# The effect of holistic, artistic devices on learner interest in Grade 9 Chemistry.

By

Philip Mirkin

Submitted in fulfilment in accordance with the requirements for the degree of

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at the

UNIVERSITY OF PRETORIA

SUPERVISOR: Professor Rinelle Evans

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"Is nobody inspired by our present picture of the universe? The value of science remains still unsung by singers, so you are reduced to hearing – not a song or poem, but an evening lecture about it.

This is not yet a scientific age."

Richard Feynman (November, 1955)

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**Declaration**

I, Philip Mirkin, student number 16080892, hereby declare that this dissertation, “The effect of holistic, artistic devices on learner interest in Grade 9 Chemistry” is submitted in accordance with the requirements for the Magister Education degree at University of Pretoria, is my own original work and has not previously been submitted to any other institution of higher learning. All sources cited or quoted in this research are indicated and acknowledged with a comprehensive list of references.

**Dedication**

My first great teacher was Richard Street, my grade 6 teacher at SACS primary school in Cape Town. He had given up the priesthood to teach. He was the first teacher I had who accepted us children for who we were with a real heartfelt love. It is because of my time in his class that I became a teacher. I dedicate this dissertation to him and all teachers whose love makes children feel at home in this world.

**Acknowledgements**

My mother, Blanca, for her gift of unconditional love. My father, Wilfred, for his gift of challenging inquiry into all matters. My wife, Tessa Olivier, for love, support, unquestioning belief in me and for filming the video. My supervisor, Professor Rinelle Evans, for accepting me as a student when science education would not, for her pointed direction, extraordinary and enthusiastic encouragement as well as her insight into this research topic. Video editor, Andre du Plessis from the Department for Education Innovation, for his assistance in creating the video. Data analyst, Johan Ferreira, for giving this research the significant difference it needed.

I would also like to acknowledge Dr Rudolf Steiner, Field Marshal General Johan Smuts as well as the hundreds of unnamed artists, scientists and Waldorf teachers whose work enabled me to develop the clarity and conviction of the importance of the healthy working together of the arts and science.

## Abstract

The practice of science requires careful observation, experimentation and rational thinking accompanied by imaginative and intuitive insights to thrive in a mood of cutting edge exploration. South African Grade 9 Chemistry deals with established facts, usually devoid of artistic stimuli for capturing the imagination or awakening the intuitions of most learners. Many previous attempts to use the arts in the teaching of Chemistry are limited to the use of pictures, and less often, music and drama which are often superficial or even distracting from the real content. Most research into Science education has its focus on improving academic results with almost no research being conducted in the use of holistic, artistic devices to improve learner interest. Child-centred, holistic education indicates that the integration of rational logic with personal, intuitive knowing through story and the arts is a seed to sustained learner interest.

This study used video-recorded experiments and a poem with holistic use of story, metaphor, rhythm and rhyme to characterise the behaviour of acids, bases and salts, to awaken greater learner interest. Class discussion centred on inquiry-based learning which challenged the validity of the characterisations used in the poem, completed the holistically integrated intervention. Changes in learner interest levels were determined by matched pairs in the pre-test and post-test. The research was undertaken with 222 learners from four schools in the greater Tshwane region.

The results show that such holistically integrated devices, or stimuli, significantly increased learner interest through good engagement in the lesson as well as an improved perception of their grasp of the content, feelings towards Chemistry and relevance of Chemistry for their lives. As a first-of-its-kind research, further research in the use of appropriate holistic, artistic devices in Science education is recommended. Research into the longer-term use of such devices as well as the effects on learner academic results should be tested.

This research indicates that teachers should consider providing a greater context and characterisation, with a broader range of stimuli, when presenting Chemistry to Grade 9 learners to allow them to relate to the experimental and academic content in a more imaginative, intuitive and personally meaningful way.

The presentation of this dissertation will follow the courses of a dinner feast in the hope that the reader will be nourished holistically on multiple levels.


**Keywords**: Holistic education, Holism, Interest, Poetry, Science education, Story.

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# Preview of enquiry: *Pre-dinner drinks*

Dear Examiner and Reader

This dissertation will try to show that the use of metaphor and story enhances the learning experience by adding layers and *flavours* for grade 9 learners of Science. To bring you to *taste* the experience yourself, this dissertation will be presented as a gourmet meal, a moment away from the rushed world, with all the atmosphere, conversation and gastronomic delights of a *feast; a banquet with like-minded and passionate academics, educators and scientists.* This added layer will be presented in the *segoe print* font. This font changes the spaces between the lines so please excuse the odd size spacing you have just witnessed above and as it occurs in the text.

