. The disadvantage of this approach is that if the small learning groups are always for the learners with special needs, these learners may feel stigmatised. The small learning groups therefore need to span various purposes and include different types of learners.

* *Team teaching*:

With team teaching, teachers work together to deliver the same material to the entire class. One teacher may lead the discussion while the other models or demonstrates the work. Team teaching affords the opportunity to model quality team and interpersonal interactions.

The advantage of the team teaching arrangement is that both educators have equal status and they can play off each other, which results in a synergy that enhances learner participation (and also invigorates the teachers). The disadvantage is that this approach requires a great level of trust and commitment and a lot of planning, and the teaching styles of the two teachers need to mesh.



(DeLuca et al 2010:Slide 16)

The co-teaching organisation used in lessons will vary depending on the content being taught, the expertise of the teachers involved and the learner needs in the class. The co-teaching arrangements that were selected for this research and the reasons for their selection are discussed in the next chapter.

2.5.3 Preparing to co-teach

A number of strategies exist to help teachers adjust to a co-teaching environment. Murawski and Dieker (2004:54) offer the following steps to help ease the actual transition to a two-teacher environment:

- Assess the current environment: What kind of collaboration currently exists between the general education and the special needs teacher? These questions allow both teachers to understand what differences will exist between the present environment and the new co-teaching environment. By defining the differences, the path to co-teaching becomes clearer.
- Move in slowly: What is the joint understanding of co-teaching? Questions like this avoid an abrupt change to the environment that the participants may not be ready for. Moving in slowly does not necessarily reflect a time value. It is an understanding that asking some questions about the expected goals is important in establishing measures of success.
- Involve an administrator: Without administrative assistance, co-teachers run the risk of not having a safety net. An administrator who is involved and supportive of the co-teaching environment will work with scheduling, parents, and the community to foster support for the co-teaching format.
- Get to know the partner: Personality differences are exacerbated in an environment where there are two leaders. Understanding the co-teacher's likes and dislikes, and teaching and classroom management styles, is necessary in creating a sound foundation for learner success.
- Create a workable schedule: How often will co-teaching occur? There are a number of practical questions that must be addressed when moving towards a co-teaching model. Scheduling is one of the most important practical considerations. Both teachers and learners benefit from a regular and transparent schedule in the classroom.

Walther-Thomas, Bryant and Land (1996:255) discuss the elements that are needed to create a successful co-teaching program and note the importance of the co-planning for co-teachers to successfully work together. The authors (Walther-Thomas et al 1996:263) found five planning themes that surfaced among co-teachers who consider themselves successful. These are:

- Skilled planners trust the professional skills of their partners.
- Effective planners design their environment to facilitate active involvement.
- Effective co-planners create an environment where each teacher's contributions are valued.

- Effective planners develop effective routines to facilitate their planning.
- Planners become skilled over time.

So the old adage “if you fail to plan, you plan to fail” can be applied here. The planning stage in the co-teaching model is therefore a key factor to its success.

Keefe, Moore and Duff (2003:36-42) suggest that in order to achieve a better chance of co-teaching success, teachers must address the following:

- Teachers must know themselves. This means that teachers must recognise their strengths and weaknesses and explore their willingness to share responsibilities, learn from each other, support one another, and share classroom control.
- Teachers must know their co-teachers. This means that teachers must be able to connect personally and professionally to provide a model for learners. Teachers must know each other’s teaching styles and preferences.
- Teachers must know the learners in their classroom and must listen to the learners and develop a trusting, accepting environment in order to address the needs of all the learners.
- Teachers must know their subject matter. Teachers have a variety of skills and knowledge; they need to share their resources to develop the best plan for the learners.

Keefe, Moore and Duff (2003:42) conclude that co-teaching requires a long-term commitment and has the potential to provide feelings of achievement, trust and mutual respect.

2.5.4 Benefits of co-teaching

Murawski and Dieker (2004:52) believe that co-teaching is likely to increase the outcomes for *all* the learners in a heterogeneous class, while ensuring that learners with special needs receive the necessary modifications.

DeLuca et al (2010) suggest co-teaching is an **advantage to learners** for the following reasons:

- More diverse learning and teaching techniques are available and the learners benefit from the teaching styles of two teachers.
- There is a lower teacher-learner ratio. This can be enhanced depending on the co-teaching arrangement being used. Zahorik (1999:50) mentions that a Wisconsin researcher found that class size reduction in a variety of formats increases attention to individual learners. Cawelti (1999:36) also notes when investigating research-based practices and programs that boost learner achievement, that smaller classes create fewer problems and more opportunities to give learners personal attention.
- There is more contact time with teachers because learners with special needs are not leaving the classroom for special help. Abdallah (2009) suggests that co-teaching can be used to benefit English language learners as well as those learners with special needs requirements, as the special needs teacher may assist English language learners with strategies to support their learning in the lesson.
- The unique learning needs of the learners are met to the greatest extent possible, because two teachers can respond more effectively to their varied needs.
- The classroom of diverse learners provides affirmation of individuality. Sapon-Shevin (2001:36) notes that when diverse teaching strategies are used, teachers not only improve their chances of reaching every learner, but also model respect for diversity and help learners understand that people are different and learn differently.
- Co-teachers serve as role models to learners by demonstrating healthy adult interaction.

The **advantages of co-teaching for teachers** suggested by DeLuca et al (2010) include:

- Another professional can provide different viewpoints and more ideas for instruction. Co-teaching therefore provides an opportunity for teachers to be exposed to different teaching philosophies, techniques and methods. It helps

them develop into more effective teachers as they are able to nurture and develop their own teaching practices. Co-teaching can therefore positively affect the general educator's instructional behaviour.

- Co-teaching develops teamwork skills. When teachers work as a team, they share responsibility, have autonomy and authority over their classes, and are better able to solve any problems that arise.
- Teachers can be motivational for one another. Co-teaching helps promote an open exchange of ideas, and experiences and encourages risk-taking.
- Planning together cuts down on individual planning time.

If co-teaching has such a positive impact on both the learners and the teachers, why has this teaching approach not been more widely used in the classroom?

2.5.5 Barriers to co-teaching

According to an editorial by Lawton (1999) teachers are sometimes resistant to the idea of having another adult in the classroom. Consequently, to work effectively co-teaching must be a partnership with each teacher given specific responsibilities agreed upon by the teachers involved.

Some of the barriers to successful co-teaching include the following (DeLuca et al, 2010):

- Lack of administrative support.
- Lack of shared planning time.
- Personalities of the two teachers do not match - a good relationship between co-teachers is critical for success.
- Misguided perceptions or lack of communication between the teachers.
- Poorly defined roles or unclear expectations of the teachers.

Obviously no single co-teaching approach works for everyone in each lesson. Teachers must learn to make use of the flexibility co-teaching offers, and together choose the best teaching methods and co-teaching model for each lesson. These choices should be based upon the learner's needs, teachers' personalities, schedule and lesson content (Abdallah 2009). Finding co-teaching arrangements that work for

each of the settings in which you teach is vitally important, otherwise the special needs teacher risks settling into a passive role or serving primarily as a teacher assistant, and their professional knowledge and skills are not used effectively (Cramer & Stivers 2007:7).

2.6 Effects of teaching approaches on learner outcomes

In a time when learner populations become more diverse, Tomlinson (2003:10) is surprised that questions are asked such as, "What is the right label for the child? Is the general classroom best or is a resource setting preferable? Should specialists focus their energies on learners or teachers?" Tomlinson warns that these questions lead nowhere, and labels often stigmatise without offering a counterbalancing benefit. Tomlinson therefore argues for thoughtful differentiation in all settings. This is supported by Rose, Fergusson, Coles, Byers and Banes (1996:119) who suggest that if teaching approaches are to be effective they should accommodate and encourage a variety of learning styles through a balanced range of learning opportunities.

Tomlinson (2003:11) suggests, that if we reframe the questions, a massive shift might occur in how decisions are made on behalf of academically diverse learners. For example, instead of asking "What deficits?" the question should be "What strengths?" She suggests that the question that might best serve diverse learners, their teachers and society is "What can we do to support educators in developing the skill and the will to teach for each learner's equity of access to excellence?" Educators should therefore examine teaching methods that help answer this question.

Tomlinson and McTighe (2006:184) suggest that each teacher and each school has the responsibility to study the effects of particular models of teaching on their own learners. The co-teaching strategy is becoming a more desirable and feasible option in diverse classrooms and can meet the needs of learners with or without disabilities in a secondary class (Murawski & Dieker 2004:52). The special needs teacher and the subject teacher help one another by providing different areas of expertise that, when joined together correctly, can result in improved instruction for all the learners.

While research literature provides an extensive rationale for why collaboration and

professional learning communities should occur, the relationship between collaborative work and the effect on learner achievement is not always clear. The research question guiding this study investigates whether a specific form of teacher collaboration, namely co-teaching, compares with gains in academic achievement for all the learners in a grade 9 natural science class at the ISK.

2.6.1 Research that supports co-teaching

Austin (2001:250) administered a survey in nine school districts in northern New Jersey USA to both general and special education teachers who were in co-teaching partnerships. Austin (2001:253) found that the majority of the teachers supported co-teaching because of the reduced learner to teacher ratio, the benefits of another teacher's expertise in the classroom, the value of remedial strategies for all the learners, and the opportunity for the learners without learning difficulties to gain acceptance for those learners who find learning difficult. A significant portion of both the general and special education teachers were of the opinion that the general education teacher did the most in the classroom, with the special education teacher being mainly responsible for the modifications of the lessons while the general education teacher was mainly responsible for the planning and instruction. Although the teachers believed that learners performed better due to the co-teaching, no evidence of this could be provided. Austin (2001:254) notes that more research is needed regarding the effects of collaboration on learner outcomes.

Gerber and Popp (1999:288-297) conducted interviews to investigate the views of learners and of their parents regarding co-teaching. According to the data, the learners and parents considered co-teaching as effective. Many of the learners in their study believed they were doing better academically and parents of learners who had difficulty with other forms of teaching reported that their children improved in their grades and self-esteem. Learners also reported that they could not get away with as much misbehaviour because there were two teachers in the classroom. Overall their study reported very positive perceptions of co-teaching. However there were also a few areas of concern.

2.6.2 Research that questions the efficacy of co-teaching

In Gerber and Popp's (1999:296) study there were reports of frustration and confusion experienced by some learners whose teachers offered different explanations or talked at the same time during the lesson. Gerber and Popp (1999:293) suggest that this might be a result of different levels of commitment by the teachers to the collaborative process to maintain adequate and effective planning time. From Kusuma-Powell and Powell's (2000:72) perspective most schools have accepted that co-teaching between teachers is a positive development in meeting the educational needs of all learners, however, many schools only pay lip service to it.

The limited research that has been carried out on effective teaching approaches in inclusive classrooms tends to focus on the primary years and when Florian and Rouse (2001:140) investigated what happened when subject teachers in high schools attempted to create the conditions for inclusive learning in their classrooms, they found that three quarters of the teachers were familiar with co-teaching, but only twenty five per cent used it. The main reason given for this is that co-teaching it is difficult to organise. All the teachers Florian and Rouse (2001:145) interviewed recognised the special needs specialist as a source of knowledge and support for learning and teaching in diverse classrooms.

Friend (1993:10) suggests that whether or not co-teaching will become a widely accepted practice in the future will depend on several issues, such as the cost of having two qualified professionals planning and sharing a group of learners that can be taught by one teacher, the number of professionals involved in a single classroom, the effectiveness of co-teaching for all the learners in the class, the amount of time spent in the co-teaching structure, and school scheduling. Friend (1993:11) concluded that co-teaching is one promising approach for supporting learners with special needs in a general education classroom. However, until there is more knowledge regarding co-teaching, Friend (1993:11) warns that co-teaching should be explored optimistically, yet cautiously.

Some schools have suggested that collaboration is the 'Silver Bullet' that is going to 'fix' the system, however, Nelson and Landel (2009) argue that co-teaching is a

necessary element, among many, present in schools that are successfully increasing learner achievement. They concluded that all collaborative processes are complex social activities that should be evidence-based when used to explain and predict classroom outcomes.

So far, most of the research on co-teaching has focused on the process of co-teaching rather than the effects on learner achievement for either special needs or regular education learners (Lawton 1999). DuFour (2003a:64) suggests that the effectiveness of any collaborative process should be assessed on results rather than perceptions, and *evidence of learner achievement should be used as a barometer of its success*. The focus shifts from teacher inputs to learner outcomes and evidence that the learners are learning at higher levels. According to DuFour (2004:8) a simple shift from a focus on teaching to a focus on learning has profound implications for schools. The focus of this research will evaluate both short-term and long-term learner understanding of grade 9 natural science learners using both an individual teaching approach and a co-teaching approach.

2.7 Concluding remarks

Teachers are faced with many challenges when trying to deal with all the learner needs in heterogeneous classrooms. No single teacher has the expertise to meet the needs of all the learners in a classroom. The literature contains many positive comments about collaboration benefiting both the learners and teachers. However, it fails to demonstrate a strong relationship between a specific system of collaboration and learner achievement. The specific form of teacher collaboration under investigation in this study is co-teaching where both a special needs teacher and high school science teacher are responsible for the planning and delivery of the lesson, learner achievement, assessment, and discipline.

The research examines if there is improved instruction for all the learners in a heterogeneous grade 9 natural science class at the ISK in Nairobi when lessons were co-taught. The learners were interviewed in an attempt to understand their views about whether or not the lessons were differentiated for their individual needs, their individual learning styles, the study skills used when preparing for tests and how the

presence of another teacher in the classroom affected them. In order to ascertain how effective and enduring learning is, the learner grades were analysed for both short term and long-term learning (four months later).

The research is a case study using a phenomenological approach. The research was evaluated for one group of eighteen grade 9 natural science learners in 2009. After the process was assessed and adjusted, the research was repeated using another group of twenty two grade 9 natural science learners in 2010. An overview of the methodology employed is discussed further in the next chapter.

Chapter 3
Research Design

3.1 Introduction

This researcher agrees with Grosvenor and Rose (2001a:10) that educational research does matter and teachers as researchers can make a difference. Beveridge (2001:259) discusses the advantages teachers have over outside researchers when it comes to the investigation of practice in their own school settings. These advantages include the wealth of background knowledge and experience of the context of their study, familiarity with school policies and procedures, and teachers usually have built up relationships of trust with those who may be involved in the research. However, there are also disadvantages that can arise from knowing the setting so well. One of the biggest challenges is probably objectivity, and the teacher researcher must be able to see things from a range of different viewpoints, rather than those that fit with the teacher's perspective (Beveridge 2001:259).

Innovations by some teachers have brought about positive changes into classroom practices, for example, research cited in Grosvenor and Rose (2001a:7), which focused on learner diversity and identified teaching approaches that promoted inclusion and access, has enabled some learners to receive a better quality of education than had previously been possible. Vulliamy and Webb (cited in Grosvenor & Rose 2001a:6) proposes that teachers should be more involved in qualitative studies that consider intervention approaches, studies of influences on learner performances and an analysis of classroom structures and their potential impact on learning.

In order to understand the research methods needed for this research study, it is necessary to revisit the rationale for conducting this research. The purpose of this research was to determine if the learning for a diverse group of grade 9 natural science learners would be more effective and enduring when delivered through a collaborative co-teaching approach involving a high school science teacher and a

special needs teacher. A mixed methods research design was used with statistical analysis of the learner's test results and a qualitative narrative account. With a focus on in-depth investigation, a case study is appropriate to this inquiry and introduced through action research, as it allows for the variety of data collection necessary to assess the impact of the co-teaching approach on the learning of all the learners in a heterogeneous class.

3.2 Case Study

In this research a case study approach is described. Yin (1984:23) defines the case study research method as "...an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used." According to Zainal (2007:1) a case study "enables a researcher to closely examine the data within a specific context". Stake (1978:5) argues that case studies "help people towards further understandings, in a way that accommodates their present understandings."

As discussed in chapter one there are both advantages and disadvantages to case study research. It is considered by some researchers in methodology as a kind of 'soft-option', however Robson (2002:180) states that "a case study is not a flawed experimental design, it is a fundamentally different research strategy with its own designs." According to Zainal (2007:5) case studies are considered useful in research as they present data of real-life situations and provide better insights into the detailed behaviours of the subjects of interest; but they have been criticised for their lack of rigour and the tendency for a researcher to have a biased interpretation of the data. Stake (1978:7) also argues that although case studies are at a disadvantage where explanation and predictive laws are the aims of research, they have an advantage where researchers are aiming for understanding or the extension of experience.

In this research the efficacy of the co-teaching approach is under investigation and therefore no predictive laws or explanations are sought. The disadvantages of case study research were carefully considered, and the potential researcher bias was minimised by getting another teacher to interview the learners. The two advantages of

case study research suggested by Edwards and Talbot (1999:56) that definitely apply to this research are that it allows a focus on the understandings of the learners in the case, giving an opportunity for the voices of the learners to be heard, and it provides readable data that brings research to life and are true to the concerns and meanings under investigation.

3.3 Action Research

According to Ferrance (2000:1) “action research specifically refers to a disciplined inquiry done by a teacher with the intent that the research will inform and change his or her practices in the future.” Action research therefore allows a researcher to study teaching practices and the proficiencies of the learners in the classroom. Stenhouse (1981:112) believes that it is through action research that teachers can be at the centre of educational research. Action research therefore “happens at the place where questions arise about how learners learn or what educators can do to improve practice; it happens where the real action is taking place and it allows for immediate action, and can serve as a chance to really take a look at one’s own teaching in a structured manner” (Ferrance 2000:30).

In conducting action research, there are usually five phases of inquiry (Ferrance 2000:9):

1. Identification of the problem area
2. Collection and organisation of the data
3. Interpretation of the data
4. Action based on the data
5. Reflection

The process begins with the development of questions, which may be answered by the collection of data. The researcher acts as the collector of the data, the analyst and the interpreter of the data. The findings are interpreted in light of how successful the action has been. At this point, the problem is reassessed and the process begins another cycle. The action research cycle is shown in the diagram on the next page:

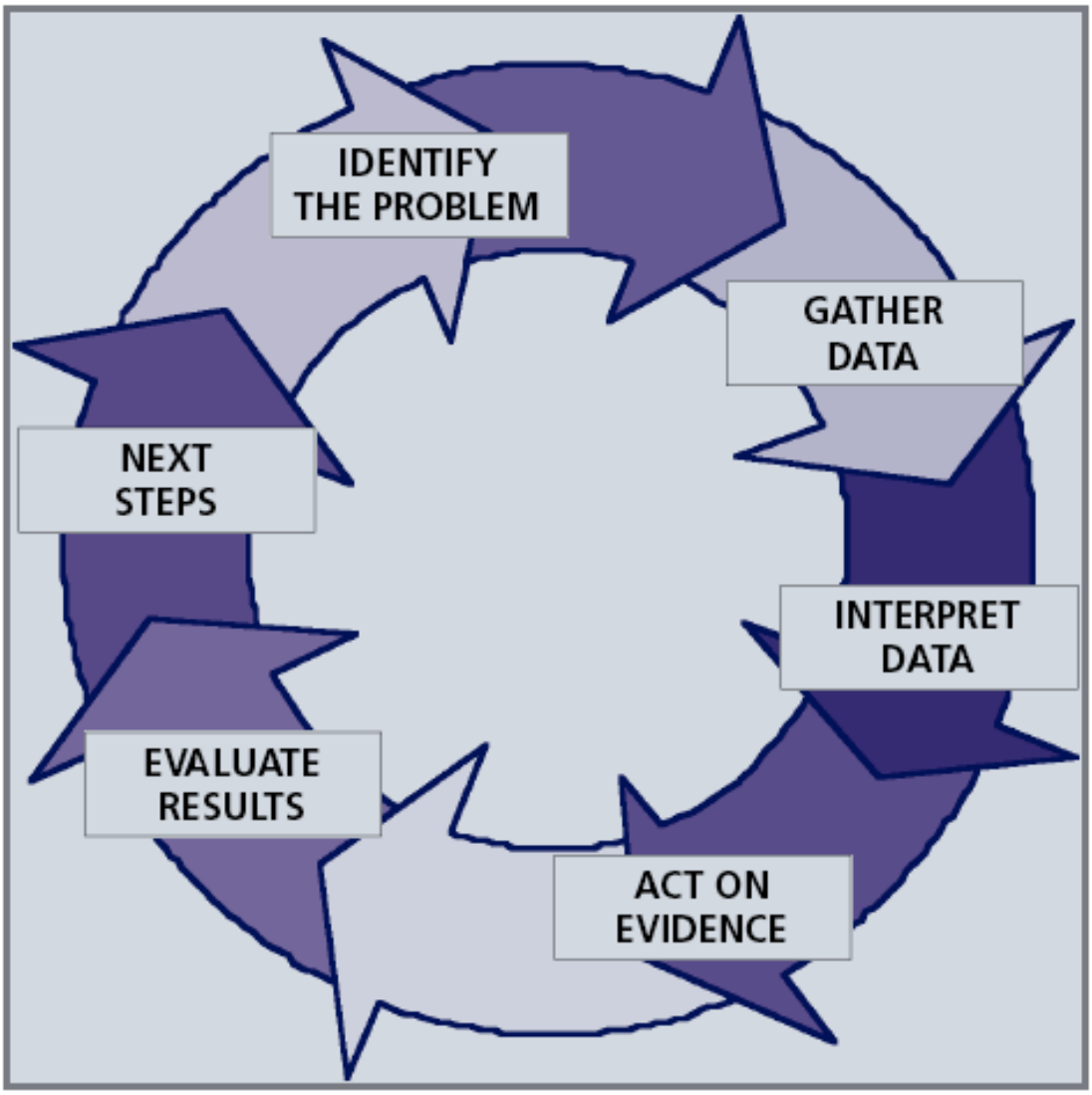


Diagram 1: Action Research Cycle (Ferrance 2000:9).

This research aims to examine current practices, which suggests that action research is a valid approach. There is a 'teacher as researcher' model in action research where the teacher identifies a problem, formulates a hypothesis, tests the hypothesis, acquires feedback and, if possible, improves practice (Bell 1999:9). As discussed in chapter one there are both advantages and disadvantages to undertaking action research. It is a favoured approach in education because of the ability it provides to focus on specific issues (Rose & Grosvenor 2001a:15).

As action research gives one the opportunity to try out an intervention, assess how it is received or how effective it is, adjust and introduce the proposed changes, two experimental groups were considered in this research.

3.4 First Experimental Group

The new academic school year of the ISK began in August 2008, and one grade 9 natural science class was chosen for the research study. There were eighteen learners in the class, two of which (numbers 4 and 17) speak English as a second language and were part of the English as a Second Language program (ESL) attending two ESL sessions a week. Three of the learners (numbers 1, 6 and 18) had been assessed by an educational psychologist and were supported once a week by the Learning Resource Centre (LRC) (see Appendix 1 for 'individual education programs' (IEP's) of learners 1, 6 and 18). Two of the learners (numbers 7 and 16) had been referred by teachers as having learning difficulties. However, parent permission for further testing was not obtained, so the Student Support Services (SSS) department did not support these learners.

Once the research proposal was approved, permission to carry out the research at the school was first obtained from the administrator of the high school of the ISK (see Appendix 2 for the permission letter from the ISK). All learners in the grade 9 natural science class were asked to participate in the research and permission was then obtained from the learners' parents since they are all minors (see Appendix 3 for the letter written to learners' parents). The consent forms provided information about the research design and also outlined anonymity and confidentiality. The parents also had the opportunity to discuss the research at a parent-teacher conference in October 2008. All the parents of the learners in the grade 9 natural science class gave permission for their children to participate in the research. Data collection and analysis began in early 2009.

3.4.1 Preparation for the research

Once the administrator of the high school of the ISK approved the proposed research project and permission was obtained from the parents of the learners in the chosen grade 9 natural science class, the special needs teacher observed the class for a few lessons in November 2008 to gain an understanding of the researcher's style of teaching and to get an insight into the learners in the class. We felt this was important as according to Powell and Kusuma-Powell (2007b:35) one of the keys to

differentiation is “knowing the learners in your class”. During this time the special needs teacher was introduced to the class and the concept of co-teaching was explained to the learners.

3.4.2 Teaching approach without collaboration

At the beginning of 2009, five lessons on ‘Soil formation’ were planned and taught by the researcher, who is a high school science teacher (see Appendix 4 for the lesson plans). The special needs teacher was not present and had no influence on the planning stage, instruction or assessment phase of the lessons. The researcher carefully considered the information available in the literature on differentiation and the individual learners in the class.

The lesson plans are simply a framework of the essential content, principles and skills that needed to be covered. Factors such as learner interests, learner readiness levels and needs were woven into the lessons. The lesson plans are organised yet flexible enough to adjust teaching depending on where the learners are in their understanding and interests. After the six lessons on ‘Soil formation’ the learners wrote a summative test to determine their understanding (see Appendix 5 for the test on ‘Soil formation’). The learners were then interviewed on a one-to-one basis, in an attempt to understand their views.

According to Edwards and Talbot (1999:101) interviews have the following advantages:

- You get a hundred per cent response rate to your questions
- You can probe and explore meanings and interpretations held by participants
- You hear the language and concerns of the participants
- Participants usually enjoy them
- They yield good rich data

A major advantage of the interview is therefore its adaptability because a response can be developed and clarified. However, interviews are time-consuming and it is a highly subjective technique and therefore there is always the danger of bias (Bell

1999:135). According to Edwards and Talbot (1999:101) the main disadvantages of using interviews are the following:

- Interviews are time-consuming
- They can be an intrusion into the lives of the participants as your probing may go too far
- The analysis of the interview data can be endless
- Arranging the interviews can be a chore
- You might be able to get the information you need from a questionnaire
- They need to be done well

According to Bell (1999:135) the more standardised the interview, the easier it is to combine and quantify the results. A semi-structured format was used, which according to Rose and Grosvenor (2001b:112) allows a greater role for the interviewer in terms of asking for clarification and elaboration. The interview guide was constructed from a comprehensive literature review and input from the special needs teacher. The purpose of the interview is to hear the views of the learners, so the learners were asked open-ended questions. Another teacher conducted the interviews in order to remove researcher bias and to encourage learners to be as honest as possible. Each learner was asked the following fifteen questions after the lessons and test on 'Soil formation':

1) Is there anything about the way your teacher teaches that helps you learn?
2) Is there variety in the way your teacher teaches? Explain.
3) Do you feel your lessons are organized and have a clear structure?
4) Does the range of materials used in lessons (such as white boards, overheads, worksheets, animations, and laboratory investigations) help you or confuse you in lessons? Explain.
5) Does your teacher help you to review a topic effectively? Explain.
6) If you don't understand something in class, do you try to find out what you have not understood? If so, how do you do it?
7) Do you think you are good at taking notes? Explain.
8) When you are trying to answer a question in a test
   a) can you picture where the answer is written in your notes, &/or
   b) do you remember what your teacher said, &/or

c) do you remember it in your head?

9) Explain how you prepare for a test?
10) Explain how you will prepare for a test on this topic four months from now?
11) Do you understand something better if you read your notes aloud or read them silently?
12) When you are given instructions in a lab, is it easier to understand what you need to do by:
    a) reading the written instructions, &/or,
    b) watching the teacher demonstration, &/or,
    c) by following what your classmates are doing?
13) Have you learnt how to use your learning strengths? Explain.
14) Have you noticed if your classmates take notes in a different way to you? If so, how are they different?
15) Have you ever experimented with different ways of note taking, learning or preparing for a test? Explain.

The following questions were added after the collaborative co-teaching approach in order to understand how the learner's felt about having another teacher in the classroom, and if the other teacher had helped them:

16) Did it help you or distract you having another teacher involved in the lesson? Explain.
17) If you can, please give an example of a strategy or technique used by the other teacher that helped you understand the work better.

The summaries of the main points of the interviews then became the starting points for comparative case analysis and the discussion of themes (Edwards & Talbot 1999:179). The four main themes that were considered during the interviews were differentiation, study skills, learning styles and the collaborative co-teaching approach:

- The first six interview questions were aimed at determining if the lessons were differentiated for the learners' individual needs.
- Interview questions 7 to 10 were asked to gain some understanding of the learners' study skills.

- Interview questions 11 to 15 determined if learners had an understanding of their individual learning styles and if they were able to recognise different learning styles.
- Interview questions 16 and 17 were asked to determine the learners' views on the co-teaching approach.

The views of the learners regarding these four themes, addressed the second aim of the research. All the interviews were audiotaped and transcribed for data analysis.

3.4.3 Teaching approach with collaboration

The five lessons and test on 'Soil formation' were followed by six lessons on 'Soil productivity', which were planned and co-taught with the special needs teacher (see Appendix 6 for the lesson plans).

The researcher and the special needs teacher followed a similar process to the one outlined in Villa and Thousand (1995:82-84) as to how the teaching partnership evolved:

- *Planning Time*: A regular planning time was established. As mentioned in the literature review, one of the benefits of co-teaching is that teachers bring different areas of expertise. These diverse skills are helpful during the planning stage as both teachers can find ways to use their strengths to ensure that the lesson is appropriately differentiated for a diverse range of learners. The planning time focused on deciding which instructional techniques were going to be the most effective in helping the learners meet the content standards. This researcher found that the special needs teacher considered the learning styles of all the learners in the class and also highlighted the weaknesses and strengths of those learners who had an IEP. This input was valuable when planning the lessons.
- *Setting goals*: The long-range goals of each lesson and the lesson objectives were discussed. Backward design was employed when planning the lessons, which first identified the desired results, then determined acceptable evidence of learning, followed by planning the learning experiences and instruction (Wiggins & McTighe 2000:8). Identifying the methods and assessments to be used in the lessons addressed the first aim of this research.

- *Defining roles*: The co-teaching approaches, which would be most effective in delivering the material to the learners, were carefully considered. The co-teaching approaches used included 'one teacher, one support', 'team teaching' and 'station teaching'. In the 'one teacher, one support' format, we alternated roles between the support teacher and the lead teacher. For example, when the researcher was explaining a concept, the special needs teacher wrote the key points on the board, asked aloud questions learners may have felt shy about asking or questions needed for clarification, provided on-the-spot help for learners, and explained techniques for remembering the concepts being discussed. The 'station teaching' format was used during laboratory and project work. The learners were positioned at different stations and both teachers moved between the groups in order to provide support. In the 'team teaching' arrangement both teachers shared the process of instructing all the learners. This organisation allowed both teachers to blend their teaching styles and expertise; however, it required more planning and higher levels of trust and commitment. During the instructing phase, as suggested by Murawski and Dieker (2004:56), unobtrusive signals to communicate teacher to teacher were developed, learners were given time to process information, which also gave the teachers an opportunity to discuss how the lesson was going. The special needs teacher discussed learning style preferences and gave examples of different ways of remembering some of the concepts.
- *Being accountable*: Once the teachers' roles were defined, the teachers helped build further trust by following through on their commitments. The special needs teacher attended every planning session and the six class lessons.
- *Reflection*: After each lesson time was set aside to discuss how the lesson went and areas for further development were identified. The teachers reflected on learner performance, their teaching and their progress as a team. The teachers incorporated the seven norms of collaboration suggested by Garmston and Wellman (1998: 32), namely; promoting a spirit of inquiry, pausing, paraphrasing, probing, putting forward ideas, paying attention to self and others, and most importantly, presuming positive intentions.

After the collaborative co-taught lessons on ‘Soil productivity’, the learners wrote a test to determine their understanding (see Appendix 7 for the test on ‘Soil productivity’). The learners were then interviewed on a one-to-one basis, in an attempt to understand their views.

After four months, the learners wrote a multiple choice test on ‘Soil formation’ and ‘Soil productivity’ (see Appendix 8 for the multiple choice test). After the test the learners were also asked to answer the following question:
Did you use any of the learning strategies the special needs teacher taught you to study for this test? If yes, explain which strategies you used. If no, explain why not?

The grades for all the tests were compared with the grades achieved for the same tests of another grade 9 natural science class that had been taught by the researcher but without the collaboration of the special needs teacher. For the purposes of this research, this grade 9 natural science class constituted a control group.

3.5 Control Group

The control group was a grade 9 natural science class that was taught by the researcher. The learners taught the same topics as the first experimental group; however, there was no collaboration with a special needs teacher in any aspect of the lessons. The control group was composed of sixteen grade 9 science learners. There were no ESL learners in the class, however, two of the learners (numbers 8 and 16) had been assessed by an educational psychologist and were supported once a week by the Learning Resource Centre (LRC).

The same lesson plans were used for the five lessons on ‘Soil formation’ as those used for the first experimental group. After the six lessons on ‘Soil formation’ the learners wrote the same test as the first experimental group. This was followed with six lessons on ‘Soil productivity’. The lesson plans used for these lessons were similar to those used with the first experimental group, except there was no contribution by the special needs teacher in the planning, delivery or assessment of the lessons. After the six lessons, the learners wrote the same test as the first experimental group. After four

months, the learners wrote the same multiple choice test on ‘Soil formation’ and ‘Soil productivity’ that was used by the first experimental group.

The results of all the tests written by the control group were analysed and compared with the results of the first experimental group. This helped to address the third aim of this research in determining the effectiveness of learning through the collaborative co-teaching and the individual approach by analysing the learner grades for short and long term (four months later) understanding and retention of concepts.

3.6 Second Experimental Group

After analysing the results from the first experimental group and the control group, the same researcher and special needs teacher conducted the research again in 2010 using another grade 9 natural science class. There were twenty-two learners in the class, two of which (numbers 1 and 2) had been assessed by an educational psychologist and were supported once a week by the Learning Resource Centre (LRC) (see Appendix 9 for ‘individual education programs’ (IEP’s) of learners 1 and 2). There were no ESL learners in the class. The necessary permission was obtained from the school and the parents. All the parents of the learners in the grade 9 natural science class gave their permission for the learners to participate in the research, and data collection and analysis began early in 2010.

The same five lessons on ‘Soil formation’ that were used in the first experimental group were taught by the researcher, and the special needs teacher was not present and had no influence on the planning stage, instruction or assessment phase of the lessons. After the five lessons on ‘Soil formation’ the learners wrote the same test as the first experimental group. The learners were then interviewed on a one-to-one basis.

The same six lessons on ‘Soil productivity’ were planned and co-taught with the same special needs teacher who collaborated in the first experimental group. The researcher and the special needs teacher followed a similar process to the one outlined in Villa and Thousand (1995:84-86) for sustaining trust in the second year of a teaching partnership:

- *Reinforcement of teaming*: The researcher and the special needs teacher were able to reinforce the foundation that had been built in the first experimental group. This relationship reduced the variables involved in the research allowing the independent variable to remain focused on the experiences of the learners and not the teachers involved.
- *Planning*: The planning time remained an essential aspect of the process and the meetings continued to follow a structured format. These times also allowed the teachers to reflect on the process used in the first experimental group and consider possible improvements.
- *Revisiting goals*: The teachers remained aware of the goal of ensuring that all the learners in the class received the appropriate instruction.
- *Redefining roles:* The teachers continued to define their roles along the boundaries of individual expertise, with the researcher focusing on the science content to be taught and the special needs teacher focusing on how to modify the science content to meet the learners' individual needs. The co-teaching approaches used were similar to the ones used in the first experimental group.
- *Maintaining accountability*: The teachers maintained a high level of commitment and were well aware of their roles. Despite having done this process once before, both teachers attended all the planning sessions and followed through on their responsibilities.
- *Reflection*: As a result of having developed a high level of trust, the teachers openly discussed their teaching and progress as a team. These discussions can be difficult, but usually yield tremendous results both individually and as a team, including increased trust and risk taking (Villla & Thousand 1995:86).

After the collaborative co-taught lessons on 'Soil productivity', the learners wrote the same test as the first experimental group to determine their understanding. The learners were then interviewed on a one-to-one basis in an attempt to understand the learners' views.

After four months, the learners wrote the same multiple choice test as the first experimental group on 'Soil formation' and 'Soil productivity'. After the test the

learners were asked if they had used any of the learning strategies the special needs teacher had taught them to study for this test.

3.7 Concluding remarks

A mixed research design was used in this research. The research is a case study using a phenomenological approach, which involves interviewing the learners and evaluating both short term and long term learning (four months later) by analysing the learners' grades. In this research, the effectiveness of co-teaching involving a high school science teacher and a special needs teacher is considered. The teaching was reflected upon and adjusted and used again through an action research model to evaluate the effectiveness of the co-teaching approach for another class of grade 9 natural science learners. The grades for the tests in the two experimental groups were recorded and compared with the grades in the control group, with each other and with those of particular learners within the experimental groups. Chapter four includes the findings and a discussion of these findings.

Chapter 4
Results and Discussion of Results

4.1 Introduction

The system of collaboration that is examined in this research is co-teaching where both the science teacher and the special needs teacher share the responsibility to teach all the learners in an inclusive grade 9 natural science classroom. Both teachers were responsible for the planning and delivery of the lessons, assessment, and discipline. According to Murawski and Dieker (2004:52) the co-teaching strategy is becoming a more desirable and feasible option in diverse classrooms and can meet the needs of learners with or without disabilities in a secondary class. However, as Lawton (1999) warns co-teachers must focus not only on how well they are co-teaching, but also on how well the learners are learning. As Dufour (2003a:64) suggests, the effectiveness of the collaborative process should be assessed on results rather than perceptions. This research examines whether co-teaching improves learner achievement. In this research the test results of the two experimental groups that were co-taught and the control group that was not co-taught, were recorded and analysed.

4.2 Test results

The two experimental groups were both co-taught for the six lessons on ‘Soil productivity’. Prior to the co-taught lessons, five lessons on ‘Soil formation’ were planned and taught only by the researcher. The control group was taught only by the researcher for both topics. The learners wrote a test after each topic and another test on each topic four months after the co-taught lessons.

The results of the four tests for all the learners in the control group and the two experimental groups on ‘Soil formation’ and ‘Soil productivity’ are recorded in the tables below. Adding all the scores and dividing by the number of learners in each group calculated the mean for each test. The mean of each test was rounded off to two decimal places and recorded at the bottom of each table.

The standard deviation (s) was calculated as a square root of variance, and is a measure of the dispersion of a set of data from its mean. The more spread apart the data, the higher the deviation. The standard deviation for each test was also rounded to two decimal places and recorded at the bottom of each table. The mean and standard deviations were calculated using an Excel program.

Table 4.1: Control group results

Learner	Soil Formation Test (%)	Soil Formation Test - 4 months later (%)	Soil Productivity Test (%)	Soil Productivity Test - 4 months later (%)
1	66	70	84	80
2	86	80	83	70
3	63	80	83	90
4	77	70	83	80
5	71	80	79	80
6	63	50	73	80
7	77	80	86	90
8 LRC	83	80	80	80
9	93	70	89	80
10	77	90	91	90
11	57	70	51	60
12	98	100	94	100
13	73	70	60	70
14	89	80	86	80
15	89	90	86	90
16 LRC	77	90	54	70
Mean	77.44	78.75	78.88	80.63
s	11.73	11.47	12.90	9.98

Table 4.2: First experimental group results

Learner	Soil Formation Test (%)	Soil Formation Test - 4 months later (%)	Co-taught Soil Productivity Test (%)	Soil Productivity Test - 4 months later (%)
1 LRC	61	80	81	60
2	70	70	77	70
3	79	90	77	60
4 ESL	66	80	76	60
5	86	90	84	90
6 LRC	57	90	77	80
7 referred	44	60	50	80
8	66	70	70	90
9	66	70	71	90
10	69	90	74	90
11	80	80	74	90
12	80	90	76	90
13	70	70	61	70
14	40	50	56	60
15	71	70	91	90
16referred	73	70	81	50
17 ESL	54	80	56	70
18 LRC	54	50	71	70
Mean	65.89	73.89	72.39	75.56
s	12.44	14.61	10.58	13.81

Table 4.3: Second experimental group results

Learner	Soil Formation Test (%)	Soil Formation Test - 4 months later (%)	Co-taught Soil Productivity Test (%)	Soil Productivity Test - 4 months later (%)
1 LRC	69	80	66	60
2 LRC	66	80	61	80
3	86	70	80	90
4	87	80	80	70
5	83	80	86	90
6	60	70	83	60
7	64	80	77	70
8	81	100	90	90
9	74	80	70	70
10	94	90	84	90
11	83	100	80	80
12	94	90	77	80
13	77	80	73	60
14	89	100	64	70
15	83	80	83	80
16	86	90	77	80
17	69	90	71	60
18	83	60	70	60
19	77	90	70	90
20	97	90	91	70
21	80	80	69	60
22	91	90	71	90
Mean	80.59	83.64	75.59	74.09
s	10.19	11.36	8.82	12.21

4.3 Analysis of results

Normally distributed data follows a bell-shaped curve with 68% of the data falling within one standard deviation of the mean, 95% of the data falling within two standard deviations and 99% of the data falling within three standard deviations. The standard deviation can be used to help decide whether the difference between two means is likely to be significant. If the standard deviations are much less than the difference in the mean values, it is very likely that the difference in the mean values is significant.