Placed within this dissertation are some short poems and writings of mine which are used to highlight certain points in a creative manner. These will be identified by the *italicised Lucida Bright* font in which they are presented. All other poems and quotes will be in Arial font, the more formal academic font used throughout this dissertation.

Some of the presentation will vary from the usual format of a dissertation. For the most part, a semi-conversational style of writing has been used to enhance the relaxed dinner conversation feel. It is only in the presentation of the data that this conversation style is interrupted in favour of a more point-focussed presentation. You should, however, still find all the relevant details needed to fulfil the requirements for an academic work.

As my research is based on a classroom intervention which includes a poem and a video you should view the video before reading any further. It is available on my Deep Science Education Facebook page with the web address of…

https://www.facebook.com/Deep-Science-Education-Science-Poetry-Holism-and-Education-in-harmony-334924460228786/

[While you are visiting the Facebook page, please feel free to browse for poetry on other aspects of Chemistry and Physics.]

*Dear reader, I now invite you to move to the dining hall for the Hors d'oeuvres.*

# **Chapter 1**: **Introduction** *Hors d'oeuvres*

*Allow me to begin by introducing you to our host for the evening.*

## 1.1 **Authorial biography and stance**:

*Who am I?*

My name is Philip Joshua Mirkin and I am 53 years old. I was privileged to attend S.A.C.S. [South African College School] school in Cape Town, the oldest school in South Africa. My single matric distinction was in a subject that came easily to me, Physical Science. I went straight from school to the University of Cape Town to study mechanical engineering on the advice of the careers councillors at the university. I did this until I realised that I was more interested in humans than in things, and then moved my studies over to education.

The intersection between the type of knowledge needed for science and that needed for education stimulated this study. Science teachers do not teach Science, they teach people to do Science. Over the years I have shifted from wanting to teach the laws of nature in the rarefied atmosphere of universal, abstract thinking, to wanting to bring an experience of engagement with the realities of nature within the realities of life. This meant embracing literature, the arts, intuitive knowledge and a diversity of perspectives on any given topic. My primary focus when teaching Grade 9's Physical Science [hereafter called "Science"] content in the Natural Science syllabus is to keep the learners interested and engaged in the work. Like all teachers, I bring my teacher's tool-kit to class. This includes the relevant work for the learners, practical applications of the knowledge, posters, pictures, graphs, videos, recent media articles on relevant topics as well as doing as many experiments as viable. I also give them historical and biographical stories, often mimicking the national accent of the scientists whose work we are studying. I get the learners to act out elements reacting, I tell unusual stories, ask direct, challenging and provocative questions, get them to imagine themselves as electrons inside electrical circuits, incorporate learner's experiences and suggestions, and whatever else may seem appropriate for the class in each moment. A special treat, for me, is to read short pieces from my treasured books on Science, "The Faber Book of Science" [which contains two chapters titled with the word poet] (Carey, 2012), "The Periodic table" (Levi, 1984), "A short History of Everything" (Bryson, 2003) and "Periodic Tales" (Aldersey-Williams, 2012). I also expose them to philosophy, social issues, family and life challenges and, of course, poetry. In these moments, I am never focussed on the learners just gaining

the relevant content to pass assessments. I am focussed on getting them to leave their worries behind, get *inside the story* and wanting to know more.

This approach has led me to the work of Dr Rudolf Steiner, the founder of the Waldorf school movement, and later, to the work Field Marshal General Jan Smuts, the bringer of the word, holism, into the English language through his book, “Holism and Evolution” (Smuts, 1926). My meeting with the holism of Jan Smuts led me to realise that the world is made of different levels with each level having different operating laws. My worldview was greatly enlarged by the ideas within holism and I intend to show its healthy application to Science education. To teach Science in this way requires a mastery of the subject matter being taught as well as a broad perspective related to the subject. It has taken me a lifetime of interest and investigation in the field of Science education to formulate my ideas, so I obviously have a vested interest in being able to show the helpful use of holistic devices in Science education.