In research it is often less clear whether differences between means are significant and a t-test should be used to determine whether there is a significant difference between the means of two groups. A difference is considered statistically significant if the probability of it being due to random variation is 5% or less. For the purposes of this research the level of significance chosen will be 5%. The larger the difference between the means, the larger t is, and the larger the standard deviation, the smaller t is. If the calculated value of t is higher than the critical value for t, then there is evidence of a significant difference between the means. The calculated t values were calculated using an Excel program, and the degrees of freedom for the critical values are the sum of the learners in both groups minus 2.

4.3.1 Analysis of the co-teaching lessons.

If the learners in the experimental groups benefitted from the exposure to the skills, ideas and energy of having two teachers in the class then you could expect an increase in the grades on the ‘Soil productivity’ test compared with the grades for the ‘Soil formation’ test, since only the topic on ‘Soil productivity’ was co-taught. In order to ascertain if the results of these two tests are significant the difference in the means are compared with the standard deviations of the tests, and the calculated and critical values for t in the t-test are also compared at 5% probability levels.

Table 4.4: Differences in the means, standard deviations and t values for the tests on 'Soil formation' and 'Soil productivity' for all the groups

	Soil Formation Test	Soil Productivity Test	Difference in the means
Control Group:			
Mean	77.44	78.88	1.44
s	11.73	12.90	
Calculated value of t	0.74		
Critical value of t	2.04		
First Experimental Group:		**Co-taught**	
Mean	65.89	72.39	6.50
s	12.44	10.58	
Calculated value of t	0.10		
Critical value of t	2.04		
Second Experimental Group:		**Co-taught**	
Mean	80.59	75.59	5.00
s	10.19	8.82	
Calculated value of t	0.09		
Critical value of t	2.02		

In all the groups the standard deviations are much greater than the difference in the mean results of the tests, and it is therefore very unlikely that the difference in the mean results of these tests is significant. This is confirmed using the t test because the calculated value of t is much smaller than the critical value, so the difference between the means is not significant. These results therefore suggest that co-teaching did not significantly help the learners in the experimental groups.

4.3.2 Analysis of learning strategies that were taught by the special needs teacher

The control group was not formally taught any learning strategies for any of the tests. Learners in the two experimental groups were not shown any study skills prior to writing the first test on 'Soil formation'. However, during the co-taught lessons on 'Soil productivity' the special needs teacher taught the learners strategies that they could use when studying for tests. When studying for the second test on 'Soil

formation' that was written four months later, the learners could have used some of these strategies.

Since the special needs teacher taught study skills during the collaborative lessons, a comparison of the test on 'Soil formation' (when the learners had not been taught learning strategies) and the test written four months later on the same topic (after the learners had been taught learning strategies) could be used as an indicator of the special needs teacher influence in the co-taught lessons.

Table 4.5: Differences in the means, standard deviations and t values for the 'Soil formation' tests for all the groups

	Soil Formation Test	Soil Formation Test – 4 months later	Difference in the means
Control Group:			
Mean	77.44	78.75	1.31
s	11.73	11.47	
Calculated value of t	0.75		
Critical value of t	2.04		
First Experimental Group:			
Mean	65.89	73.89	8.00
s	12.44	14.61	
Calculated value of t	0.09		
Critical value of t	2.04		
Second Experimental Group:			
Mean	80.59	83.64	3.05
s	10.19	11.36	
Calculated value of t	0.35		
Critical value of t	2.02		

In all the groups the calculated value of t is much smaller than the critical value. It is therefore unlikely that the difference in the mean results of these tests is significant. These results again suggest that the learners in the experimental groups did not benefit significantly from the learning strategies that were taught by the special needs teacher during the collaborative co-teaching lessons and that learners probably used their usual learning strategies for both tests.

4.3.3 Analysis of long term understanding.

To determine if the learners' long term understanding of concepts improved as a result of learning strategies that the experimental groups learnt during the co-taught lessons, a comparison was made between the test results on the topic on 'Soil productivity' and the test written four months later on the same topic.

Table 4.6: Differences in the means, standard deviations and t values for the 'Soil productivity' tests for all the groups

	Soil Productivity Test	**Soil Productivity Test – 4 months later**	**Difference in the means**
Control Group:			
Mean	78.88	80.63	1.75
s	12.90	9.98	
Calculated value of t	0.67		
Critical value of t	2.04		
First Experimental Group:	**Co-taught**		
Mean	72.39	75.56	3.17
s	10.58	13.81	
Calculated value of t	0.45		
Critical value of t	2.04		
Second Experimental Group:	**Co-taught**		
Mean	75.59	74.09	1.50
s	8.82	12.21	
Calculated value of t	0.64		
Critical value of t	2.02		

In all the groups the calculated value of t is much smaller than the critical value. It is therefore unlikely that the difference in the mean results of these tests is significant. The learners employing similar strategies when studying for these tests could explain the small differences in the means of the two tests on 'Soil productivity' in all the groups.

4.3.4 Analysis of the learners with special needs requirements

None of the group results appear to be significant. One possible explanation could be that the experimental groups had different numbers of learners with special needs requirements and this could have influenced the results. There were only two LRC learners in the second experimental group, whereas there were five LRC (two of whom had been referred by teachers as having learning difficulties) and two ESL learners in the first experimental group. These were the only learners that had individual education programs (IEPs) and the special needs teacher had a deep knowledge of these learners and how they learn best. In order to determine if the special needs teacher had an effect on these learners, a t-test was used to determine whether or not there is a significant difference between these learners i.e. the special needs individuals and the other learners in the same class who were together during the lesson.

In order to examine the effect of co-teaching on the different types of learners, the test results for ‘Soil formation’ that was not co-taught was compared to the results of the test on ‘Soil productivity’ that was co-taught in the two experimental groups.

Table 4.7: Differences in the means, standard deviations and t values for the 'Soil formation' and 'Soil productivity' tests for the learners with special needs requirements and those without special needs requirements in the first experimental group

	Soil Formation Test (%)	Soil Productivity Test (%)	Difference in the means
First Experimental Group (Special needs)		**Co-taught**	
Learner 1 LRC	61	81	
Learner 4 ESL	66	76	
Learner 6 LRC	57	77	
Learner 7 referred	44	50	
Learner 16 referred	73	81	
Learner 17 ESL	54	56	
Learner 18 LRC	54	71	
Mean	58.43	70.29	11.86
s	9.36	12.41	
Calculated value of t	0.07		
Critical value of t	2.18		
First Experimental Group		**Co-taught**	
Learner 2	70	77	
Learner 3	79	77	
Learner 5	86	84	
Learner 8	66	70	
Learner 9	66	71	
Learner 10	69	74	
Learner 11	80	74	
Learner 12	80	76	
Learner 13	70	61	
Learner 14	40	56	
Learner 15	71	91	
Mean	70.64	73.73	3.09
s	12.11	9.63	
Calculated value of t	0.52		
Critical value of t	2.09		

Table 4.7 (continued): Differences in the means, standard deviations and t values for the 'Soil formation' and 'Soil productivity' tests for the learners with special needs requirements and those without special needs requirements in the second experimental group

	Soil Formation Test (%)	Soil Productivity Test (%)	Difference in the means
Second Experimental Group (Special needs)		**Co-taught**	
Learner 1 LRC	69	66	
Learner 2 LRC	66	61	
Mean	67.50	63.50	4.00
s	2.12	3.54	
Calculated value of t	3.86		
Critical value of t	4.30		
Second Experimental Group		**Co-taught**	
Learner 3	86	80	
Learner 4	87	80	
Learner 5	83	86	
Learner 6	60	83	
Learner 7	64	77	
Learner 8	81	90	
Learner 9	74	70	
Learner 10	94	84	
Learner 11	83	80	
Learner 12	94	77	
Learner 13	77	73	
Learner 14	89	64	
Learner 15	83	83	
Learner 16	86	77	
Learner 17	69	71	
Learner 18	83	70	
Learner 19	77	70	
Learner 20	97	91	
Learner 21	80	69	
Learner 22	91	71	
Mean	81.90	77.30	4.60
s	9.73	7.47	
Calculated value of t	1.42		
Critical value of t	2.03		

In the first experimental group (special needs) the standard deviation for the ‘Soil Formation’ test is smaller than the difference in the mean results, and in the second experimental group (special needs) the standard deviation for both tests is smaller than the difference in the mean results. This could indicate that the learners with special needs in the experimental groups benefitted from the collaborative approach by the special needs teacher and the subject teacher. However, in the t-test the calculated values of t are smaller than the critical values. Therefore the differences between the means of the two tests are not statistically different from each other.

During the co-taught lessons the special needs teacher taught the learners in the experimental groups particular study skills. The learners were not taught any study skills prior to the first test on ‘Soil formation’, however they were shown learning strategies before they wrote the second test on ‘Soil formation’. In order to examine if the different types of learners benefitted from the study skills that were taught during the co-taught lessons, the test results for the ‘Soil formation’ tests were compared in the two experimental groups.

Table 4.8: Differences in the means, standard deviations and t values for all the 'Soil formation' tests for the learners with special needs requirements and those without special needs requirements in the first experimental group

	Soil Formation Test (%)	Soil Formation Test - 4 months later (%)	Difference in the means
First Experimental Group (Special needs)			
Learner 1 LRC	61	80	
Learner 4 ESL	66	80	
Learner 6 LRC	57	90	
Learner 7 referred	44	60	
Learner 16 referred	73	70	
Learner 17 ESL	54	80	
Learner 18 LRC	54	50	
Mean	58.43	72.86	14.43
s	9.36	13.80	
Calculated value of t	0.04		
Critical value of t	2.18		
First Experimental Group			
Learner 2	70	70	
Learner 3	79	90	
Learner 5	86	90	
Learner 8	66	70	
Learner 9	66	70	
Learner 10	69	90	
Learner 11	80	80	
Learner 12	80	90	
Learner 13	70	70	
Learner 14	40	50	
Learner 15	71	70	
Mean	70.64	76.36	5.72
s	12.11	12.86	
Calculated value of t	0.30		
Critical value of t	2.09		

Table 4.8 (continued): Differences in the means, standard deviations and t values for all the 'Soil formation' tests for the learners with special needs requirements and those without special needs requirements in the second experimental group

	Soil Formation Test (%)	Soil Formation Test - 4 months later (%)	Difference in the means
Second Experimental Group (Special needs)			
Learner 1 LRC	69	80	
Learner 2 LRC	66	80	
Mean	67.50	80	12.50
s	2.12	0.00	
Calculated value of t	0.08		
Critical value of t	4.30		
Second Experimental Group			
Learner 3	86	70	
Learner 4	87	80	
Learner 5	83	80	
Learner 6	60	70	
Learner 7	64	80	
Learner 8	81	100	
Learner 9	74	90	
Learner 10	94	90	
Learner 11	83	100	
Learner 12	94	90	
Learner 13	77	80	
Learner 14	89	100	
Learner 15	83	80	
Learner 16	86	90	
Learner 17	69	90	
Learner 18	83	60	
Learner 19	77	90	
Learner 20	97	90	
Learner 21	80	80	
Learner 22	91	90	
Mean	81.90	85.00	3.10
s	9.73	10.51	
Calculated value of t	0.34		
Critical value of t	2.03		

The standard deviations for the learners with special needs in both the experimental groups are lower than the difference in the means, which might suggest that the learners with special needs requirements benefitted from the learning strategies taught by the special needs teacher during the co-taught lessons. However, the t-test results do not confirm this statistically.

Another factor that was considered was whether the different types of learners' long term understanding of concepts had improved as a result of learning strategies that they were taught during the co-taught lessons. The results of the 'Soil productivity' tests could be used to determine if the learners had improved their understanding four months later.

Table 4.9: Differences in the means, standard deviations and t values for the 'Soil productivity' tests for the learners with special needs requirements and those without special needs requirements in the first experimental group

	Soil Productivity Test (%)	Soil Productivity Test - 4 months later (%)	Difference in the means
First Experimental Group (Special needs)	**Co-taught**		
Learner 1 LRC	81	60	
Learner 4 ESL	76	60	
Learner 6 LRC	77	80	
Learner 7 referred	50	80	
Learner 16 referred	81	50	
Learner 17 ESL	56	70	
Learner 18 LRC	71	70	
Mean	70.29	67.14	3.15
s	12.41	11.13	
Calculated value of t	0.63		
Critical value of t	2.18		
First Experimental Group	**Co-taught**		
Learner 2	77	70	
Learner 3	77	60	
Learner 5	84	90	
Learner 8	70	90	
Learner 9	71	90	
Learner 10	74	90	
Learner 11	74	90	
Learner 12	76	90	
Learner 13	61	70	
Learner 14	56	60	
Learner 15	91	90	
Mean	73.73	80.91	7.18
s	9.63	13.00	
Calculated value of t	0.16		
Critical value of t	2.09		

Table 4.9 (continued): Differences in the means, standard deviations and t values for the 'Soil productivity' tests for the learners with special needs requirements and those without special needs requirements in the second experimental group

	Soil Productivity Test (%)	Soil Productivity Test - 4 months later (%)	Difference in the means
Second Experimental Group (Special needs)	**Co-taught**		
Learner 1 LRC	66	60	
Learner 2 LRC	61	80	
Mean	63.50	70.00	6.50
s	3.54	14.14	
Calculated value of t	0.63		
Critical value of t	4.30		
Second Experimental Group	**Co-taught**		
Learner 3	80	90	
Learner 4	80	70	
Learner 5	86	90	
Learner 6	83	60	
Learner 7	77	70	
Learner 8	90	90	
Learner 9	70	70	
Learner 10	84	90	
Learner 11	80	80	
Learner 12	77	80	
Learner 13	73	60	
Learner 14	64	70	
Learner 15	83	80	
Learner 16	77	80	
Learner 17	71	60	
Learner 18	70	60	
Learner 19	70	90	
Learner 20	91	70	
Learner 21	69	60	
Learner 22	71	90	
Mean	77.30	75.50	1.80
s	7.47	11.91	
Calculated value of t	0.57		
Critical value of t	2.03		

These results are not statistically significant and therefore the learning strategies that the learners were taught during the co-taught lessons did not necessarily improve the learners' long term understanding of concepts.

4.3.5 Summary of findings

From the results of the t-tests the difference between the means of the various tests are not significant. However, grades on their own do not always tell the whole story. The learners in the two experimental groups were also interviewed on a one-to-one basis in an attempt to understand their views about whether or not the lessons were differentiated for their individual needs, about the study skills they used when preparing for tests, their individual learning styles, and how the presence of another teacher in the classroom affected them.

4.4 Interviews

The four main themes that were considered during the interviews were differentiation, study skills, learning styles and collaboration.

4.4.1 Differentiation

Interview questions 1 to 6 (see Chapter 3, section 3.4.2) attempted to determine if the lessons were differentiated for the learners' individual needs. Differentiating a lesson for all the learners is a challenging task and according to Tomlinson (1999a:13) the teacher in a class with differentiated learners needs to draw on a wide range of instructional strategies.

None of the learners in the first experimental group indicated any major differences between the differentiation of lessons with or without collaboration, and all of the learners in the second experimental group indicated that there was already variety in the lessons prior to the collaborative co-teaching lessons. This suggests that differentiation was probably not the key difference of the collaborative teaching approach. However, two of the learners with special needs in the first experimental group, learner 1(LRC) and learner 7 (referred by teachers as having learning difficulties) indicated that there was no variety in any of the lessons. These two

learners were of the opinion that the broad repertoire of instructional strategies did not engage them adequately in their learning experience. Learner 1 (LRC) gave negative responses to all the questions, which was not surprising because he has an oppositional attitude and is very resistant to change (see learner profile in Appendix 1). However, learner 1 did indicate that the topic was more effectively reviewed after collaboration.

Learners 9 and 18 (LRC) in the first experimental group both indicated that there was more variety in the lessons during the co-teaching sessions, which helped them in their understanding of the content. On the other hand, learner 8 from the first experimental group mentioned that the broad variety of instructional strategies in the lessons was confusing and she had difficulty concentrating on each of them. In the second experimental group only learner 7 commented on more variety during the co-teaching lessons, and learner 4 made the comment that too much variety can be confusing. One of the characteristics of successful differentiation is designing and facilitating "multiple paths" to reach defined learning goals (Carolan & Guinn 2009:15). However, some learners may find too much choice distracting and therefore confusing. Learners get to know and trust their subject teacher and the mere presence of another individual who also talks when their teacher teaches can be unsettling to some learners.

These comments help to reinforce the complexity of trying to meet the needs of all the learners in a classroom and that in reality differentiation is complex and challenging work. It appears from the two experimental groups that the lessons were appropriately differentiated for the learners' needs in both the lessons with and without collaboration. This finding is not surprising because this researcher has always been aware of using varied approaches to the curriculum in order to address the different learning needs of the learners in the classroom.

In order to create a true community of learning according to Tomlinson (1999a:33), the teacher must appreciate each child as an individual, and teach the whole child - this includes his or her emotional, physical and academic needs. This can be problematic in reality because of large class sizes. Having another teacher in the

classroom definitely aided this researcher in addressing some of these issues and confirming that the lessons were appropriately differentiated.

4.4.2 Study skills

Interview questions 7 to 10 (see Chapter 3, section 3.4.2) were asked to gain some understanding of the learners' study skills. At the secondary level "soft" skills such as study skills often are not a conscious part of the curriculum, but are frequently a part of learners' IEPs and they are critical for the success of all learners (Murawski & Dieker 2004:56).

Thirty four of the forty learners interviewed indicated that they had reasonable to good study skills. Only four of the learners in the first experimental group, numbers 1 (LRC), 4 (ESL), 17 (ESL) and 18 (LRC), and two of the learners in the second experimental group, numbers 4 and 21, indicated that they had poor study skills that did not seem to improve during the collaborative lessons. There were only six lessons that were co-taught with the special needs teacher, and a possibility for further research would be to examine if more collaborative lessons could contribute to an improvement in learners' study skills.

Four of the learners in the first experimental group, numbers 6 (LRC), 12, 14 and 15, and three learners in the second experimental group, numbers 1 (LRC), 2 (LRC) and 10, indicated during their interviews that they had tried different methods to study as a result of what they had learnt during the co-taught lessons. When the grades of these learners for the 'Soil formation' test (after the non-collaborative lessons) are compared with their grades for the later test on 'Soil formation' (after they had been taught study skills by the special needs teacher), there was an improvement in most of these learners' grades. In the first experimental group the grades for the 'Soil formation' tests for learner 6 (LRC) improved by 33%, and the grades for learners 12 and 14 improved by 10%. In the second experimental group the grades for learner 1 (LRC) improved by 11% and the grades for learner 2 (LRC) improved by 14%. There was a decrease of 1% in the grades for learner 15 in the first experimental group and 4% in the grades for learner 10 in the second experimental group.

The improvement by the LRC learners is particularly encouraging as it indicates that despite their learning difficulties, these learners were prepared to try different methods of studying and also that they benefitted from trying out different strategies.

4.4.3 Learning styles

Interview questions 11 to 15 (see Chapter 3, section 3.4.2) were asked to determine if learners had an understanding of their individual learning styles and if the learners recognised different learning styles. As discussed in the literature review, if teachers are differentiating lessons, they need to plan lessons that reach and teach all the learners in the class by designing learning tasks that are responsive to different styles of learning and different levels of ability. Learners learn best using their preferred learning styles or modality preference, for example, auditory, visual, and tactile/kinaesthetic. People use all three learning styles when they learn, but in different combinations of preference (Powell & Kusuma-Powell 2007b:69). The special needs teacher explained these different learning styles to the learners and showed them activities that appeals to the various types of learners.

Eight of the learners (or 44%) in the first experimental group, numbers 1 (LRC), 5, 8, 10, 11, 12 and 17 (ESL) and 18, and ten learners (or 45%) in the second experimental group, numbers 1 (LRC), 4, 7, 8, 11, 14, 15, 18, 19 and 21, had a very limited understanding of their learning strengths both before and after the collaborative co-teaching lessons.

All the other learners (55%) indicated an improvement in their understanding of their learning styles after the collaborative lessons. During the interview after the collaborative co-teaching session these learners were able to articulate what their preferred learning style was and also indicated that they had tried different ways to study. However, none of the learners in the experimental groups indicated that they had a very good understanding of what their learning styles were, and it was interesting that ten of the learners (learners 1 (LRC), 6 (LRC), 7 (referred) and 17 (ESL) from the first experimental group, and learners 1 (LRC), 8, 14, 15, 19 and 22 from the second experimental group) did not even notice different note taking techniques used by their classmates. In order to address this obvious lack of

knowledge, different learning styles should possibly be taught to all the learners in a more formal setting in the high school curriculum.

4.4.4 Collaboration

Interview questions 16 and 17 (see Chapter 3, section 3.4.2) were asked to determine if the learners benefitted from the collaborative co-teaching approach. Co-teaching, involving collaboration between a high school science teacher and a special needs teacher was the instructional strategy that was examined in this research, and it is therefore important to investigate how the learners felt about having another teacher in the classroom.

The learners were also asked after they had a written a test on the work they had been taught four months later, if they had used any of the learning strategies the special needs teacher had taught them to study for the test. These strategies included:

- **Association** - by linking a word, topic or phrase to another more memorable item either through words or pictures. For example, a 'Big Mac' hamburger was linked to the macronutrients with carbon and oxygen being the buns, hydrogen the gap between the buns, nitrogen being the salad, phosphorous the meat and potassium the lettuce.
- **Visualization** – turning the words into a picture. For example, a pot with a crown in a prison cell represents the symbol and role of the macronutrient potassium in plants.
- **Number shape** – turning numbers into a story. For example, using number rhymes such as, 1 bun, 2 shoe, 3 tree, 4 door, etc.
- **Mind mapping** – using colour, shape and symbols to map information. For example, adding the colour of the nutrient test results to the appropriate diagram of the element.
- **Letter shape** – using the first letter of words to make a sentence. For example, '**c**arry **o**n **h**ollering **p**oisonous **p**lants', for remembering the plant macronutrient names **c**arbon, **o**xygen, **h**ydrogen, **p**hosphorous and **p**otassium.

All the learners in the first experimental group, except for four learners (numbers 1, 9, 10 and 17) found the presence of the special needs teacher in the lessons helpful. Three of the learners (numbers 1, 16 and 17) did not use any of the learning strategies the special needs teacher had taught them to study for tests. It is important to analyse the negative comments from these learners and these are discussed further in the following paragraphs.

As already mentioned Learner 1 (LRC) in the first experimental group gave negative responses to all the questions, however, some of his answers did indicate that he had learnt something from the co-teaching approach. For example, he felt the review worksheets were helpful (question 5), he used more strategies when trying to answer a question (question 8) and he had tried using flash cards when preparing for a test (question 15). The other LRC learners in the first experimental group, learners 6 and 18, both mentioned that they had found it helpful having a concept explained in two different ways. They also mentioned that they had found the association of facts in a diagram very helpful to remember these facts.

Learner 17 (ESL) in the first experimental group had a very poor understanding of English and struggled to understand the questions, and as a result she gave negative responses to most of the questions. She mentioned that when she had been in Korea she had exercise books with pictures and these had helped her remember facts (question 8 – before co-teaching) but the diagrams don't make sense to her now (question 15 – after co-teaching) because they are not supported in a language with which she is familiar. The other ESL learner in the first experimental group (learner 4) mentioned that having another teacher in the class was helpful because if she did not understand an explanation given by one teacher, she had the benefit of the other teacher's explanation. She felt that the learning strategies she had been shown by the special needs teacher would not only help her in natural science but could also be useful in her other subjects.

Learner 10 in the first experimental group indicated being 'very irritated' by the presence of another teacher in the classroom and did not like having two teachers in the class. Her answers to all the questions were mostly negative and her irritation was clearly evident in her voice during the interview. Her mother, who is also a teacher at

the ISK, told us that her daughter was going through a very moody stage and this was impacting negatively on all her schoolwork. The co-teaching approach used in her science classes does not appear to be the trigger for her moodiness; however, it did seem to contribute to her irritation levels.

Learner 9 in the first experimental group is a confident academic and found the presence of the other teacher 'distracting, unnecessary and overbearing'. However, she did use some of the strategies that were discussed in the co-teaching sessions to study for the test four months later. Her interview responses prior to the co-teaching sessions indicated that she prepares well for tests and probably found the discussion of study skills and learning styles by the special needs teacher superfluous.

Learner 16 in the first experimental group, who was referred by teachers and identified as having learning difficulties, found having two teachers in the class helpful because if one teacher was busy, there was another teacher to help him. He found some of the studying techniques that the special needs teacher had taught him to study for a test to be useful. However, when he wrote a test four months later, he did not remember any of the strategies. This was borne out by the results because he was the worst performing candidate in the test on 'Soil productivity' and one of the lowest in the test on 'Soil formation' that was written four months after the co-teaching lessons.

The same trend was found in the second experimental group with the majority of learners reporting positive perceptions of having the special needs teacher in the lessons. However, five of the learners in the second experimental group (numbers 1 (LRC), 11, 12, 17 and 21) found the presence of another teacher in the classroom 'distracting, confusing and unhelpful' and learner 7 was distracted because the special needs teacher kept 'walking about'. Learner 1 (LRC) was confused in the co-taught lessons, and according to her IEP (see Appendix 9) any change in her environment could cause inattention and feelings of being overwhelmed. She did however try to use some of the learning strategies when studying for the tests four months later, and her grade for the later test on 'Soil formation' was higher than the first test she wrote on this topic. Learner 11 also used some of the strategies the special needs teacher had shown him in the co-teaching lessons and scored 100% on his test on 'Soil formation'

that he wrote four months later. The other three learners in the second experimental group that were distracted by having another teacher in the lessons, namely learners 12, 17 and 21, did not use any of the strategies the special needs teacher had taught them to study for tests.

The negative responses by learners to the presence of another teacher in the class were not unexpected because research by Gerber and Popp (1999:294) investigating the views of learners with and without learning disabilities regarding their experiences with the co-teaching approach, mentioned that there were reports of frustration and confusion from learners whose teachers offered different explanations or talked at the same time during the lesson.

Despite these negative responses, the majority of the learners, with and without learning difficulties, indicated that they had benefited from the collaborative co-teaching approach - 14 out of 18 (78 %) in the first experimental group, and 17 out of 22 (77%) in the second experimental group. These benefits included the following:

- Increased contact time with teachers: Learners 16 and 18 (LRC) in the first experimental group found that if one teacher was busy the other teacher was available to help them, and learners 2 (LRC), 4, 13, 14 and 16 in the second experimental group, mentioned that it helped having another teacher in the class to ask questions.
- Teaching using different styles: Learner 14 in the second experimental group found the repetition of important facts by the two teachers helpful, and learner 5 commented on the special needs teacher ‘also being a learner’ and interpreting the content in a different way. Learners 2, 3, 4 (ESL), 6 (LRC), 7, 11, 15 in the first experimental group, and learner 20 in the second experimental group found the different teaching styles helpful in remembering facts.
- Teaching learning strategies: Learners 5 and 8, 13 in the first experimental group mentioned that the special needs teacher had taught them new ways of learning and revising, and learners 12 and 14 in the first experimental group felt they had a clearer understanding of their own learning styles. Learner 3 in the second experimental group found the ‘doodles’ she was shown by the

special needs teacher helpful in remembering facts. Learner 18 also commented on how helpful the diagrams were, and learner 19 mentioned an improvement in his note taking techniques.

- Discipline issues: Learner 15 in the second experimental group commented on being ‘kept on task because there was a bigger chance of getting caught talking’ when another teacher was in the classroom.
- Respect issues: None of the learners during their interviews referred to the other teacher in the co-taught lessons as the ‘special needs teacher’. They mentioned her by name and treated her as a normal teacher. They also never referred to any learner in the classroom receiving ‘special’ attention. This lack of labelling indicates that not only is every teacher valued but also that every learner is valued in an inclusive classroom.

4.5 Summary of findings

The research question in this research examined the following:
How effective and enduring is the learning for a diverse group of grade 9 science learners when delivered through a collaborative co-teaching approach involving a high school science teacher and a special needs teacher?

The data from the learners’ grades and the interviews do not give a definitive answer to this question other than that there is no significant improvement in results when co-teaching. However, the collaborative co-teaching approach could be considered as a strategy for helping learners with and without learning difficulties in a heterogeneous grade 9 natural science class based on the following findings:

- During the interviews, 78% of the learners in both experimental groups (31 out of 40) indicated that they had benefitted from the collaborative co-teaching approach.
- 55% of the learners in both experimental groups indicated an improvement in their understanding of their own learning styles as a result of the collaborative lessons.

- Those learners who were prepared to try the different methods of studying that were suggested by the special needs teacher found the experience both fruitful and worthwhile.
- The standard deviations for the test results of those learners with special needs requirements in both experimental groups on ‘Soil productivity’ (that was co-taught) compared with the test on ‘Soil formation’ (that was not co-taught), were lower than the difference in the mean results of the tests (see table 4.7). This could indicate that some of these learners benefitted from the co-taught lessons.
- The standard deviations for the test results of those learners with special needs requirements in both experimental groups for the tests on ‘Soil formation’ were also lower than the difference in the mean results of the tests (see table 4.8). This could indicate that some of these learners benefitted from using learning strategies that they were shown by the special needs teacher during the co-taught lessons.
- This researcher found the collaborative co-teaching experience professionally fulfilling, exciting and enjoyable, and as a result believes she was a far more effective teacher in the classroom.

Chapter five discusses the main benefits from the findings of this research, together with recommendations that need to be met for the co-teaching approach to be successful, an indication of the limitations of this research and future research considerations.

Chapter 5
Conclusions, Recommendations and Limitations

5.1 Conclusions

It would be easy for a school like the ISK to be exclusive and hand-pick academic performers to guarantee outstanding exam results. However, most international schools look for a learner body that reflects the diversity of real life. The inclusive instruction approach is based on the premise that all learners benefit from interactions with a wide variety of learners. Lawrence-Brown (2004:34) suggests that differentiated instruction can enable learners with a wide range of abilities, from gifted learners to those with mild or even severe disabilities, to receive an appropriate education in inclusive classrooms. However, she suggests that on going and effective team collaboration such as those involving the general and special needs teachers is critical for successful inclusion. This is mainly because the special needs teacher has the expertise in learning profiles and can suggest ways to differentiate instruction to the benefit of every learner in a class (Lawrence-Brown 2004:57).

This research examined whether the collaborative co-teaching approach between a special needs teacher and a high school science teacher improved the learners' grades for both short and long-term understanding. The co-teaching sessions in this research did not significantly affect the learners' test results; however there may be benefits for both the learners and the teachers in the co-teaching approach even though the research does not confirm it. The majority of the learners in the two experimental groups in this research reported very positive perceptions of the co-teaching approach. Some learners reported frustration and confusion of having another teacher in the classroom, and these negative responses are similar to those found in research done by Gerber and Popp (1999:294). However, despite these concerns from a few learners, the main benefits from the findings of this research of the collaborative co-teaching approach for the learners included:

- An improvement in their understanding of learning styles and associated study skills,

- increased contact time with the teachers, and
- the benefit of another teacher's expertise in the classroom.

The researcher also found the co-teaching approach yielded:

- A clearer focus on the individual learning styles,
- new strategies for differentiation, and
- a positive teaching experience.

The benefits for both teachers and learners are examined further in the following paragraphs:

5.1.1 Individual learning styles and study skills

Education is about learning and good teaching is judged by successful learning, which is usually reflected by high grades by the learner. In order to be a successful, the teacher must be knowledgeable of the subject matter, content standards and teaching materials, but also aware of each learner's varied learning needs. According to Tomlinson and McTighe (2006:19) "attending to student learning profiles enables efficiency of learning". This sentiment is echoed by Rose et al (1996:119) who suggest that if teaching approaches are to be effective they should accommodate and encourage a variety of learning styles through a balanced range of learning opportunities. Regarding the place of differentiation in special needs, McNamara (1999:56) suggests that if a teacher is not meeting the needs of a particular learner, the teacher should interview the learner and find out their preferred learning style and then check if different forms of differentiation have taken place that incorporate the learner's learning style. So in order to maximize individual learning, learners and teachers need to be more aware of individual learning styles in the class.

This is an area where the special needs teachers can play a vital role because they have an intimate knowledge of each of the special needs learner profiles. In the co-teaching approach used in this research, the high school science teacher was mainly responsible for the content and delivery of the curriculum, while the special needs teacher focused on helping the learners with strategies, clarification and adding information to enhance their understanding, and overseeing the activities that support the lessons, such as peer tutoring and group activities.

During the co-taught lessons the special needs teacher addressed individual learning styles and the learners were shown different ways to remember the scientific facts. When the test results for the 'Soil formation' tests were compared in the two experimental groups, to ascertain if the different types of learners benefitted from study skills that were taught during the co-taught lessons, the findings of the t-tests indicate that co-teaching did not significantly change the learners' test results. However, the interview responses from the first experimental group indicated that fifteen of the eighteen learners (83%) and nineteen of the twenty two learners in the second experimental group (86%) used a strategy or technique taught by the special needs teacher that helped them to learn the work four months later.

5.1.2 Increased contact time with the teachers

It is difficult for one teacher to monitor the progress of every learner in the classroom. During their interviews some of the learners commented on the benefit of having another teacher in the class to ask questions. This was particularly noticeable during hands-on instruction, such as experimental work, which provides a great opportunity for the learners to understand and/or reinforce the concepts discussed in class. During the research, a number of different co-teaching organisations were used, namely 'one teacher, one support', 'team teaching' and 'station teaching'. These arrangements helped change the class groupings and could lead to more opportunities to give learners personal attention.

5.1.3 Benefits of another teacher's expertise in the classroom

One of the major benefits of co-teaching in this researcher's opinion was that the special needs teacher considered different modes of instruction and assessment, and suggested modifications, accommodations, and new activities. This supports Nunley's (2006:19) comment that teachers tend to teach with the teaching style in which they were taught and collaboration is one way to improve the range of instructional approaches.

As mentioned in the literature review, the challenges and demands of differentiating a rigorous academic curriculum can be overwhelming. According to Powell and Kusuma-Powell (2007b:18) there is a direct positive correlation between the quality

of thought that the teacher puts into planning a lesson and the quality of learning that results from the lesson. This researcher found the help of the special needs teacher invaluable when planning differentiated instructional strategies for the learners in the class. Ideas, experiences and suggestions that were shared by both teachers helped in creating more variety in the teaching methods that were employed in the co-taught lessons. The researcher found that the co-teaching approach allowed for more expertise to be focused on individual instructional strategies, and according to Tomlinson (1999a:118) we must move toward teaching that meets individuals at their points of readiness, interest and learning profiles.

Grades tend to carry a lot of weight at high school and teachers are often concerned about the consequences of modifying assignments. Winebrenner (2001:129) recommends that during the planning stage for any unit of work teachers should design learning activities for all types of learners in the class, and the learners should be able to select a task that allows them to learn the designated key concepts in a way that appeals to their learning style. During this research the special needs teacher helped the researcher modify assignments and suggested a variety of options to assess the learners. For example, the special needs teacher suggested that the learners select the way they wanted to present the element they studied in the nutrient project. This technique allowed for differentiation because the learners chose an assignment that best met their particular learning style. The special needs teacher also helped this researcher create rubrics that enabled the learners to understand exactly what was being assessed.

5.1.4 Professional satisfaction

The co-teaching approach requires a lot of planning, however, this researcher found the collaborative experience professionally fulfilling and has become a far more effective teacher as a result of the experience. Having two teachers present during the co-teaching sessions, allowed for flexibility and creativity during the lessons, and as Murawski and Dieker (2004:56) also notes, having another adult with whom to work definitely broke the monotony of the typical school day. The researcher and the special needs teacher who was involved in the co-teaching sessions got along very well and gained from each other’s comments and teaching styles.

In addition to providing different viewpoints and new ideas for instruction, co-teaching can positively affect the class teacher's instructional behaviour, help develop teamwork skills, and motivate one another (DeLuca et al 2010). In the research done by Austin (1999:254) that examined the general and special needs teachers' perceptions about their co-teaching experiences, many teachers benefited from the other teacher's expertise in the class. Lipsky (2003:34) also mentions that co-teaching reduces the isolation of being a solo-practitioner and adds enjoyment to teaching. This researcher echoes all these views, but co-teaching is a multifaceted social activity and the personalities of the two teachers involved are crucial for the success of this collaborative approach.

As teaching is a complex undertaking the question arises: How can teachers meet the needs of the wide range of abilities and learning styles of learners to encourage them to work at their maximum ability? The answer often seems daunting and unmanageable, however, having implemented co-teaching, albeit for a short time, this researcher is encouraged by the findings that a co-teaching approach could possibly lead to more successful learning, especially for the learners with special needs. Collaboration, not isolation, appears to be far more beneficial for all parties involved in the learning process.

As a result of this research there are a number of conditions that need to be met for the collaborative co-teaching approach to be successful:

- Administration needs to provide time in a school day for collaboration to take place. One of the major difficulties encountered in this research was finding time when both the researcher and the special needs teacher were free to plan the lessons together. Regularly scheduled time needs to be allocated for relevant discussions that lead to real change. Lawton (1999) also warns that one of the more persistent problems in co-teaching is finding time to plan and co-ordinate. Hirsh and Sparks (1999:40) strongly urge school boards to redesign the teacher workday to provide time for collaboration. DuFour and Burnette (2002) also note that in order for schools to have a collaborative culture, there must be consistent time for teachers to work together during the school day. Every aspect of the collaborative process takes time and on-going

attention, and the school's administration therefore needs a shared vision and broad agreement about practices related to the collaborative practices.

- Prior to any co-teaching sessions, there needs to be some 'settling time' where the special needs teacher interacted with the class on an informal basis in order to become familiar with the subject teacher's teaching style and the individual learners in the class.
- Trust, respect and a willingness to change, are the key ingredients needed by the teachers involved in the collaborative partnership. The teachers need to be open-minded to other teaching and assessment strategies, use two-way dialogue and assume good intent on the part of colleagues. The seven norms suggested by Garmston and Wellman (1998:32) and discussed in the literature review, were employed by the teachers involved in this research and definitely enhanced the collaborative skills. Even if the teachers know each other well, knowledge of collaboration skills can still help teachers work more effectively together.
- The teachers involved in co-teaching need to work together as equals to assist all the learners in the classroom. For example, it is important to alternate roles in the 'one teacher, one support' approach, otherwise the special needs teacher may feel like a teacher's assistant and not feel like part of a co-equal teaching partnership.
- Teachers in co-teaching activities should share common goals and be actively involved in decision-making. The goals should be specific, measurable, and focused on learner achievement. The researcher found that keeping the focus on learner achievement enabled the co-teachers to honestly discuss instructional strategies that were effective as well as those that were not.
- There should be reflective dialogue about the practices used in collaborative approaches. The teachers should discuss, question, congratulate and critique professional practice with their broader "professional learning community". This could lead to other teachers trying instructional practices that may increase learner success. Collaboration is a partnership and the teachers should work as a team and share learning experiences that are meaningful and developmentally appropriate.

5.2 Limitations of the study

There are three noteworthy limitations to this study:

Firstly, the study was limited to two sample groups - one of eighteen grade 9 natural science learners in 2009 (the first experimental group), and another of twenty-two grade 9 natural science learners in 2010 (the second experimental group). Despite the small sample size there were at least nine learners (22.5%) with learning and ESL difficulties, and therefore there was variation from information rich participants, and the effectiveness of learning through the collaborative co-teaching and individual approach could be studied in some depth within a limited time scale.

Secondly, the study was limited to two trials at the ISK and is therefore unlikely to provide information that could be generalised beyond this school. However, this classroom action research did provoke discussion, generated ideas and provided a possible basis for further enquiry, which according to Grosvenor and Rose (2001b:72) is sufficient justification for doing the research.

The final limitation is linked to assessment. There are an infinite number of ways to measure learning, but for the purposes of this research the learners were tested by means of a formal written test. The word ‘test’ can be stressful for some learners and it may not give as accurate a picture of learning that other methods of assessment may do.

Despite the limitations of this research, co-teaching is one approach that could allow teachers to include their colleagues as an important resource when trying to address the needs of a range of different learners in a classroom.

5.3 Future research considerations

Many schools follow a more inclusive policy whereby learners with special needs are supported within the classroom. Further research is needed to investigate if some learners in an inclusive classroom with special needs still require the individualised, intensive instruction that is offered in pull out settings. An approach to consider when

determining a learner's eligibility for special education services is the Response to Intervention (RTI) program suggested by Brown-Chidsey (2007:45) and discussed in the literature review.

The inclusion model in this research focused mainly on learners with mild learning difficulties and ESL requirements. It did not consider those learners who are 'gifted and talented'. Further research is required to investigate if the co-teaching approach could benefit those gifted and talented learners in a heterogeneous classroom.

One of the issues Friend (1993:10) discusses as whether or not co-teaching will become a widely accepted practice in the future was the cost involved in having two qualified professionals planning and sharing a group of learners that can be taught by one teacher. The co-teaching approach that involves two teachers (a special needs teacher and the classroom teacher) is a luxury that most schools cannot afford and many schools do not have specialist personnel. Through careful management of time and resources, the same special needs teacher could develop collaborative relationships with many teachers. Further research is needed to determine whether there is a minimum time a special needs teacher needs to be in a collaborative co-teaching relationship with a subject teacher for the special needs teacher's time to be used effectively and to provide the desired results.