*Some housekeeping rules for the evening before we get started.*

## 1.2 **Scope**:

This study has limited itself to four Grade 9 Chemistry classrooms in the greater Tshwane municipality of South Africa. Although the research was carried out in both private and government schools, its focus is on urban government schools. The semi-rural, small private school, which does not offer the last three years of secondary schooling but ends in Grade 9, was added to represent a very different type of school, as a form of control, to see how their results would compare. Types of secondary schools in Tshwane region not tested are Afrikaans schools, urban private schools, township schools and rural schools of all types.

Only the Grade 9 Chemistry section of acids, bases and salts was tested. Other sections in the Grade 9 Natural Science curriculum of Physics and Life Sciences were not tested. Other age groups were also not tested. The sample size was 222 learners and four teachers.

## 1.3 **Reliability and validity**:

To test the reliability of the pre- and post-tests, I ran a pilot study with my own class with the full intervention. The questions had already been designed with three questions testing for cognitive and affective domain responses each, as well as individual questions testing for future action, personal relevance and the extension of interest from the intervention content to the subject of Science in general. In the pilot, each question and question type showed enough significant variation in learner responses to be regarded as reliable.

The sample schools were selected to represent a range of schools. The schools and teachers willing to participate were the only schools where this research took place, which could bias the results. The single school which was approached and declined to partake in the study may have given different results. The selection of sample schools was not altogether random, due to the limited geographical area in which I could work. However, their freedom to decline to partake in my study did provide some randomness.

The classes used in the research were determined by the teachers who were willing to participate in the research, placing a potential positive bias to the study. To eliminate the bias of the individual teachers, this research was carried out by myself. I, however, acknowledge my passion and interest in Science and holistic education, and therefore my bias. There is no doubt that the experience of the learners and their results would be different if the intervention had been presented by a teacher who had no interest in the material. The differences due to the influence of the researcher was limited as the intervention was designed [see addendum C] to limit teacher input and influence. To further moderate for researcher bias, the Science teacher of the class was present during the intervention.

The questionnaires were answered anonymously and confidentially by the learners, to enable them to respond in freedom from any repercussions from their teacher or myself.

### 1.4 **Concept Contextualisation**: *Smoked salmon salad cups*

An example to demonstrate holism:

The holism of Field Marshal Johan Christiaan Smuts, and its Waldorf Education application to chemistry, informed this research (Smuts, 1926; Edelglass, 1992).

When we teach Chemistry at school, no context is ever given for how it relates to any other aspect of Science or anything else. In my own work on holism I have layered the world in more detail than that done by Smuts (Mirkin, 2017). Evolution began at the Big Bang by energy transforming into matter (Smuts, 1926). This is the layer of particles and forces, as studied in Physics. Once matter had evolved into elements, the level of activity as studied by Chemistry began. It took many ages until the level of life emerged, which is studied in the Life Sciences. The human level emerged much later. The laws and life of all the levels just mentioned operate within us as well as our own laws, which are studied in multiple fields including Psychology, Sociology, History, Politics, Literature, Music and many others.

When we recognise that all things are linked, especially our inner lives with the outer world, it becomes obvious that the Science of Chemistry can be more easily appreciated with our full

range of human faculties. If we embrace holism as an accepted scientific fact, we can go a step further and say that Chemistry can be more accurately portrayed when its relationship to other levels of the world, including our inner lives, is taught alongside the usual academic content; *putting some meat on the bones.*

Our artistic sense, our wish for meaning and our need for an integrated relationship with ourselves and the world, require us to feel as much as to do, observe and think logically. When we add imagination, previous experiences and our love of stories to the process we get a multiple-layered interaction in the learning process.

## The hors d'oeuvres: One option only; an early nineteenth century dish:

## The Smoked Salmon salad cups

In 1798 Dr Erasmus Darwin (Darwin, 1798), the grandfather of Charles Darwin, described photosynthesis in his poem, The Botanic Garden, like this…

> “When Morn, escorted by dancing Hours,
>
> O’er the bright plains her dewy lustre showers;
>
> Till from her fable chariot Eve serene
>
> Drops the dark curtain o’er the brilliant scene;
>
> *You* form with chemic hands the airy surge,

Mix with broad vans, with shadowy tridents urge.