5.4 Concluding remarks

This research examined if there was improved teaching and learning for all the learners in heterogeneous grade 9 natural science classes at the ISK in Nairobi when both a special needs teacher and high school science teacher were responsible for the planning and delivery of the lesson, assessment and discipline. Even though the quantitative data did not indicate any significant difference between the means of different test results, the qualitative data suggests that the co-teaching approach could offer many benefits for both the subject teacher and the learners, especially those learners with special needs. Co-teaching can therefore be considered as one pedagogical approach that could be used in schools to help improve learner achievement.

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Appendix 1

First Experimental Group: IEP's for learners 1, 6 and 18

Student Support Services
Individual Education Program

Note: All dates are MM/DD/YYYY

IEP Date: 9/29/2008

Student Number: \

Mtg. Participants

	Position
	Student
Mr. and Mrs.	Parents
	LRC teacher

Next IEP Due (MM/DD/YYYY)
9/29/2009

Firstname: **Last Name:**

☒ Male ☐ Female **Grade:** 9 **DOB:** 11/7/1993

Parent/Guardian: **Email:**

Address: **Home Phone:** **Language at Home:** English

Address: **Work Phone:** **Other Language:** Spanish

Eligibility Date: 9/29/2008 **Last Psych-Ed Date:** 8/21/2007 **Other Tests /**

Triennial Date: 8/21/2010 **Last Achievement Date:** 8/21/2007 **Notes:** Wide Range Achievement Test-3
Gates MacGinitie Reading Test

Student Strengths

- English: Positive student, good social interactions, initially stayed after class to get notes, HW done, good effort
- Math: Raises hand, has high standards
- Science: Brings brilliant oral ideas, has an inquiring mind, good science brain
- French:Trying hard in French, participates more, more effort, interested.
- Home: Intelligent and fun loving

Student Needs

- English: Takes time to take notes in class, quality of written work of both short and long assignments, comprehension, Discrepancy between oral and written production quality.
- Math: Quizzes - he needs to come for help during tutorial
- Science: Organization of his notes, handouts, etc. in a file lacking; confrontational attitude.
- French: Shows up to class without note paper, pen, etc.: needs to catch up; needs a dictionary; interaction with other students (rude remarks, arguments)
- World civ: Seems disconnected and is missing assignments
- Home: Tends to forget what is asked of him e.g. seeing a teacher at tutorial time, Is it processing of info? or memory?

Program Recommendation(s)

LRC Subjects: Organization skills, Writing skills, Study skills, Self-advocacy skills

Support: ADHD medication - Concerta
LRC block 4
Math Inclusion

General Classroom Accommodations

- Permit to be close to the classroom teacher to allow for frequent redirection of attention to cue changes in behavior and to reward positive behavior.
- Redirect behavior quietly and positively by the use of nonverbal cues.
- Establish eye contact with during oral directions and lectures.
- Use key words to explain tasks, use one step directions.
- Require the application or restatement of newly presented information to ensure that . has been listening.
- Alternate highly desirable activities with less desirable activities.
- Provide appropriate interesting alternative activities when assignments are completed.
- Set clear, consistent behavioral limits.
- Stress the quality rather than the quantity of work.
- Communicate frequently with the parents to enable them to have follow-up consequences for good and bad behavior at home
- When possible alternate quiet activities with tasks that require action.
- Encourage use of word processing for written assignments.
- Provide opportunities periodically for to be allowed appropriate movement about the room or running errands for the teacher.
- Organization of the environment is crucial. Please let parents know any things that they might do to help achieve a high level of organization (pencil boxes, desk drawer dividers, use of assignment sheets and calendars).
- Because the low level demonstrated on the present testing was fine motor skills, his handwriting may require special attention. He may benefit from mastering the computer keyboard at as young an age as possible.
- Provide a second set of books for the parents to have at home to allow them to assist with homework/tutoring.
- Because has an oppositional attitude, it is important to be firm and consistent. Avoid engaging in a power struggle or arguments. Always follow through with discipline.

Student Support Services
Individual Education Program

Note: All dates are MM/DD/YYYY

IEP Date: 3/9/2009

Student Number: 6

Mtg. Participants	Position
	Student
	LRC teacher
	Father

Firstname: **Last Name:**

☒ Male ☐ Female **Grade:** 9 **DOB:** 1/9/1993

Parent/Guardian: **Email:**

Address: **Home Phone:**

Address: **Work Phone:**

Language at Home: English

Other Language:

Next IEP Due (MM/DD/YYYY) 3/9/2010

Eligibility Date: 8/13/2007 **Last Psych-Ed Date:** 01/15/2007 **Other Tests / Notes:**

Triennial Date: 01/15/2010 **Last Achievement Date:** 01/15/2007

Student Strengths

- Likable, cooperative, knows his learning style, pleasure to have in the Science class
- Eager, often the first to volunteer or have a go and take initiative in Drama
- Doing well in World civ, is consistent
- Good self advocate, responsible in English
- Grade 9 officer
- Focused dedicated to school work, has a math tutor (parents)
- Hardworking and sticks with it

Student Needs

- Learning facts - but he is aware of his learning style and is trying different strategies to memorize facts/concepts in science
- Visual motor coordination (handwriting + copying from the whiteboard), auditory memory and sequencing - may be affecting his taking notes in class (notes are needed to have a record of what has been learned as well as to use when studying for tests)

Program Recommendation(s)

LRC Subjects: Writing, spelling, auditory memory and sequencing, organization skills, math, note taking skills

Support: LRC block 5
Math tutor

General Classroom Accommodations

- Support Verbal instructions with written cues on the board.
- Keep instructions brief and clear
- Encourage to use his planner fully for recording assignments
- Encourage to use the writing process for all written assignments
- should be encouraged to use the computer/laptop for all written assignments and to take notes in class
- Encourage to read - and to use audio tapes to supplement this skill where necessary
- Help follow the sequence carefully.
- Provide with keywords on the white board and encourage him to note them in his notebook.
- Teach how to take notes in your class and from textbooks to use to study for tests.

Student Support Services
Individual Education Program

Note: All dates are MM/DD/YYYY

IEP Date: 2/19/2009

Student Number: 18

Mtg. Participants	Position
	Student
	LRC teacher
	Parents

Firstname: **Last Name:**

☒ Male ☐ Female **Grade:** 9 **DOB:** 5/5/1993

Parent/Guardian: **Email:**

Address: **Home Phone:** **Language at Home:** English

Address: **Work Phone:** **Other Language:** Spanish

Next IEP Due (MM/DD/YYYY) 2/19/2010

Eligibility Date: 2/19/2009 **Last Psych-Ed Date:** 12/2/2008 **Other Tests / Notes:** Speech and Language Evaluation

Triennial Date: 12/2/2011 **Last Achievement Date:** 12/2/2008

Student Strengths

Sweet teenager
Overcompensating

Student Needs

- Verbal comprehension - Working memory
- Language issues - difficulty following instructions, understanding spoken paragraphs,recalling and formulating complex sentences e.g. embedded clauses
- Receptive and expressive language
- Language memory - Spelling
- Abstract reasoning skills - Higher Order Thinking (HOT) e.g. compare and contrast
- Calculation skills
- Not coping with the normal social science curriculum

Program Recommendation(s)

LRC Subjects: Study skills, test taking skills, math skills, abstract reasoning skills, writing skills, spelling skills

Support: - Recommended undated audiological evaluation to measure hearing acuity and speech and language therapy to develop receptive and expressive language. - Modify Social Science curriculum - LRC block 7

General Classroom Accommodations

1. Preview new materials/information prior to class presentation using an outline to familiarize student with new vocabulary and concepts, enabling him to follow and participate more readily in his classroom environment. Require him to add details to the outline. Review main concepts after presentation. 2. Seating should be in front considering his hearing history. 3. Key vocabulary should be listed, prior to class discussion, building the discussion around the vocabulary. 4. Use a variety of graphic organizers e.g. tables, spider diagrams, mindmapping, Venn diagrams for comparing and contrasting, etc. 5. Salient clues should be provided to emphasize important information e.g. This is important, this is a test question.
6. Present information simultaneously with visual modalities to augment his weaknesses in auditory input. 7. Students with auditory difficulties tend to require more individual assistance. 8. Eligible for extended time in tests.
9. After being given instructions, student should be requested to repeat the content of the instructions to provide both teacher and himself with feedback as to how much of the instruction was comprehended accurately, allowing the instructor to monitor which instructional components need to be repeated or rectified.
10. To minimize this fatigue, lessons should be short and intensive with frequent breaks provided. 11. Questions and phrases may require rephrasing as they may contain sounds that are not easily discriminated. 12. The length and complexity of both verbal and written language should be reduced a more simplified level.
13. Clarification of student's comprehension should be made by querying " What are you supposed to do?" as opposed to "Do you understand?"

Appendix 2

Permission letter from the International School of Kenya

International School of Kenya Ltd.

Joseph Hollenbeck
High School Principal
jhollenbeck@isk.ac.ke

KIRAWA ROAD P.O. BOX 14103, NAIROBI 00800, KENYA TEL: 254 20 4183622 FAX: 254 20 4183272

October 23, 2008

Dear Linda,

I have received your letter requesting permission to conduct research with our students related to your Master of Natural Science Education course. I am pleased to grant you permission to proceed with this project. I am happy our school can be of assistance in this matter.

Please don't hesitate to contact me regarding other ways that our school can be of assistance to you with this course.

Regards,

Joseph Hollenbeck

Joseph Hollenbeck, High School Principal
International School of Kenya

International School of Kenya
High School Office
P. O. Box 14103,
00800 - Nairobi.

Appendix 3

Letter to learners' parents

24 October 2008

Dear Parents,

I am studying for a Master's degree in Natural science Education by correspondence from the University of South Africa. My dissertation is based on evaluating the effectiveness of a collaborative co-teaching approach with a grade 9 science class.

I am writing to ask your permission to include your child in my research project. The research design involves interviewing the learners before and after teaching a topic in collaboration with a colleague Mrs Scilla Davey. This will involve a series of two, approximately five-minute interviews spaced throughout the third and fourth quarter. Participation to be interviewed is totally voluntary and will not affect the learners' grades. The children involved in this research will remain anonymous and all interviews will be strictly confidential.

If you are not willing to allow your child to be interviewed, I would be grateful if you could contact me at

Thank you for your co-operation.

Mrs L Henderson
Grade 9 Integrated Science Teacher

Appendix 4

Lesson Plan: Soil Formation 1

Teacher Name: Linda Henderson School Year: 2008/9

Semester: 2nd

I. Lesson Outline

a. Title: Development of soils.

b. Long Range Goal: Understanding of the processes involved in soil formation.

c. Lesson Objectives:

1) To investigate the processes of physical, chemical and biological weathering.

2) To write a research question and hypothesis for a lab that artificially weathers rock samples.

II. Teaching Materials: Internet (animations; www.uky.edu/AS/Geology/howell/goodies/elearning/module07swf sg.geocities.com/c_pling/weathering.html) projector, rock and soil samples, textbook - Science Interaction, Course 4, Copyright 1999 by Glencoe/McGraw-Hill, worksheet, laboratory equipment and chemicals.

III. Review: Summary of abiotic and biotic factors in an ecosystem.

IV. Key Vocabulary: Physical/mechanical weathering, ice wedging, chemical weathering, biological weathering, research question, hypothesis.

V. Introductory Motivation: What are the conditions and processes that cause soil to form?

V. Lesson Development:

1) What is soil? (Explain using rock and soil samples.)

2) Explanation of weathering. (Use of textbook and Internet animations)

3) Complete the worksheet on ‘The development of soils’. (Learners work in pairs).

NAME _____ DATE _____ CLASS _____

STUDY GUIDE Chapter 9

9-1 The Development of Soils

Match each item in Column I with the most appropriate item in Column II. Write the letter for that item in the blank at the left.

Column I	Column II
_____ **1.** rock breaking down without chemical change	**a.** temperature
_____ **2.** forms where Earth's surface contacts the atmosphere	**b.** expansion
_____ **3.** occurs when water freezes	**c.** soil
_____ **4.** Earth material changing into a new chemical compound	**d.** surface area
_____ **5.** influences chemical weathering	**e.** physical weathering
_____ **6.** produced by plants during growth	**f.** acids
_____ **7.** increases as a cube is cut up	**g.** chemical weathering
_____ **8.** natural source of acid	**h.** carbon dioxide

In the space provided, write the term from the following list that best matches each phrase: physical weathering, chemical weathering, or biological weathering. Answers may be used more than once.

_____ **9.** increases the surface area that is exposed to the atmosphere

_____ **10.** increased surface area increases its rate

_____ **11.** frost wedging

_____ **12.** expansion and contraction of lichens when wet and dry and their release of organic acids

_____ **13.** acid rain effects on buildings and statues

_____ **14.** increases with increased temperature

_____ **15.** burrowing activities of earthworms

_____ **16.** important in climates with low to moderate rainfall

4) Check worksheet. (Learners grade each other's worksheets).
5) Explanation of the lab investigation (pages 266 and 267 in textbook - Science Interaction, Course 4, Copyright 1999 by Glencoe/McGraw-Hill) to model the processes of weathering by designing an experiment to artificially weather rock samples. (Use of rock samples, laboratory equipment and chemicals.) Include an explanation of how to write a research question and a hypothesis for a laboratory investigation.
6) Lab activity: Learners work in pairs and each group writes a research question and a hypothesis for the lab on weathering.
7) Learners share their research questions and hypotheses with the class.
8) Homework: Revision questions 1-3 on page 270 in the textbook.

VI. Adjustments for special needs learners: The worksheet on 'The development of soils' will be completed in class with the help of a colleague and then checked immediately afterwards. The lab activity will be done with a partner. Internet animations, lab activity, board work and use of textbook incorporate many different styles of learning.

VII. Means of Assessment: Research question and hypothesis for lab on weathering (in class), revision questions from textbook (next lesson).

Lesson Plan: Soil Formation 2

Teacher Name: Linda Henderson School Year: 2008/9
Semester: 2nd

I. Lesson Outline

a. Title: Soil characteristics.

b. Long Range Goal: Understanding of the important factors affecting soil formation and composition.

c. Lesson Objectives:

1) To investigate the factors of climate, parent material, topography of an area, the length of time and the role of organisms on the characteristics of a soil.

2) To compare and contrast the different soil horizons.

II. Teaching Materials: Internet,

(Animations:www.landfood.ubc.ca/soil200/animate.htmserc.carleton.edu/NAGTWorkshops/visualization/collections/soil_horizons.html) projector, soil samples, textbook, worksheets.

III. Review: Summary of a description of soil.

IV. Key Vocabulary: Parent material, topography, humus, soil profile, sandy, silt and clay soils.

V. Introductory Motivation: What are the important factors in soil formation and composition?

V. Lesson Development:

1) Collect homework on revision questions 1 to 3 on page 270 in textbook.
2) Why are soils not the same? (Use of soil samples)
3) Explanation of factors involved in soil formation and composition. (Use of textbook and animations.)
4) In pairs, learners complete the concept map worksheet on ‘Soil characteristics’.
5) Check worksheet together.
6) Explanation of a soil profile, texture and differences in soil types. (Use of animations and the textbook).
7) Complete the worksheet ‘A soil is born’ for homework.

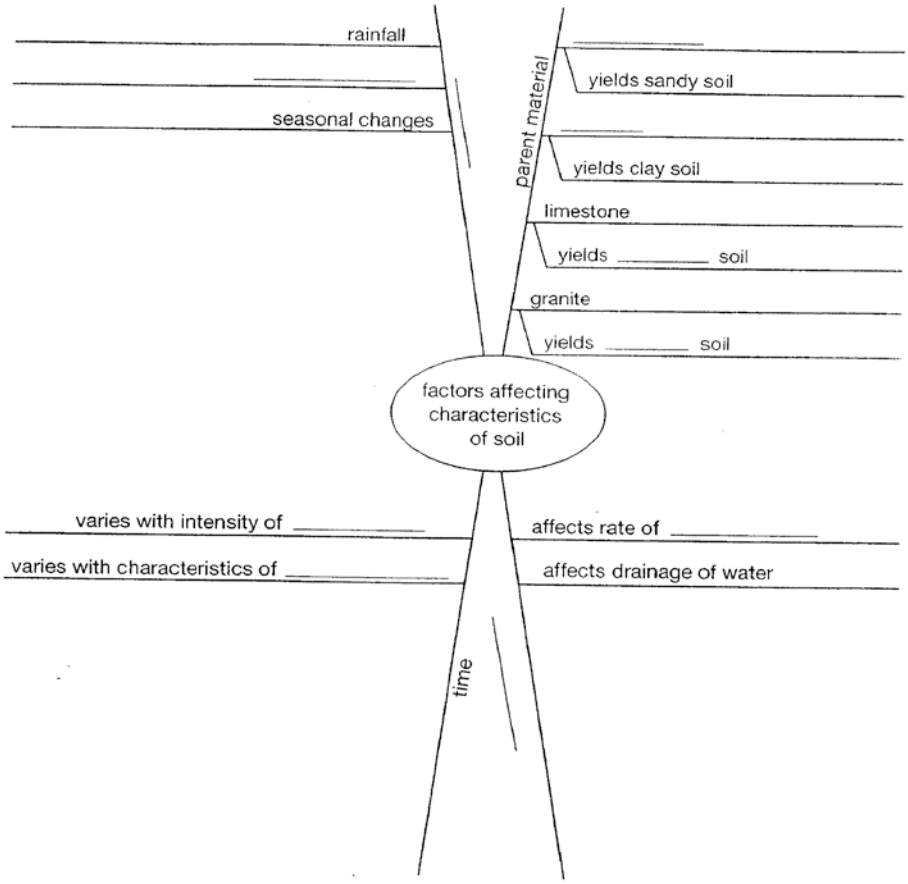
NAME _____ DATE _____ CLASS _____

CONCEPT MAPPING

Soil Characteristics

Chapter 9

Complete the concept map on factors affecting characteristics of soil using the following terms: acidic, climate, neutral, parent material, sandstone, shale, temperature, topography, weathering. Some of the terms may be used more than once.



9-2 A Soil Is Born

If the underscored word or phrase makes the sentence true, write "TRUE" in the space provided. If the underscored word or phrase makes the sentence false, write the correct word or phrase in the space provided.

_____ **1.** Weathering of the organic material results in an accumulation of soil.

_____ **2.** The time needed for soil formation depends on characteristics of the parent material and the intensity of weathering.

_____ **3.** Weathering of parent material occurs most rapidly in a dry climate.

_____ **4.** Layers called zones make up a soil profile.

_____ **5.** Decaying organic matter releases acid.

_____ **6.** Soils that appear yellowish brown in color have a high organic content.

_____ **7.** Dead leaves, branches, and other plant parts are called litter.

Use Figure 1 to answer the following descriptions. In the space provided, write the letter of the layer of soil that best matches each statement.

_____ **8.** Plant roots concentrate in this layer.

_____ **9.** Partly weathered parent material is in this layer.

_____ **10.** Clays and minerals wash into this layer.

_____ **11.** Parent material is found in this layer.

_____ **12.** Humus is in this layer.

_____ **13.** Desert soils have high levels of calcite in this layer.

_____ **14.** This layer becomes dark when organic matter is dense.

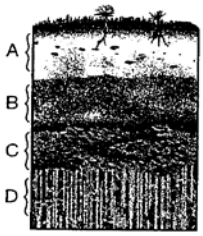


Figure 1

In the blank, write the word or phrase that best completes the sentence.

15. Soil characteristics relate to the climate and vegetation, _____, and the length of time of formation.

16. The remains of decomposed litter is called _____.

17. Different particle sizes cause different _____ in soils.

18. When _____ combines with oxygen, a yellow brown to red color develops.

19. Humus-rich soil releases _____ as decaying organic matter soaks up water and reacts with it.

VI. Adjustments for special needs learners: The worksheet on the ‘Soil characteristics’ will be completed in class with the help of a colleague and then checked immediately afterwards. Internet photographs and animations, worksheets, board work and use of textbooks incorporate many different styles of learning.

VII. Means of Assessment: Worksheet ‘A soil is born’ (next lesson).

Lesson Plan: Soil Formation 3

Teacher Name: Linda Henderson School Year: 2008/9

Semester: 2nd

I. Lesson Outline

a. Title: Lab on ‘Composition of soils’.

b. Long Range Goal: Understanding of the different sizes of particles that make up a soil.

c. Lesson Objective:

To investigate the composition of two different types of soil (sandy soil and Kenyan red clay soil) by measuring the mass of soil in each sieve section to determine the percentage composition of the different particle sizes.

II. Teaching Materials: Laboratory equipment and soil samples.

III. Review: Summary of the texture of a soil.

IV. Key Vocabulary: Particle size, gravel, sand, clay, raw data, processed data.

V. Introductory Motivation: What determines the composition of different types of soils?

V. Lesson Development:

1) Collect worksheet on ‘A soil is born’.

2) Revise the three different soil types – clay, silt and sand (use soil samples and textbook)
3) Explanation of the lab instruction worksheet on ‘Composition of soil lab’. (Demonstrate use of lab equipment and soil samples).
4) Lab activity in groups of 2/3.
5) Homework: Record results and calculate the percentage composition of the two types of soil for each of the particle sizes. Illustrate the processed data in table and graphical form.

VI. Adjustments for special-needs learners: The lab activity will be demonstrated beforehand and then learners will do the lab activity with a partner. Explanation of how to write up of the lab report will also be explained beforehand.

VII. Means of Assessment: Lab report including data presentation in a table and graphical form, and answers to the four questions on the lab sheet (next lesson).

Composition of Soil Lab

Purpose: To determine the composition of two different types of soil and analyze and compare them.
Question: Will sandy soil and Kenyan red dirt (clay) soil have different compositions (as determined by the measuring their different particle sizes)?
Hypothesis:

Materials: Stack of sieves, two soil types, triple beam balance, beaker
Procedure: ***In this lab, it is critical to make sure all your raw data is properly and correctly labeled so you can interpret the results later on.***

1. Measure the mass of a 600 ml beaker on the balance. *Record.*
2. Measure the mass of each of your sections of sieves – making sure to properly *record* each mass with the correct sieve section.
3. Fill beaker with approximately 350 ml of soil from one of the types.
4. Measure the mass. *Record*
5. Subtract the mass of the beaker to determine the mass of the soil in the beaker. *Record.*
6. Make sure your stack of sieves is in the proper order, from largest sieve (smallest number of openings per square inch) to smallest sieve (largest number). Also make sure the sieve stack has a bottom (to collect the finest particles size) and a cover.
7. Pour your soil from beaker into top of sieve. Cover and, in a controlled manner, shake repeatedly side-to-side for approximately 5 minutes.
8. You should now have a collection of soil in each sieve section. Carefully measure and record the mass of each sieve section with soil.
9. Determine the mass of the soil in each section of sieve.
10. We will save some of the soil for later analysis. Empty the rest back into the bucket from which it came.
11. Repeat for second soil sample.
12. Analyze the results - using the table below

Data Presentation and Analysis

Properly display all your raw data
Illustrate in table and graphical form your processed data

Questions.

1. Which sieves (by name) have the most soil in them?
2. Which soil type has the most mass in the lowest three sieves?
3. What is the percent composition of the soil for each particle size listed below?
4. Give your soil a name based on its dominant composition

Particle size names
5-gravel
10-fine gravel
35-very coarse sand
60-coarse sand
120-medium sand
230-fine sand
Pan-silt and clay

Lesson Plan: Soil Formation 4

Teacher Name: Linda Henderson School Year: 2008/9

Semester: 2nd

I. Lesson Outline

a. Title: Lab on 'Soil permeability and adhesion'.

b. Long Range Goal: Understanding how the different textures of soil affect the permeability and adhesion of water.

c. Lesson Objective:

To perform a laboratory investigation on the soil permeability and adhesion of two different types of soil (sandy soil and Kenyan red clay soil).

II. Teaching Materials: Laboratory equipment and soil samples.

III. Review: Summary of the results of the 'Composition of soil lab'.

IV. Key Vocabulary: Permeability, adhesion, and particle size.

V. Introductory Motivation: Does water drain equally through all types of soils?

V. Lesson Development:

1) Collect the lab report on the 'Composition of soil lab'.

2) Explanation of the lab instruction worksheet 'Soil composition Lab Part II: Soil permeability and adhesion' (Demonstrate use of lab equipment and soil samples).

3) Lab activity in groups of 2/3.

4) Homework: Record results and calculate the permeability and percentage adhesion of the two different types of soils. Illustrate the processed data in table and graphical form.

VI. Adjustments for special-needs learners: The lab activity will be demonstrated beforehand and then learners will do the lab activity with a partner. Explanation of how to write up the lab report will also be explained beforehand.

VII. Means of Assessment: Lab report including data presentation in a table and graphical form, and explanation of the results based on particle sizes from the previous lab (next lesson).

Soil Composition Lab Part II. Soil Permeability and Adhesion

1. Put some cotton wool into the opening of the funnel
2. Put 30 ml (full smallest beaker) of soil I into funnel using the most prevalent particle size.
3. Place 50 ml beaker at end of funnel to collect water.
4. Add 50 ml of water, slowly, to top of funnel.
5. Carefully record the time it takes for the water to go through the soil into the collecting beaker. This is your permeability result
6. Measure the amount of water that has collected in the beaker. How much water did the soil adhere to?
7. Calculate the adhesion of the soil as a percent of water held by the soil.
8. Repeat for other soil.
9. Illustrate all the results with tables and graph.

Lesson Plan: Soil Formation 5

Teacher Name: Linda Henderson School Year: 2008/9

Semester: 2nd

I. Lesson Outline

a. Title: Ground water and soils animation.

b. Long Range Goal: Understanding what happens to water when it is in the soil.

c. Lesson Objective: To use the animation to answer the questions on the worksheet.

II. Teaching Materials: Laptop computers, worksheet, animation: http://techalive.mtu.edu/meec/module06/title.htm

III. Review: Lab on soil permeability and adhesion.

IV. Key Vocabulary: Ground water, porosity, permeability, water table, saturated zone.

V. Introductory Motivation: How do the different types of soil affect the amount of water in soils?

V. Lesson Development:

1) Return graded lab reports on 'Soil composition Lab'. Discuss.
2) Collect lab reports on 'Soil permeability and adhesion'.
2) Hand out laptops – one to be shared by two people.
3) Explanation of the animation and worksheet on 'Ground water and soils animation questions'.
4) Complete worksheet during class.
5) Check worksheet together.
6) Review of work covered on soils.

VI. Adjustments for special-needs learners: The animation activity will be demonstrated beforehand and the activity is done with a partner.

VII. Means of Assessment: Test on all work covered so far on soils (next lesson).

http://techalive.mtu.edu/meec/module06/title.htm

Ground Water and Soils Animation Questions

1. What is **ground water**? Relate it to the hydrologic cycle.
2. State the range of sizes for the following soil particles: (USDA system in metric units)
   a. Gravel _____
   b. Sand _____
   c. Silt _____
   d. Clay _____
3. Define **porosity.**
4. **Calculate** the porosity of a soil with a volume of 0.5 cubic meters and a pore volume of 0.1 m^3.
5. Explain the term **packing.** Use a diagram in your explanation.
6. Explain why soils with many different particle sizes may have a low porosity.
7. Define and explain the term **permeability.**
8. Does porosity influence permeability? Explain.
9. Predict the how much higher the permeability of gravel is to the other soils shown in the diagram. If it takes two minutes for water to travel through 1 meter of pure gravel, write you prediction for the other soils
   a. **Gravel – two minutes**

	Prediction	**Actual**
b. **Sand**	_____	_____
c. **Silt**	_____	_____
d. **Clay**	_____	_____

10. **Click on the compare button, and write the actual times in the second column above**
11. Define the terms **water table and Saturated zone.** How are they are related.
12. Using the slide in the animation, describe how both soil particle size and amount of precipitation effect the depth of the water table.
13. Define the term **aquifer.**
14. Define **recharge and recharge area**
15. Where does groundwater go?
16. What is a spring? How does a spring occur?
17. How might high and low water tables effect the flow of a stream?
18. What is an artesian well?
19. Pick the best site for a new well. Write the number of the quad here _____.

Appendix 5

Test on Soil Formation

TEST ON SOIL FORMATION

NAME: _____

Match the columns

Match each item in Column I with the most appropriate item in Column II. Write the letter for that item in the blank at the left.

Column I	Column II
_____1. The action of acids on parent rock	a. litter
_____2. The remains of decomposed litter	b. soil
_____3. Composed of weathered rock and organic matter	c. humus
_____4. Dead leaves, sticks and plant parts	d. soil profile
_____5. Contains layers that give a record of the total environment in which soil is formed	e. physical weathering
	f. chemical weathering

Multiple Choice

Circle the correct letter

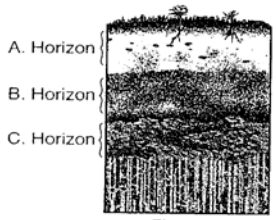


Figure 1

1. In Figure 1, the A horizon is a layer _____
a. of unaltered parent material
b. that is the most fully evolved
c. of partly weathered parent material
d. where calcite or clays may build up

2. A thick layer of organic matter is present in the _____
a. B horizon of soils in dry areas
b. B horizon of soils in rainforests
c. A horizon of soils in humid forests
d. C horizon of soils in moist, warm climates

3. The C horizon in a soil profile
a. consists of partly weathered parent material
b. consists of unweathered parent material
c. contains a large amount of organic material
d. consists of plant roots and animal burrows

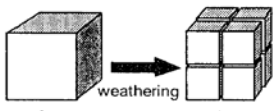


Figure 2

4. Assume that the cube shown in Figure 2 is a rock. Which of the following is true?
a. Physical weathering occurs after chemical weathering.
b. Chemical weathering is more effective on the cube labelled A because there is more surface area.
c. Physical weathering results in more soil particles and a smaller total surface area.
d. Physical weathering breaks the rock into smaller pieces and exposes more surface area for chemical weathering.

5. Physical weathering is caused by_____
a. wind
b. water
c. ice
d. all of the above

6. Earthworms contribute to soil formation by _____
a. aerating the surface sediment
b. secreting organic acids
c. burrowing through the parent material
d. preventing erosion.

7. Which of the following values refers to the size of sand particles?
a . 2mm to 75 mm
b. 0.05 mm to 2mm
c. 0.002mm to 0.05mm
d. less than 0.002mm

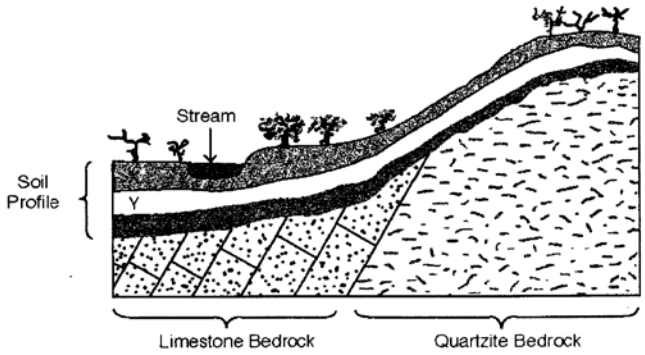


Figure 9-2

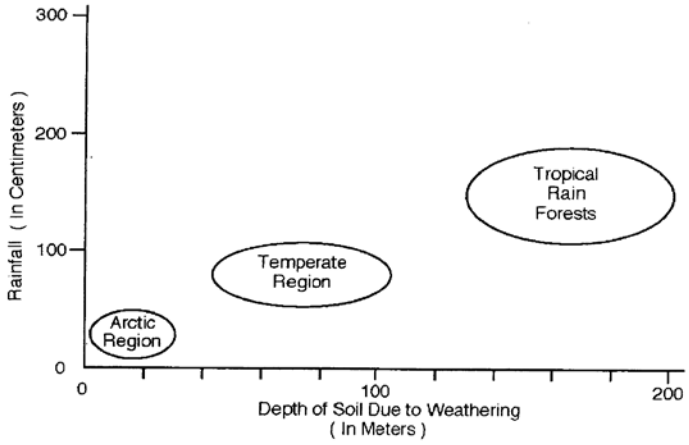
8. The lack of large trees at the top of the hill in Figure 9-2 is most likely due to
a. less oxygen at the higher elevation
b. thin, poorly developed soil
c. higher salinity
d. all of the above

9. On Figure 9-2, the most fertile soil for agriculture will be found _____
a. at the top of the hill
b. on the steep slope
c. in the valley near the stream
d. in the layer labelled Y

10. The amount of groundwater _____
a. decreases when there is more precipitation
b. can affect stream flow
c. increases when soil particles get smaller
d. none of the above

Application Question

Use the following graph to answer the questions below:



1) In which region would the thickest soil profile be found?

_____

2) Which region would most resemble a desert region?

_____

3) What other climatic variable that is not shown in the graph above, contributes to the depth of soil due to weathering?

_____

4) In which region will soils be most poorly developed?

_____

5) In which region is chemical weathering most important?

_____

Understanding Concepts

1) Why does chemical weathering become more effective with the help of frost action?

_____

2) Is frost wedging effective in polar areas? Explain. (2)

_____

_____

3) List *four* factors that influence soil formation and how each factor affects the composition of soil. (8)

_____

_____

_____

_____

_____

_____

_____

4) A scientist investigating the water holding capacity of soils collects two different samples of soil. Analysis of the two samples indicates that one of the soils contains mostly sand particles and the other sample contains mostly silt particles. Predict how these two soil samples will compare in terms of their ***adhesion*** and ***permeability***? (4)

_____

_____

_____

_____

_____

TOTAL: 35

Appendix 6

Lesson Plan: Soil Productivity 1

Teacher Name: Linda Henderson & Scilla Davey School Year: 2008/9
Collaborative teaching models used: 'Team teaching' and 'One teacher, one support'.
Semester: 2nd

I. Lesson Outline

a. Title: Plant macronutrients.

b. Long Range Goal: Understanding the role of the macronutrients nitrogen, potassium and phosphorous in plants, and the effect of soil pH on plant growth.

c. Lesson Objective: To use Internet animations and the information in the booklet on plant nutrients to determine why plants need nitrogen, phosphorous and potassium.

II. Teaching Materials: Internet animations, projector, information booklet, and worksheets.

III. Review: Plants need to obtain certain elements from the soil for good growth. Review of the nitrogen cycle.

IV. Key Vocabulary: Macronutrients, nitrogen, nitrogen cycle, potassium, phosphorous, soil pH.

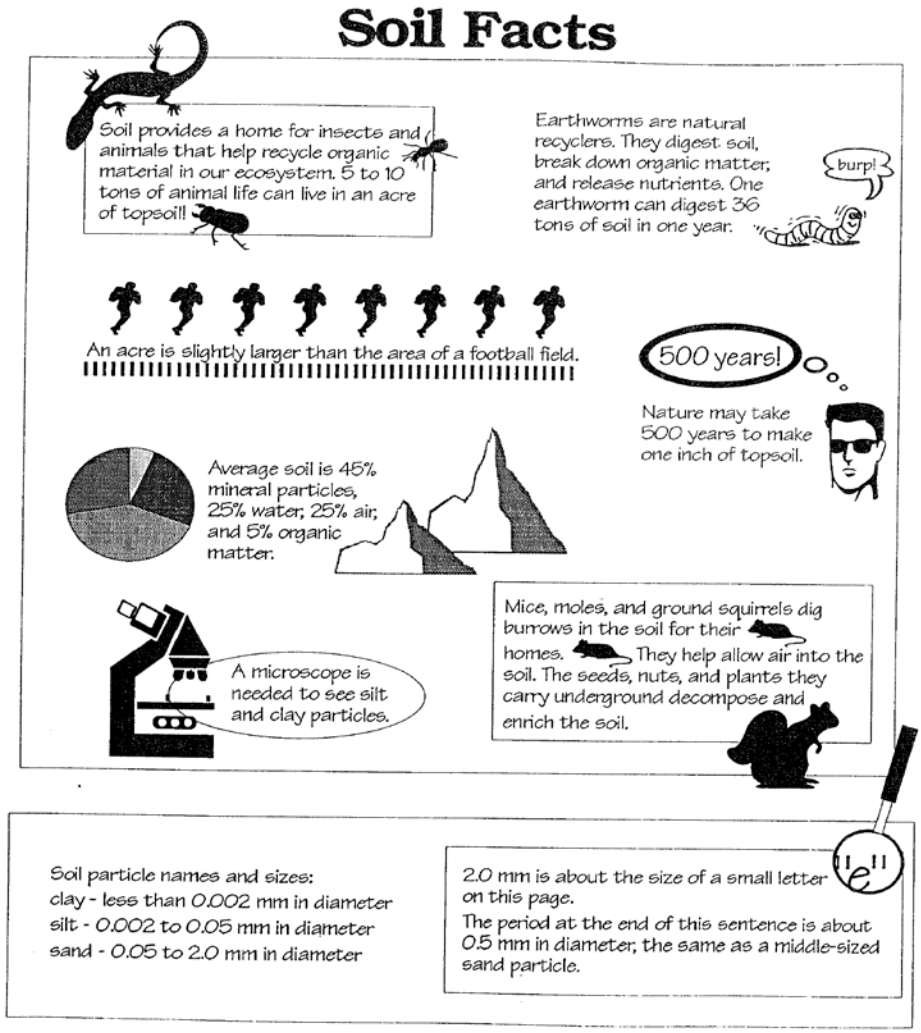
V. Introductory Motivation: Why do plants need certain nutrients from the soil?

V. Lesson Development:

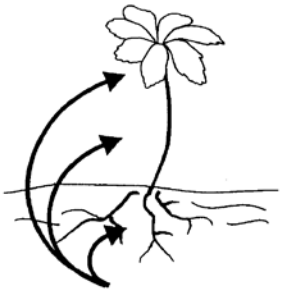
1) Discuss worksheet on 'Soil Facts'. (Scilla models a mind map.)
2) Discussion of the information booklet on plant nutrients (use of Internet animations, laptops, booklet and board).
3) Worksheet on 'Soil nutrients activity questions'. (Scilla models methods of how to spell terms.) Complete for homework.

VI. Adjustments for special needs learners: The worksheet on soil nutrient questions will be done with a partner, and checked before the quiz is given.

VII. Means of Assessment: 'Soil nutrient activity questions' will be graded next lesson.



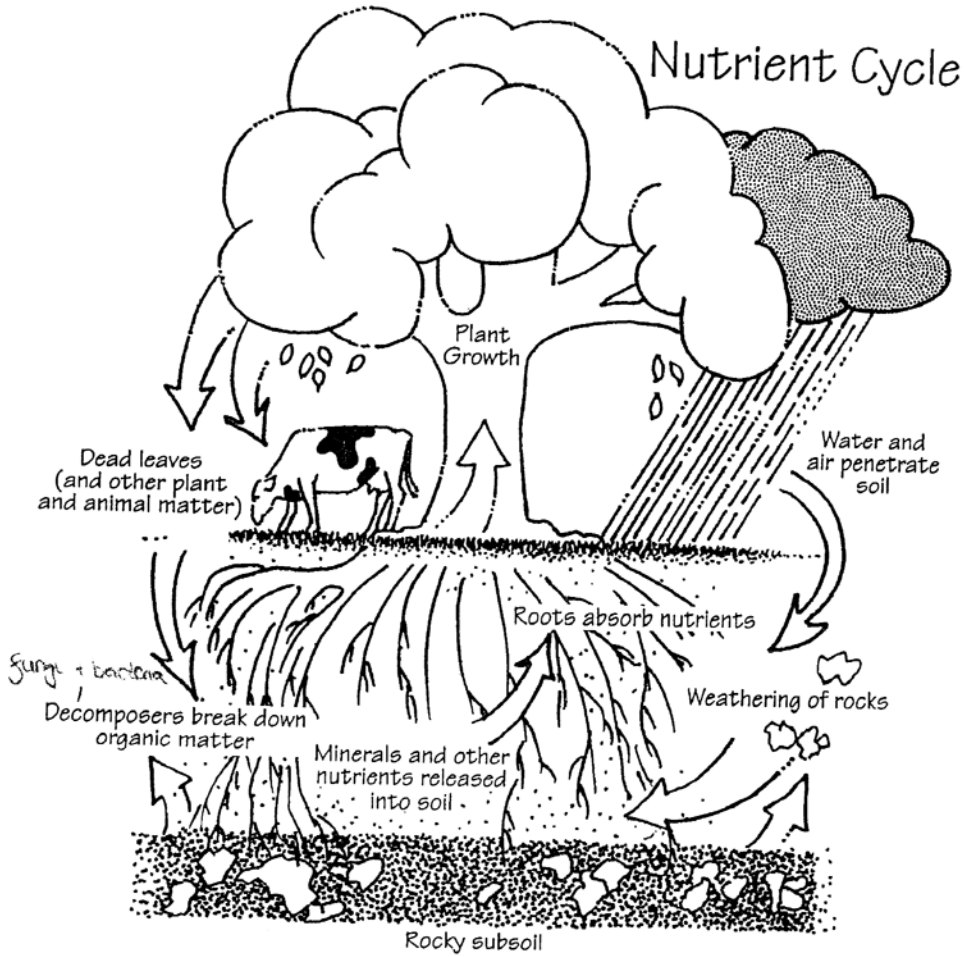
Plant Nutrients



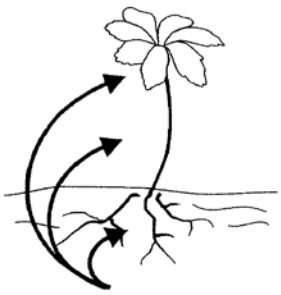
People need food to survive and grow. Plants make their own food using energy from sunlight and essential nutrients in the form of chemical elements. Plants require some nutrients in large amounts for good growth. These are called macronutrients. Macronutrients include: carbon (C), oxygen (O), hydrogen (H), nitrogen (N), phosphorus (P), and potassium (K). Plants get carbon, oxygen, and hydrogen from water and air. Plants get nitrogen, phosphorus, and potassium from the soil.