*Sylphs!* from each sun-bright leaf, that twinkling shakes

O'er Earth's green lap, or shoots amid her lakes,

Your playful bands with simpering lips invite,

And wed the enamour'd OXYGENE TO LIGHT.---"

## *With finely chopped walnuts*

The "McGraw-Hill Encyclopedia of Science and Technology" (Parker, 1992), book 13, on page 455 describes photosynthesis in a way similar to the standard way described in text-books, like this…

"the manufacture in light of organic compounds (primarily certain carbohydrates)."

And further down the page, adds the chemical equation with the explanation,

"$H_2O + CO_2 +$ light energy $\rightarrow \{CH_2O\} + O_2$

Where $\{CH_2O\}$ stands for a carbohydrate (sugar)"

## *On a bed of crisp lettuce*

In 2015, I wrote about photosynthesis in the poem "The Periodic Table" like this…

*Carbon*
*"This powerful ground of the compounds organic*
*Weaves into one the Heavens and Earth as*
*It secures in its bonds the Summer day sunlight*
*That soothes our ache on a cold Winter's night."*

How we educate determines how young people experience their world. It determines where they put their attention and what they believe is valid knowledge.

Erasmus Darwin was an upper-class Englishman raised on a classical education. He uses *beings* like Sylphs, Eve and *You* [probably meaning God] to inspire our imagination to pictures of action and co-ordinated will. His description of the dawn, light and leaf are multi-layered and textured. It is a living work of art possibly more than a work of Science. In other

words, it is a work of feeling, inspiration and imagination more than a work of information and reason. In his time, this was acceptable.

Erasmus Darwin also wrote more purely scientific works. His study on the effects of light on the human eye describes how our retina and cornea respond to changing light and colour conditions (Darwin & Darwin, 1786). At a slightly later time the German poet, philosopher and scientist, Goethe, wrote a scientific work on the half-spectra of light that you see when you look at the boundaries of light and dark through a prism, describing these as the “deeds” and “suffering” of light (von Goethe & Eastlake, 1840). Both these extraordinary men still included human elements in their scientific work. They did not separate their humanity and feeling for life from their scientific work. Their intimacy with life and the world was what enriched their world and their Science. To use Feynman’s definition, this must have been part of a true scientific age where the scientist, artist and poet were one. The scientific work of both men is mostly ignored in the modern day.

The encyclopaedia description is an expression of pure knowledge and reason, similar in manner and identical in information to what can be found in any textbook on the topic of photosynthesis. The facts are put into a logical sequence that needs only the scientific paradigm to be understood. The symbolic reduction into an equation is the briefest and most abstract way we have of expressing photosynthesis. With this equation, it does not matter who expresses the work. The facts remain devoid of human interference, to avoid bias and other human sources of error. The influence of “Beings” of any sort is consciously avoided; actively rejected. The fruit of this objective and rational approach needs little elaboration in our technological age. This is due to its ability to obtain objective facts on the behaviour of materials and forces, which industrialists have used to produce machinery and products that can be relied upon to perform as required.

In the last description, my poem, I have remained faithful to the modern scientific wish to not include “Being”, but have tried to infuse the objective scientific facts with human qualities and included its relationship to ourselves. Carbon is portrayed as a character with wish and behaviour driven by her own nature. For many modern scientists, this would be a potential problem as it assigns *will* to inanimate nature. They might argue that this is a fallacy and risks confusing facts from fantasy. I will argue in return that holism can show how our *will* is identical to the *drives* of the elements, just on a different level of evolution (Smuts, 1926). My research has shown that these feeling-enriching elements open the door to increased learner insight and interest in, as well as their grasp of, the content being covered.

Using story, rhythm and rhyme as well as the inclusion of anthropomorphism, it was the focus of my study to test whether these more personal elements would assist learners to touch the world of Science with their more familiar experiences and human nature. The hope was that it would assist learners to grasp the new content as well as to find new or greater interest in the scientific content. More ultimately, this was to make another attempt at a birth of a truly scientific age. An age where, in the Science classroom, we can once again look upon nature with all our personal and objective faculties, and recognise in her a macrocosm to our own microcosmic self, to be moved by the intimacy and inspired to express this full experience in reasoned and heartfelt art, poetry, dance or song.

## *With a squeeze of sour lemon*

In the following poem, Wordsworth poignantly expresses the loss of this personal relationship to the world, and the resultant confusion and fragmentation of relationship, that results from our modern, materialistic, objective, scientific approach.

"The World Is Too Much With Us

The world is too much with us; late and soon,
Getting and spending, we lay waste our powers;
Little we see in Nature that is ours;
We have given our hearts away, a sordid boon!
This Sea that bares her bosom to the moon;
The winds that will be howling at all hours,
And are up-gathered now like sleeping flowers;
For this, for everything, we are out of tune;
It moves us not. Great God! I'd rather be
A Pagan suckled in a creed outworn;
So might I, standing on this pleasant lea,
Have glimpses that would make me less forlorn;
Have sight of Proteus rising from the sea;
Or hear old Triton blow his wreathèd horn."

1806

By William Wordsworth (Wordsworth & Rogers, 1980)

Wordsworth here expresses the loss of intimacy with nature because of his own education within an industrialised England. Wordsworth was one of the poets of Romanticism, who

turned to nature to find solace from the fragmented ideas of his religious education and industrial pragmatism of his time (McFarland, T. 2014). He senses the vitality and intimacy with nature but has not been given the ideas and experiences in his own education to fill the gap between himself and what he intuitively feels. The resultant pain and plea fills this poem with the yearning for living ideas that can overcome his experience of separateness. The contention of my research is that the answer to his call for such knowledge and experience in education can only come with feeling-enriched ideas within which the scientific content is embedded. It is also Feynman's plea for a scientific age to begin (Feynman, 1955), where Wordsworth's poem can be written with the same experience of nature not robbed of its magnificence and significance, but enlivened and deepened with insights gained through Science.

## 1.5 **Practical context**:

My research was performed in three government high schools and one private school in the Tshwane South district, known as district four. The intervention was implemented with the Grade 9's in term two [from April to June] when the South African CAPS [Curriculum Assessments Policy Statements] curriculum stipulates that the topic of acids, bases and salts should be covered. All four schools are co-educational. The government schools are all large, urban, ex-model C schools [white schools under the old apartheid government] and attract learners from similar cultural, language and economic background in the established residential areas. One of the government schools is conventional in their approach, one attracts learners with an interest in creativity and the arts, while the third attracts those with a more practical interest and with an emphasis on Science and technology.

The private school was also chosen because it is small, semi-rural and offers an alternative curriculum, based on the NCS [National Curriculum Statement, the primary curriculum on which all other South African curricula must be based] but not on CAPS. This school's results will be used as an outside measure, or control, to compare to the results of the government schools.

My research explored the use of poetry, chemical experiments demonstrated in the video and class discussion to improve learner grasp of, as well as interest in, the content. The contents of the poem, which describes multiple experiments, were examined in the light of the performed experiments, as viewed in a 15-minute video, to critically assess if the poetic descriptions of the experimental reactions were accurately portrayed. The result was intended to be a series of impressions which could be holistically integrated into an understanding of the nature of acids, bases and salts.

Acids, bases and salts fall into the topic of Chemistry, which is one component of the Grade 9 Natural Science course, and then becomes part of the Physical Science syllabus from Grade 10, so it is a very important section of work.

I have previously found it challenging to engage the learners' interest in this work due to its very theoretical and abstract nature. As a result, I wrote a poem to compliment experimentation to awaken the interest of my learners. It is the focus of my study to see if the use of this poem which uses story, rhythm and rhyme while describing acid and base as male and female characters with specific behaviours, would bring about improved learner interest in the work.

*Our host describes the main course menu while small, lightly buttered bread rolls are served to cleanse the palate.*

### 1.6 **Introducing the key ideas in my research**:

This holistic approach of linking scientific content to human qualities in an artistic form is not new. Over two thousand years ago, the ancient Greeks of Plato and Aristotle looked at the world holistically in the well-known statement of "the whole is more than the sum of the parts". By linking the physical *elements* of earth, water, air and fire to the human *temperaments* of melancholic, phlegmatic, sanguine and choleric respectively (Easton, 1997), they were showing a holistic relationship between the two otherwise unrelated fields of Science and Psychology. About two hundred years ago, there were several scientists/philosophers/artists who expressed scientific knowledge in artistic ways which linked human qualities to worldly phenomena. Perhaps the most famous among these are the poems and writings of the two gentlemen mentioned earlier, Charles Darwin's grandfather, Dr Erasmus Darwin (Darwin, 1798) and the writings and experimenting of Johan von Goethe (von Goethe, 1840). More recently, Rudolf Steiner introduced holistic practices into his education system known in South Africa as Waldorf education (Steiner, 1972) and in 1926 Jan Smuts wrote a ground-breaking book called "Holism and Evolution" (Smuts, 1926) where he explores the theme of holism in the evolution of energy to matter, matter to life and so on.