How plants get nutrients from the soil

Water, entering the soil, dissolves nutrients in the soil, forming a soil solution. Plant roots absorb dissolved nutrients from the soil solution and they are transported throughout the plant. Often nutrients are present in the soil, but not in a form that plants can use. Many factors affect the "availability" of soil nutrients, but the most important is soil pH. Later in the Topsoil Tour, you will measure the pH of your own soil sample.


Nutrient Cycle
Plant Growth
Dead leaves (and other plant and animal matter)
Water and air penetrate soil
Roots absorb nutrients
fungi + bacteria
Decomposers break down organic matter
Weathering of rocks
Minerals and other nutrients released into soil
Rocky subsoil

Extraction



Distilled water alone cannot be used for nutrient tests as it was in the pH test. Soil nutrients - nitrogen, phosphorus and potassium - are tightly stuck to soil particles. The Floc-Ex TesTabs contain a powdered form of acetic acid, the same acid found in vinegar. When the extraction tablets are added to distilled water, an extraction liquid is formed which frees the nutrients from the soil particle so that we can measure them.

Remember - plants get nutrients from soil after the nutrients dissolve into solution in the soil. Plants absorb the dissolved nutrients through their roots. The soil tests work in a similar way - nutrients dissolved in the soil extract are measured.

BEEF UP

Decomposing organic matter, like manure and compost, and commercial fertilizers are the most common sources for adding nitrogen to the soil. Some plants, called "legumes", have special bacteria in their roots that enable them to take nitrogen from the air.

A plant that doesn't get enough nitrogen will have yellowing of the leaves, beginning with the newest leaves.

Giving a plant too much nitrogen may cause long, weak stems and inhibit flowering.

Why Do Plants Need Nitrogen?

Plants use nitrogen to make chlorophyll, the green color in leaves that enables plants to take energy from sunlight and make food for growth. This process is called photosynthesis. That's why plants grow towards light! Nitrogen is responsible for rapid plant growth and healthy green leaves. Sufficient nitrogen is especially important for lawns, green-leafy vegetables like spinach, lettuce, and cabbage, and for forage crops like soybeans, alfalfa, and corn.

BEEF UP

Most phosphorus stored in the soil is in a form not readily available to plants. Soil microorganisms help change soil phosphorus into available forms. Phosphorus is most available to plants when soil is moist and soil pH is between 6 and 7. The weathering of minerals in the soil can release phosphorus as phosphate. Commercial phosphorus fertilizer is made by mining phosphorus ores from the earth.

A plant that doesn't get enough phosphorus may have purplish or deep green color on lower leaves and a poor root system.

Giving a plant too much phosphorus usually does not produce symptoms.

Why Do Plants Need Phosphorus?

Phosphorus is necessary for root development and growth. It helps plants grow strong and helps them produce flowers and fruit.

Phosphorus is especially important for crops such as beets, potatoes, carrots, and radishes because the roots are the part of these plants that we eat.

BEEF UP

Soil potassium comes from the weathering of feldspar and mica, minerals commonly found in the soil. If your soil sample had flecks of shiny gold particles in it, it was probably, mica, not gold - sorry!

Wood ashes and seaweed yield small but useful amounts of potassium.

A plant that doesn't get enough potassium will have slow growth, small size, and may have browning of the edges of leaves so that leaves look "scorched".

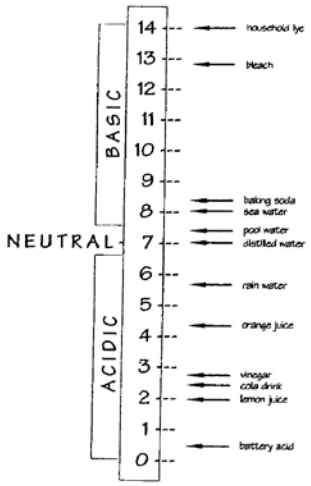
Giving a plant too much potassium may cause the plant to take up too little calcium, another important nutrient.

Why Do Plants Need Potassium?

Potassium is necessary for new cell growth throughout the plant. It also helps plants resist disease and survive in dry or freezing weather. It helps plants make strong stems.

New cells rapidly form at root tips and buds, so root crops such as: beets, potatoes, carrots, and radishes, and bud crops; such as: asparagus, broccoli, and cauliflower benefit from sufficient potassium.

pH



pH is a measure of how acidic or basic things are. We assign a number scale from 0 to 14 to things to tell us how acidic or basic they are.

- A pH less than 7 is acidic. Vinegar is acidic with a pH of about 3.5.
- A pH above 7 is basic. Ammonia is basic with a pH of 10. *(When soil pH is basic, it is usually called "alkaline".)*
- pH 7 is at the middle of the scale. This is neutral pH. That is, it is neither acidic nor basic.

Soil pH

When we measure the pH of soil, we actually measure the pH of the soil solution. The pH of the soil solution affects how much soil nutrients are available to plants. When soil is too acid or too basic, important soil nutrients, like nitrogen, phosphorus, and potassium are not available to plants. Other soil nutrients, especially metals, become more available and may reach levels toxic to plants. Most plants prefer neutral or slightly acidic soils in the pH range of pH 6.0 to 6.8. Some plants, like insect-eating carnivorous plants, such as the Venus flytrap, prefer strongly acid soils with pH values between 4.0 and 5.0.

Plants that prefer slightly acid soil (pH 5.0 to 6.5)	Plants that prefer neutral soil (pH 6.0 to 8.0)	Plants that prefer strongly acid soil (pH 4.0 to 5.0)
American holly	alfalfa	sundew*
orchids	bluegrass	pitcher plants*
many evergreen trees & shrubs	most vegetables (lettuce, tomato)	Venus flytrap*
strawberries	grains (corn, wheat)	azalea
potato		rhododendron
carrot		Camellia
fescue grass		

**carnivorous plants!*

To raise the pH of acidic soil, powdered limestone, called "lime", is added to the soil. Your school may use lime to make the white lines that mark the boundaries of the playing fields.

To lower the pH of basic soil, aluminum sulfate, or alum, is added.

Scientist's Name _____ Date _____

Data Sheet

Soil pH

1. Your soil sample pH test result:

color _____ pH _____

2. Circle some plants that would prefer this pH soil.

Alfalfa	6.0-7.0	Cotton	5.5-6.5	Peanut	5.0-6.0
Apple	5.5-6.5	Cucumber	6.0-8.0	Petunia	6.0-8.0
Asparagus	6.0-7.0	Daffodil	6.0-6.5	Phlox	5.0-6.0
Azalea	4.0-5.0	Douglas Fir	6.0-7.0	Pitcherplant	4.0-5.0
Banana	7.0	Geranium	6.0-8.0	Potato	4.8-6.5
Beech	6.0-7.0	Grapefriut	5.0-7.0	Radish	6.0-8.0
Beet	5.8-7.0	Grass	6.0-7.0	Rice	6.0-7.0
Broccoli	6.0-7.0	Holly	5.0-6.0	Rose	6.0-8.0
Cabbage	6.0-7.0	Kentucky Bluegrass	6.0-8.0	Soybean	6.0-7.0
Camelia	4.0-5.5	Lemon	5.5-7.0	Spinach	6.5-7.0
Carnation	6.0-8.0	Lettuce	6.0-7.0	Spruce	5.0-6.0
Carrot	5.5-6.5	Lima Bean	5.5-6.5	Strawberry	5.0-6.0
Cauliflower	6.0-7.0	Maple	6.0-8.0	Tomato	6.0-7.0
Chestnut	5.0-6.0	Mint	6.0-8.0	Venus Flytrap	4.0-5.0
Clover	6.0-7.0	Orchid	5.0-6.0	Wheat	6.0-7.0
Coleus	6.0-8.0	Pea	6.0-8.0	Zinnia	6.0-8.0
Corn	6.0-7.0				

Soil Nutrients Activity Questions

1. How does pH affect the availability of nutrients in the soil to plants?
2. For the following pH ranges, first identify them and then name a few plants that prefer these ranges:
    a. 5.0-6.5
    b. 6.0-8.0
    c. 4.0-5.0
3. If you wanted to manage a soil, state how you would raise or lower the pH.
4. State important sources of each of the 3 main macronutrients studied in this activity.
5. If your soil had a pH of 5 with low amounts of nitrogen, phosphorous, and potassium, how would you manage it so that you could have a nice garden of vegetables including nice green leafy lettuce?
6. Find the soil fact sheet and fill in the following:
    a. Weight of animal life in an acre of soil _____
    b. Size of clay, silt, and sand particles _____ _____ _____
    c. Time it takes for nature to make one inch of topsoil _____
    d. How big is an acre _____
    e. Amount of soil one earthworm digests (and recycles) in one year _____
7. Composition of average soil? _____
8. Why do plants need the following nutrient:
    a. Nitrogen (N)
    b. Potassium (K)
    c. Phosphorous (P)
9. How do plants obtain the nutrient elements C, H, O, N, K, and P??

Lesson Plan: Soil Productivity 2

Teacher Name: Linda Henderson & Scilla Davey School Year: 2008/9

Collaborative teaching models used: 'Station teaching'.

Semester: 2nd

I. Lesson Outline

a. Title: Lab on soil nutrients.

b. Long Range Goal: Understanding how to test soils for pH, nitrogen, potassium and phosphorous.

c. Lesson Objective: To be familiar with the procedure of testing the pH of soil and nutrient extraction.

II. Teaching Materials: Laboratory equipment and soil samples.

III. Review: The role of the macronutrients nitrogen, phosphorous and potassium in plants.

IV. Key Vocabulary: Macronutrients, soil pH, nitrogen, and potassium, phosphorous.

V. Introductory Motivation: How can we test for certain elements in soils?

V. Lesson Development:

1) Collect worksheet on 'Soil nutrients activity questions'.

2) Review of the macronutrients needed by plants.

3) Explanation and demonstration of the lab instruction worksheet 'Soil nutrient activity' (demonstrate use of lab equipment).

4) Lab activity – work in groups of 2/3.

5) Homework: Record results for all the tests – pH, nitrogen, phosphorous and potassium. Review all work covered in last two lessons in preparation for a quiz next lesson.

VI. Adjustments for special needs learners: The lab activity will be demonstrated beforehand and will be done with a partner.

VII. Means of Assessment: Write up of the results for all the nutrient tests (next lesson).

Soil Nutrient Activity

Soil Facts

Plants need food to survive and grow. Plants make their own food in a process called photosynthesis. Plants require some nutrients in large amounts for good growth. These are called macronutrients, and are made up of essential elements. These include Carbon (C), oxygen (O), hydrogen (H), nitrogen (N), phosphorous (P), and potassium (K).

Plants get Carbon, Hydrogen, and oxygen from water and air. They get the other nutrients (N, P, and K) from the soil. Water enters soil and dissolves nutrients in the soil. Plants absorb dissolved nutrients in their roots and transport them throughout the plant for use. Not all nutrients are in a form useable by plants. Many factors effect the availability of nutrients, the most important being soil pH.

I. Procedure for pH test

1. Fill a test bag to line C with distilled water (if available).
2. Use the plastic spoon to add about 1/2 teaspoon of soil
3. Add one soil pH TesTab to bag. Roll the top of the bag down 3 or 4 times. Hold top of bag and shake for 15 seconds
4. Let the bag sit for 1 minute so the soil can settle out
5. Compare the color of the liquid above the soil to the *Color Chart Poster*. Record the pH fo the sample. Is it acidic, neutral, or basic??
6. Pour out liquid only into sink. Dump soil in the trash. Rinse out the test bag for reuse.
7. Write the names of plants that would prefer to grow in soil of this pH. (get names from *Topsoil Tour Manual*)

II. Procedure for Nutrient extraction

1. Pour 180 ml of water into a quart size zipper top bag.
2. Add 8 Floc-Ex Testabs (5504). Seal the bag. Shake until tablets dissolve.
3. Add 5 teaspoons of the soil sample.
4. Close the bag tightly and shake briskly for one minute (this should extract many soil nutrients, including nitrogen)
5. Hold the bag at an angle and let the soil particles settle for at least one minute
6. Pour the clean liquid into a clean beaker or cup.
7. This extract can be used for all our nutrient tests.

III. Procedure for Nitrogen Testing

Nitrogen is used by plants to manufacture chlorophyll, the green pigment that enables plants to photosynthesize food.

1. Fill a test bag to line C with soil nutrient extract (from procedure II

above)
2. Add one nitrate Number 1 TesTab (2799). Roll the bag down 3 or 4 times. Fold the yellow tabs back around the bag and shake until the tablet dissolves.
3. Add one nitrate number 2 TesTab. Roll down again and shake until tablet dissolves (could take 2 minutes)
4. Wait 3 minutes for pink color to develop
5. Compare color to *Color Chart Poster* (in Manual)
6. Record result. Remember to save extract. Rinse test bag for later reuse

IV. Procedure for Potassium Test

Potassium is necessary for new cell growth, to resist diseases, and to survive difficult weather

1. Fill a test bag to line C with soil nutrient extract
2. Add one Potassium TesTab (5424). Roll, fold tabs, and shake until dissolved
3. Compare the cloudiness of the reaction to the ***Color Chart Poster***. Hold the bag over the black salamanders in the left hand column and see how fuzzy they look. Compare them to the grey salamanders in the right hand column.
4. Record results. Save extract. Rinse out test bay for reuse.

V. Procedure for Phosphorous test

Phosphorous is necessary for root development and growth It helps them stay strong and to develop flowers and fruit.

1. Put seven teaspoons of water in a cup or beaker. Add one teaspoon of soil extract. Stir it up.
2. Fill a bag to line C with the diluted soil extract
3. Add one Phosphorous TesTab (5422). Roll, fold tabs, and shake until dissolved (may take 3 minutes)
4. Wait five minutes for blue color to develop
5. Compare the color of the reaction to the ***Color Chart Poster***.
6. Record the result. Discard the leftover solution. Rinse and save bag.

Lesson Plans: Soil Productivity 3, 4 & 5

Teacher Name: Linda Henderson & Scilla Davey School Year: 2008/9
Collaborative teaching models used: 'Team teaching' and 'Station teaching'.
Semester: 2nd

I. Lesson Outline

a. Title: Essential nutrient elements

b. Long Range Goal: Understanding the role of two macronutrients, two secondary nutrients and two micronutrients required by plants.

II. Teaching Materials: Internet, projector, laptop computers and worksheets.

III. Review: Plant nutrient worksheet, and the periodic table. (Scilla to teach different learning strategies.)

IV. Key Vocabulary: Macronutrients, secondary nutrients, and micronutrients.

V. Introductory Motivation: What is the role of nutrients in plants?

V. Lesson Development:

1) Collect lab reports on pH, nitrogen, phosphorous and potassium tests.
2) Quiz: Crossword puzzle.
3) Each learner is given one element to study in detail from the 'Essential nutrient elements' list.
4) Discussion of the project and presentation requirements. (Use of worksheet and Internet.)
5) Explanation of the nutrient element project and presentation rubric.
6) Use of Internet and laptop computers for research.

VI. Adjustments for special needs learners: The expectations for the nutrient element project and presentation will be discussed and a rubric will be given to each learner.

VII. Means of Assessment: Written projects and presentations of essential nutrient elements over the next two lessons.

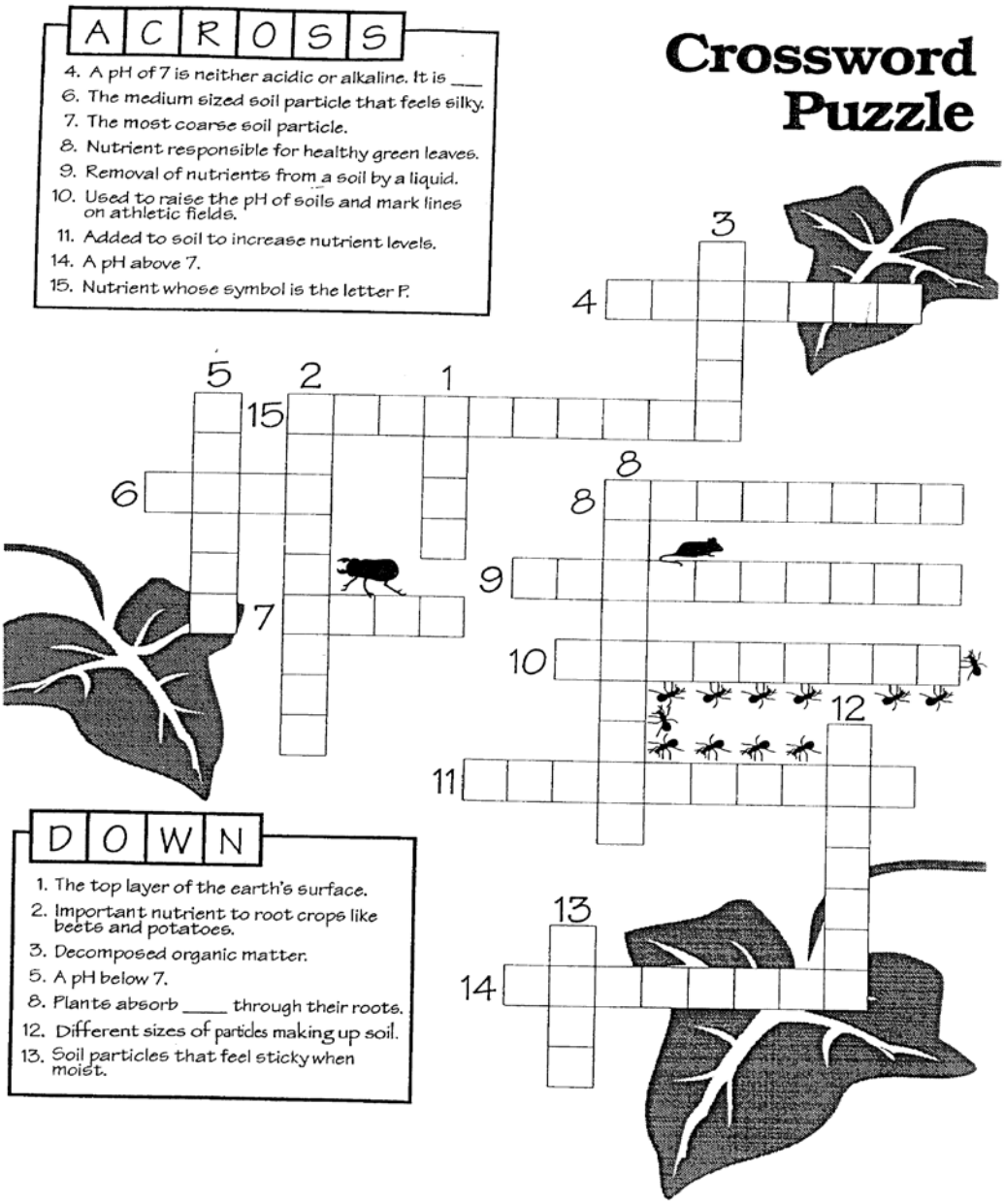


Table 1. Essential nutrient elements.

Nutrient	Symbol	Form available	Category
Carbon	C	CO_2, H_2O	Non-fertilizer elements supplied through air, water, and soil nutrients
Hydrogen	H	H_2O	
Oxygen	O	CO_2	
Nitrogen	N	NO_3^-, NH_4^+	Macronutrients required by plants in large amounts
Phosphorus	P	$PO_4^=$	
Potassium	K	K^+	
Calcium	Ca	Ca^{++}	Secondary nutrients required by plants in moderate amounts
Magnesium	Mg	Mg^{++}	
Sulfur	S	$SO_4^=$	
Boron	B	HBO_4^-	Micronutrients required by plants in small amounts
Chlorine	Cl	Cl^-	
Copper	Cu	Cu^{++}	
Iron	Fe	Fe^{++}, Fe^{+++}	
Manganesse	Mn	Mn^{++}	
Molybdenum	Mo	$Mo_4^=$	
Zinc	Zn	Zn^{++}	

Nutrient Element Presentation Requirements

1. Name, symbol, atomic number, and family of element
2. Category, description, abundance (macro/micro/trace etc.)
3. Sources of the nutrient element, whether natural or artificial
4. Importance to the plant. How obtained and utilized
5. Results of nutrient deficiency and toxicity
6. Essential nutrient in humans? Briefly explain
7. Other interesting facts or anecdotes concerning this element

Essential Plant Nutrients

	Very Poor 1 pt	Poor 2 pts	Mediocre 3 pts	Satisfactory 4 pts	Good 5 pts	Very Good 6 pts	Excellent 7 pts
Plant Nutrient - General Information	Not able to identify & explain the essential plant nutrient by symbol, family, description, & abundance.	Able to identify & explain the essential plant nutrient by symbol, family, description or abundance.	Able to identify & explain the essential plant nutrient by symbol, family, description, &/or abundance. (Two needed)	Able to identify & explain the essential plant nutrient by symbol, family, description, &/or abundance. (Three needed)	Able to identify & explain the essential plant nutrient by symbol, family, description, & abundance.	Able to identify & explain the essential plant nutrient by symbol, family, description, & abundance. Shows occasional insight or originality.	Able to identify & explain the essential plant nutrient by symbol, family, description, & abundance. Shows insight or originality.
Plant Nutrient - Functions for Plants	Not able to identify essential plant nutrient functions.	Able to identify one essential plant nutrient function.	Able to identify two essential plant nutrient functions.	Able to identify three essential plant nutrient functions.	Able to identify at least four essential plant nutrient functions.	Able to identify four or more essential plant nutrient functions. Shows occasional insight or originality.	Able to identify more that four essential plant nutrient functions. Shows insight or originality.
Plant Nutrient - Deficiencies & Toxicity	Not able to identify and explain deficiencies & toxicity symptoms.	Able to identify and explain one deficiency or toxicity symptom.	Able to identify and explain one deficiency & one toxicity symptom.	Able to identify and explain one or two deficiencies & one or two toxicity symptoms. (Three needed)	Able to identify and explain two deficiencies & two toxicity symptoms.	Able to identify and explain two deficiencies & two toxicity symptoms. Shows occasional insight or originality.	Able to identify and explain two or more deficiencies & two or more toxicity symptoms. Shows insight or originality.
Plant Nutrient - Other Facts *(importance/ history/ anecdotes)*	Not able to identify other facts & no bibliography.	Able to identify at least one other fact including: importance to organisms, history, anecdotes, & a bibliography.	Able to identify at least two other facts including: importance to organisms, history, anecdotes, & a bibliography.	Able to identify at least three other facts including: importance to organisms, history, anecdotes, & a bibliography.	Able to identify other facts including: importance to organisms, history, anecdotes, & a bibliography.	Able to identify and explain other facts including: importance to organisms, history, anecdotes, importance to humans, & an adequate bibliography.	Able to identify and explain other facts including: importance to organisms, history, anecdotes, importance to humans, & a thorough bibliography.

Lesson Plan: Soil Productivity 6

Teacher Name: Linda Henderson & Scilla Davey School Year: 2008/9

Collaborative teaching models used: 'One teacher, one support."

Semester: 2nd

I. Lesson Outline

a. Title: Soil productivity and nutrient content

b. Long Range Goal: Understand methods to maintain soil fertility and prevent erosion.

c. Lesson Objective:

1) Describe the three methods that can be used to maintain soil fertility.

2) Explain deforestation and its effects.

II. Teaching Materials: Internet, projector and worksheets.

III. Review: Essential nutrients may not be present in every soil that develops.

IV. Key Vocabulary: Crop rotation, contour ploughing, terracing, erosion, and deforestation.

V. Introductory Motivation: What makes a healthy soil?

V. Lesson Development:

1) Discuss pictures showing erosion and the effects it has on plant growth (use of the Internet).

2) Discussion of methods that prevent erosion and boost soil productivity, and our dependence on soil. (Use of textbook, worksheet and Internet.)

3) Worksheet on 'Soil productivity and nutrient content'.

4) Check worksheet using peer review.

5) Homework: Worksheet on 'Chapter review'.

VI. Adjustments for special needs learners: The worksheet on ‘Soil productivity and nutrient content’ will be done with a partner and checked before the homework is given.

VII. Means of Assessment: Worksheet on ‘Chapter review’. Test on entire chapter next lesson after a revision session with Scilla explaining different learning strategies.

NAME _____ DATE _____ CLASS _____

STUDY GUIDE

Chapter 9

9-3 Soil Productivity and Nutrient Content

In the space provided, explain what the terms have in common or how the terms relate with one another.

1. water, soil, nutrients _____
2. hydrogen, carbon, nitrogen, oxygen _____
3. phosphorus, potassium, calcium, nutrients _____
4. cultivated crop, small grain, grasses _____
5. animal manure, garbage, fish scraps _____
6. crop rotation, contour plowing, terracing _____

In each of the following statements, a word has been scrambled. Unscramble the word and write it on the line provided.

_____ 7. On steep hillsides, **ciretarng** minimizes erosion.

_____ 8. Soils that have too much acid can be treated with **meil**.

_____ 9. **Shopsorhup** in minerals becomes available to plants when it is released by weathering.

_____ 10. **Tinlarteccug** in rainforests leads to nutrient-depleted soils and erosion.

_____ 11. **Lirefitrez** supplies essential nutrients, such as nitrogen and phosphorus.

_____ 12. Deforestation often depletes soil of all nutrients except iron and **mumnulia**.

Answer the following questions in phrases or complete sentences.

13. What benefit comes from plowing crops under the soil instead of harvesting them?

_____

14. How can the United States lose millions of acres of farmland? _____

_____

_____

15. Why do some people object to the use of artificial fertilizers and pesticides? _____

_____

_____

NAME _____ DATE _____ CLASS _____

CHAPTER REVIEW

Chapter 9

Soil Formation

I. Vocabulary Review

Complete the following sentences using these terms: chemical, humus, litter, physical, profile.

1. _____ consists of dead leaves, branches, and other plant parts.
2. A soil _____ gives a record of the total environment in which the soil was formed.
3. _____ weathering involves no chemical change in the rock.
4. Weak acids are important in _____ weathering.
5. Litter decomposes to form _____.

II. Concept Review

In the blank at the left, write the letter of the choice that best completes the statement.

_____ 6. Frost wedging is most effective when temperatures _____.
- a. are between −15 and 0°C
- b. are between −15 and +15°C
- c. are between +15 and +30°C
- d. stay at 0°C

_____ 7. The most chemical weathering occurs in climates _____.
- a. with low average temperatures and low rainfall
- b. with high average temperatures and low rainfall
- c. with average temperatures above 0°C and moderate to high rainfall
- d. that have little seasonal change

_____ 8. Biological weathering by lichens _____.
- a. involves secretion of acids
- b. involves expansion and contraction of the lichens when water is absorbed
- c. causes rocks to crumble over a long time period
- d. all of the above

_____ 9. At a temperature between 25° and 35°C, you would expect to find _____.
- a. the formation of humus from litter
- b. less weathering of parent material
- c. more frost wedging
- d. soil turning yellow brown to red

_____ 10. Crop rotation _____.
- a. minimizes erosion
- b. minimizes acidity
- c. keeps the soil productive
- d. decreases runoff

If the underscored word makes the sentence true, write "TRUE" in the space provided. If the underscored word makes the sentence false, write the correct term in the space provided.

_____ 11. An <u>increase</u> in a rock's surface area increases the rate at which chemical reactions occur.

_____ 12. <u>Carbonic</u> acid in acid rain weathers stone buildings.

_____ **13.** Water that collects in small cracks in rocks contracts when temperatures fall below 0°C, causing rocks to crack even more.

_____ **14.** Hydrogen, potassium, nitrogen, and carbon are some of the nutrients present in air and water that are essential for plant growth.

III. Skills/Process Review

In the Investigate activity, you tested several soil samples. Refer to the table below to answer the questions.

15. Fill in the lettered spaces in the table to show organic matter content and soil acidity for Sample 1 and Sample 2.

	color	texture	organic (high/low)	HCl reaction (+/–)	pH (+/– acid)
1.	dark grey	loam	a.	–	b.
2.	light grey	sandy	c.	+	d.

16. Explain what the HCl test shows. _____

_____

17. Label the soil profile in Figure 1, using the following terms: *humus, nutrients and clay, weathered parent rock.*

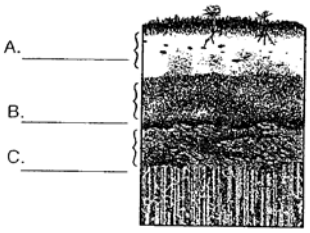


Figure 1

IV. Feature Review

18. Science and Society: **Organic Farming—Is Natural Better?** Why do organic farmers think that artificial fertilizers are inadequate? _____

_____

_____

_____

Appendix 7

Test on Soil Productivity

TEST ON SOIL PRODUCTIVITY

NAME: _____

Match the columns

Match each item in Column I with the most appropriate item in Column II. Write the letter for that item in the blank at the left.

Column I	Column II
_____1. Science of growing plants in a nutrient solution	a. minimum tillage
_____2. A neutralizing agent	b. soil
_____3. Plant that is widely produced for fabric	c. contour plowing
_____4. Practice of not plowing a field after the harvest	d. corn
_____5. Composed of weathered rock and organic matter	e. hydroponics
_____6. Process that moves weathered rock from one place to another	f. lime
_____7. The growing of trees	g. silviculture
	h. cotton
	i. erosion

Understanding Concepts

1) A farmer's field has been cropped for 3 successive years and has a pH of 5. He wants to plant corn on it. Corn loves a pH of 6 or 7, and requires large amounts of all the macronutrients.

a. State how he should manage this soil in order to have a great corn crop. (2)

_____

_____

b. If you were a soil conservationist, what advice would you give this farmer to better manage the soil over the next several years? (2)

2) For any ***macronutrient*** required by plants and obtained from soil and fertilizers, state the following:
a. Its name and chemical symbol. (2)

b. Importance of this macronutrient for plant health. (1)

c. One symptom in plants if this macronutrient is **not available.** (1)

3) For any ***micronutrient*** required by plants and obtained from soil and fertilizers state the following:
a. Its name and chemical symbol. (2)

b. Importance of this micronutrient for plant health. (1)

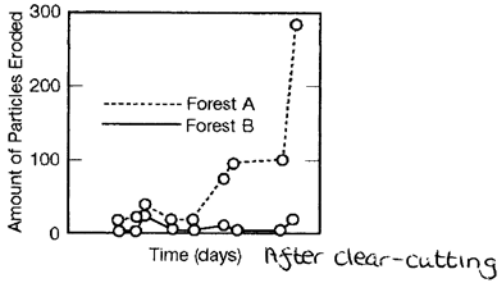
c. One symptom in plants if this micronutrient is in **excess.** (1)

4) Calcium is important for general plant vigour and promotes growth of young roots and shoots. Why is calcium classified as a *secondary nutrient* required by plants? (1)

5) Name the element you did a presentation on and discuss two interesting facts about this element. (2)

Application Question

Use the following graph to answer the questions below:



1) Which line in Figure 3, A or B, represents a forest that was clear-cut? Explain. (2)

2) Infer why there is a time lag before line for Forest A begins to show an increase. (2)

3) Infer what the effects of clear-cutting would be on the soil's temperature and nutrients. (2)

CRITICAL THINKING/PROBLEM SOLVING

Soiling Solutions

In the spring of 1992, the World Resources Institute in Washington, D.C., completed the first-ever study of world soil degradation, which is the loss of fertility in the soil. The verdict was not too promising. According to the study, more than 3 billion acres of land—roughly the size of China and India combined—have been seriously degraded since World War II. About 22 million acres of land have lost so much soil fertility that they can no longer sustain crops. The major damage to the soil has been a result of the stressful demands of Earth's human population on the environment. Valuable vegetation is stripped away from land, while wind and water erode, or wear away, the upper layer of topsoil. The many nutrients in the topsoil are washed away, leaving only the hard subsoil, which is not very fertile.

This is truly a global problem because no country has escaped soil degradation. Almost two-thirds of the damaged soil can be found in Africa and Asia. However, North America is not excluded from this plight. Roughly one-quarter of the cropland in the United States has eroded enough to make it unable to sustain agricultural productivity. Europe has lost more than 34 million acres of land due to pollution from pesticides.

However, there are solutions to the problem of soil degradation. Proper land and range management can preserve valuable vegetation that holds the topsoil in place. These techniques include not tilling the soil, leaving crop residues on the land, and rotating crops. The current damage can be partially repaired by adding nutrients to the existing soil. Methods such as natural manure fertilizers and organic growing techniques may be able to accomplish this.

1. How does nutrient-rich soil become degraded soil? _____

_____ (2)

2. What land and range management techniques can help combat soil degradation? _____

_____

_____ (2)

3. How can leaving crop remnants on the surface prevent erosion? _____

_____ (1)

4. What agricultural techniques may help repair damaged land? _____

_____ (1)

5. What fundamental problems limit utilizing these new techniques? _____

_____

_____ (1)

TOTAL: 35

Appendix 8

Multiple Choice Test on Soils

Name:_____

Multiple Choice Questions on Soil Formation

1) Soil may be defined as a combination of
A. physical and chemical weathering.
B. air, organic matter, and water.
C. broken down rock and mineral matter.
D. both B and C.

2) The rock from which a soil originates influences the nature of soil. This rock is called
A. sediment
B. parent material
C. topography
D. horizons

3) Which of the following do NOT contribute to humus?
A. Quartzite and limestone.
B. Fungi and bacteria.
C. Decaying animals.
D. Litter such as dead leaves.

4) Raindrops, friction, and dissolving of minerals by water illustrate what category of weathering?
A. All three are physical.
B. All three are chemical.
C. The first two are physical; the third is chemical.
D. The first is chemical; the second and third are physical.

5) Areas of the world having climates with high average rainfall and high average temperatures show
A. higher rates of physical weathering.
B. no physical weathering at all.
C. higher rates of chemical weathering.
D. no chemical weathering at all.

6) Which of the following statements is correct?
A. Sand has a high permeability and a high adhesion.
B. Sand has a high permeability and a low adhesion.
C. Clay has a low permeability and a low adhesion.
D. Clay has a high permeability and a low adhesion.

7) Which pattern for soil thickness is correct?
A. Thin soils are seen in tropical regions.

B. Thick soils are seen in arctic regions.
C. Thick soils are seen in desert regions.
D. Thick soils are seen in tropical regions.

8) In a typical soil profile
A. the topsoil layer has changed or evolved the most.
B. the topsoil layer has changed or evolved the least.
C. the subsoil layer has changed or evolved the most.
D. both B and C are correct.

9) Which of the following would increase the rate of **chemical** weathering of a rock?
A. Cracks in the rock.
B. Decreased temperature.
C. Running water.
D. Plant roots.

10) Why are earthworms essential to soil development?
A. Burrowing cuts off the air supply to the lower levels of the soil.
B. The worms recycle nutrients and help to further develop soil.
C. Burrowing packs down existing soil, enabling water to flow through it more easily.
D. Earthworms have no effect on soil.

Multiple Choice Questions on Soil Productivity

1) The farming technique called minimum tillage is effective in
A. increasing soil erosion.
B. decreasing soil erosion.
C. increasing thickness of the subsoil layer.
D. decreasing thickness of the topsoil layer.

2) Crop rotation
A. minimizes erosion.
B. minimizes acidity.
C. keeps the soil productive.
D. decreases runoff.

3) Which of the following nutrients essential for plant growth are NOT present in air and water?
A. Hydrogen
B. Potassium
C. Nitrogen
D. Carbon

4) Why is soil 'turned over' before planting?
A. Gives the soil less water-holding properties.
B. Allows litter to decompose faster into humus.
C. Allows nutrients to leach out the soil.
D. Changes the soil texture.

5) How can you raise the pH of a soil?
A. Add powered limestone (lime).
B. Add aluminium sulfate (alum).
C. Add hydrochloric acid.
D. Add vinegar.

6) Which of the following nutrients is regarded as a ***micronutrient*** in plants?
A. Sulfur
B. Calcium
C. Copper
D. Magnesium

7) The growing of trees is known as
A. hydroponics
B. erosion
C. ploughing
D. silviculture

8) What happens to the soil after trees are removed?
A. Soil is no longer held in place and can be carried away by rain or wind.
B. Soil temperature decreases.
C. The soil restores its nutrient content.
D. Oxygen levels in the soil increase.

9) What role does **phosphorous** play in plants?
A. Is responsible for rapid plant growth and healthy leaves.
B. Is necessary for root development and growth.
C. Is necessary for new cell growth throughout the plant.
D. Is necessary for the manufacture of chlorophyll.

10). A deficiency of the nutrient **nitrogen** in plants causes the leaves to
A. turn light green or yellow.
B. have a bronzed appearance.
C. roll backwards along the margins.
D. develop a purple colouration.

Appendix 9

Second Experimental Group: IEP's for learners 1 and 2

INTERNATIONAL SCHOOL OF KENYA
P O Box 14103 00800 Nairobi Kenya
Tel +254 20 4183622 | 2691308/9 | Fax +254 20 4183222
Cell +254 733 639365 | +254 720 639365
isk_admin@isk.ac.ke | www.isk.ac.ke
EMPOWERING STUDENTS TO CREATE SOLUTIONS FOR TOMORROW'S CHALLENGES

Note: All dates are MM/DD/YYYY

IEP Date: 01/11/2010

Student Support Services - Individual Education Program

Mtg. Participants | **Position**
Student
LRC teacher
Parents

Firstname: **Last Name:**
☐ Male ☒ Female **Grade:** 9 **DOB:** 3/16/1995 **Student Number:** 1
Parent/Guardian: **Phone:** **Language at Home:** English
Email: **Cell Phone:** 0722 516170 (F) **Other Language:**

Next IEP Due (MM/DD/YYYY) 01/11/2011

Eligibility Date: 80/12/2009 **Last Psych-Ed Date:** 11/05/2009 **Other Tests /** BRIEF
Triennial Date: 11/05/2112 **Last Achievement Date:** 11/05/2009 **Notes:** Conner's Rating Scale
Memory

Student Strengths

- Word attack - Grade Equivalent (GE) 12.9
- Letter word identification GE 9.8
- Digit Span - High Average
- Coding -High Average

Student Needs

- Design memory, picture memory (borderline) - will be impacted by visual overload
- Story memory - Low Average - Passage comprehension - GE 8.9
- Reading fluency - GE 8.7
- Verbal Learning -borderline - will interfere with foreign language acquisition
- Calculation GE 8.9 - Conners indicates attentional issues
- BRIEF indicates issues with organization and planning
- Anxiety, which could cause inattention and feelings of being overwhelmed which causes her difficulty in grasping new concepts.

Program Recommendation(s)

LRC Subjects: Reading comprehension, Self-monitoring skills, Organization, Writing skills, Math comprehension/ application

Support: Recommendations: LRC support, inclusion
Outside counseling,
Outside tutoring for Spanish & Math
Medication recommended for attention issues

General Classroom Accommodations

Multi-sensory teaching
Instructional concepts broken down to increase comprehension
Provide concrete models as a standard and guideline for student to compare own work
Long-term assignments broken down into smaller units with deadlines
Provide an outline of new information prior to instruction/lesson
Use of outline or graphic organizer for prewriting
Allow extra time on tests and quizzes (up to 25%)
Use of a calculator for math
Reduced number of math problems to show mastery
Visual diagrams of steps needed to solve complex mathematical operations

International School of Kenya
Student Support Services
Individual Education Program

Note: All dates are MM/DD/YYYY

IEP Date: 08/15/2009

Student Number: 2

Mtg. Participants	Position

Firstname: **Last Name:**

☐ Male ☒ Female **Grade:** 9 **DOB:** 07/14/1995

Parent/Guardian: **Email:**

Address: 30218 **Home Phone:** 4183572

Address: Nairobi, Kenya **Work Phone:** 622967

Eligibility Date: 11/22/2006 **Last Psych-Ed Date:** 11/22/2006 **Other Tests / Notes:** CELF WRAML

Triennial Date: 11/22/2009 **Last Achievement Date:** 11/22/2006

Language at Home: English

Other Language:

Next IEP Due (MM/DD/YYYY) 08/15/2010

Student Strengths

Reading
Memory in context
Attitude is more positive
Friendly

Student Needs

Spatial awareness
Sequencing
Verbal memory
Math
Writing skills
Inferential reading comprehension
Higher order thinking skills

Program Recommendation(s)

LRC Subjects: Math
Writing
Reading comprehension

Support: Resource and Inclusion

General Classroom Accommodations

Confirm that has understood the Math vocabulary
Give flash cards with Math process for reference
Highlight key words when working on word problems, showing step sequence
Provide visual diagrams to help solve complex computations
Check and review sequencing skills
Ensure proof reads and edits her own work
Ensure follows the research process
Give an outline to help her see the big picture