The use of story in this research, in the form of a poem, is to draw on the usual way in which we capture the interest and attention of young people (Mandler & Johnson, 1977; Nezworski, Stein & Trabasso, 1979). Grade 9 Chemistry contains possibly the most theoretical content in the Natural Science syllabus with all its symbols, formulae and reactions. The unfamiliar and complex content is a challenge to convey to the uninitiated young teenager, so it makes

sense to use story as a powerful and well known tool for communication (Mandler, 1977; Nezworski, 1979).

My research focus, of improving the learners' grasp of content and interest, is in line with the South African national goal of developing lifelong learning (Education, 2015). Short term goals of the learners' achieving good exam and test results may not lead to learners' remaining interested in the subject later in life. Lifelong learning requires the learner to have a personal reason for their continued interest. Engaging the learners simultaneously through video, poetry and class discussion has here been shown to increase their perceived grasp of the content and interest level in the subject. If this were to be widely used, this would hopefully remain an interest for learners in the future. My research only tested the immediate effect of the intervention and not its long-term effects.

It is not just in the field of Chemistry where such an approach can be made to learning Science. What follows is a story of a Grade 9 magnetic-field lesson, which is part of the Physics syllabus in Natural Science, where some of the holistic devices mentioned above bring learners to a more personal experience of the content used.

## The host shares a story of a previous hors d'oeuvres.

### *Magnetic gaze of attraction*

> *Teaching magnetic fields, attraction and repulsion, the class looked at effects of 2 magnets on lots of little compasses.*
>
> *The magnetic field raying out from any one pole is not in straight lines; they curve outwards like a fountain, pouring their influence into the space around them like the spreading of a tree upwards and outwards towards the light. A radiant basking in total openness.*
>
> *As we bring an opposite pole closer, the field lines closest to the approaching pole turn their attention inwards towards this new influence. Instead of a dreamy outpouring, their interest is captured. They can't take their eyes off it. Pure blind attraction, drawing the poles together. While still a distance apart they just gaze fixedly at each other. But at a certain distance they can no longer resist and they collapse into each other's arms as the magnets collide.*
>
> *When a "like" or same pole approaches, the field lines seem to avoid each other as they ray out in search of their opposite. If forced closer, the lines are squashed outwards more strongly as they try to avoid looking at each other*

*and eventually the magnets push each other away, repulsed by the closeness of one doing the same as themselves.*

*Does the objective world of magnetism feel..., bound as it is to behave so predictably..., mechanically... faithfully? And how do you get the "formal, academic learning" back on track after the whole group has felt themselves as a part of this passion interplay?*

*"O.K. guys, go back to your seats and draw what you have seen."*

## Light conversation inspired by the story

Over my almost 30 years of teaching Science, I have noticed no general improvement in the mastery of content or interest levels of learners at Grade 9 level for Science. In the Netherlands, in an extensive study of learners in the upper primary school, it was noticed that learners' interest in Science decreased as the children aged (Denessen, Vos, Hasselman & Louws, 2015). In Australia, a country with an educational history built on the old British system in a similar way to our own, a study showed that many learners regarded their Natural Science course as irrelevant and difficult, giving rise to them not selecting the course for their further education (Lyons, 2006). Even top learners in top universities in the United States of America require good teaching and motivation to sustain good enough grades to want to keep doing Science (Strenta, Elliott, Adair, Matier & Scott, 1994). Their research showed that even learners who are capable in the subject would not continue studying it unless they had some external motivation like good grades and strong teacher support.

In South Africa, we have a consistently declining proportion of learners who select Science and Maths for their last three years of schooling (Campbell, 2014). This reflects the diminishing of learner grasp of the content as well as interest. Getting young learners to become, or remain, interested in Science currently seems a world-wide challenge and yet most studies that look to improve the situation, stay within the existing scientific paradigm where pure, decontextualized scientific knowledge is presented to learners to be studied and mastered for utilitarian purposes. My research sets out to present science content to Grade 9 learners in a holistic manner, using story, rhyme and rhythm, personification and imagery as portrayed in the video, in order to investigate whether their general interest levels and grasp of the work will increase.

Preparing for assessments is a specific skill which needs to be addressed prior to, and post, assessments. Unlike most research into Science education, my research did not concern

itself with assessment or the improvement of assessment results. I focused on whether the use of holistic Science content would increase learner engagement and interest in the subject.

During their Grade 9 year, learners in South Africa need to select their subjects for their last three years of schooling, the FET [Further Education and Training] phase. From my experience and the results of some research, most of the learners who select Science for this phase do not do so out of personal interest, but for the social status the subject provides, for tertiary learning options or because they achieve good grades in it (Gail Campbell, 2014). This results in learners who find it hard to motivate themselves in the subject and who therefore do not engage with the content in the way required to perform well in assessments (Swanepoel, 2010, pg 39). At the start of the introduction to Goethe's book "Outline of a Theory of Colours" (von Goethe & Eastlake, 1840) he says,

> "The desire of knowledge is first stimulated in us when remarkable phenomena attract our attention. In order that this attention be continued, it is necessary that we should feel some interest in exercising it".

If learners were to choose to do Science because they are genuinely interested and want to know more, then the amount of time and effort they will invest in the subject will be more pleasurable and hopefully, therefore, more productive.

In my attempt to address the question as to how to engage learner interest in Chemistry, this dissertation challenges the existing scientific paradigm of objectivity, and gives reasons why it is not only helpful but also appropriate to draw on the wisdom of holism, and take a holistic approach to engage the learners on multiple levels.

## 1.7 **Research questions**:

The primary question for my research is, "To what degree can learner interest in Grade 9 Chemistry be engaged by holistic, artistic devices?"

Because the intervention includes the use of the video and poem with class discussion, I will also include, "How effective are each of the used holistic devices at engaging learner interest? and "How will the holistic devices influence learners' cognitive and effective domains as well as their perception of how relevant Chemistry is for their lives?"

These questions will be answered with reference to the effect on learners of different gender, home language, type of school and initial learner interest.

## 1.8 **Chapter summary**:

In this chapter, the main themes of this research have been introduced to give a *taste* of the type of experience that this research intervention will bring to the learners. A few reasons as to why my research is needed, and why I have a personal bias in showing its effectiveness have also been given.

In the coming chapter, each aspect of my research will be delved into, looking at each of the key ideas individually. A further literature search into the current situation in Science education with respect to the use of the arts and other holistic devices follows.

*Having whet your appetite with some subtle flavours you are now invited to peruse the main course menu. Please take your time as each item carries its own unique experience and you will not want to rush what will surely become not just another meal, but a lasting memory.*

# **Chapter 2**: **Literature review**: *Main course*

## 2.1 **Introduction**:

*The guests are guided as to why only wholesome dishes are on the menu, as they look to order their main course.*

Having taught physical and natural science in South African and New Zealand schools for almost 30 years it is my opinion that learners are not generally invited to *fall in love* with Chemistry. There is usually no invitation to attach any feelings to the work. The content is not intended to engage us personally. In general, to study Science at school in South Africa is to not engage any faculty other than our objective senses, rational, mathematical and abstract thinking, pragmatic sense of reality and the memories associated with this thinking. Any opinion held by the learners will be proved right or wrong with little or no grey area. Personal affinities, insights, associations and preferences play little part. All aesthetic sensitivities are irrelevant. Unexpectedly, as Science is so markedly practical, the implications of the impact on nature or society of the work being covered are rarely considered. It is truly a non-human, if not inhuman practice. Science in South African schools is almost exclusively interested in the impersonal, universal thoughts relevant to the work with few practical applications. The ideas taught can be thought by anyone. Any great personal intimacies, insights, experiences or heights of emotion a learner may associate with the content are not relevant and therefore unwelcome. The learners' own knowledge gained through pursuing investigations that lie outside of the syllabus has no place. A good teacher will always welcome these but will not be able to allow much time for them in the lessons or reward the learner in any way for this in tests and exams.

A brief look at the greater context to any section of work studied in Science, and we will immediately find multiple implications that its history and applications have on our lives. Science has changed society, education and the greater world in which we live. It has even changed the way we see our world and yet these aspects of the work are not part of the syllabus and are not generally given any time in the South African Grade 9 Science classroom.

To develop a framework which underpins an approach to Science that can include all our human faculties this dissertation has drawn on the great minds of General Jan Smuts and Dr Rudolf Steiner, and needed the ideas within holism, Waldorf education, quantum mechanics, story and lifelong learning.

2.2 **Concept development:** *The guests order their main course from the following options*

**Interest**: *A range of hot and mild curries served with Naan bread and rice*

**Holism**: *Salmon steaks, baked to perfection on layers of spinach and subtly flavoured sauce.*

**Holistic education**: *A simple dish of sautéed, diced beef and broccoli served on a bed of rice*

**Waldorf / Steiner education**: *A meal for four of roast chicken served with a variety of seasonal vegetables, herbs and fruit.*

**Quantum mechanics**: *Penne pasta served with a variety of seasonal vegetables with an unexpectedly full flavour.*

**Story**: *Bell peppers filled with lamb and beef mince. Subtly different flavours with every bite.*

**Lifelong learning**: *Char-grilled sirloin steak, rare, with al dente large-diced seasonal, organic vegetables*

*The food arrives*

*The familiar garnishing with some original flavours*

### 2.2.1 **Interest**: *A range of hot and mild curries served with naan bread and rice*

My research hinges on establishing interest, as well as an increased grasp of content, in the acids, bases and salts section of Grade 9 Chemistry. One researcher who has investigated interest in education is Suzanne Hidi (Schraw, 1994; Hidi, 2000; Hidi, 2006). She has looked into motivating unmotivated learners (Hidi, 2000) and even developed a four-phase model for determining different levels or types of interest (Hidi, 2006). Her model describes developing interest as follows:

> "The first phase of interest development is a *triggered situational interest*. If sustained, this first phase evolves into the second phase, a *maintained situational interest*. The third phase, which is characterized by an *emerging (or less-well developed) individual interest*, may develop out of the second phase. The third phase of interest development can then lead to the fourth phase, a *well-developed individual interest*." (Hidi, 2006).

What she is showing with this model is that not all interest is the same. For lifelong learning, interest levels would need to be in the fourth category of *well-developed individual interest*. My research tried to awaken the first level of interest, that of *triggered situational interest*, but with enough "hooks" to engage the learners in areas where they have already developed the third and fourth levels of *individual interest*. The *triggered situational interest* was stimulated through multiple devices. The poem has rhythm and rhyme which make the words easy on the ear and easy to remember. The singing of nursery rhymes and the reciting of simple verses are common uses of these devises to engage the interest of younger children.

In my research, interesting things happened in the experiments to engage learner interest. Any teacher of Science will tell you that most learners become enthusiastic and engaged when experiments are being done. The best way to do experiments is for the learners to do the experiments themselves. Next best is a demonstration where the learners can see from close-range what is happening as it happens. In my study, to shorten the time needed for the intervention, the experiments were recorded on video. The influence on learner interest of different ways of doing experiments was not tested here, but they all stimulate *triggered situational interest*.

The background for the video was created by placing some sculptures as well as a colourful poster and an African theme cloth as further *hooks* for already *developed learner interest*. An artistic learner, with already *developed personal interest* in artworks may find these as openings to their interest in the video. These *hooks* are called *seductive* devices (Schraw, 1994), in an overview of the book “The role of interest in learning and development”, as they are not related to the content to be learned but are used to attract the learners’ interest. The poetic use of language and the anthropomorphic characterising of acids and bases are further *hooks* used here to help engage learners interest. All these interest *hooks* are important for those learners who have not yet developed much interest in Science.

Hidi also clearly indicates that interest has a big influence on learning, and specifically for learner attention, goals and levels of learning. In my research, this understanding will be used to get a measure of *triggered situational interest*. Hidi goes on to say how many educators seem to think that interest is a fixed thing, one that is hard to change. She shows that through sustained exposure, the learners will develop the desire to re-engage with the content through their own interest. Because mine is a single intervention research, we will not see much of this wish to re-engage with the content on a personal level, but because the learners in Grade 9 are still in a formative phase in their relationship to Science, we should see a stronger increase in interest than if the learners were older with a more entrenched attitude to the subject.

In investigating interest in Science education, Andreas Krapp  emphasises that interest is not to be confused with “enjoyment while learning”, as enjoyment can be based on many factors besides interest (Krapp, 2011). He further states that one does not simply have interest, rather, “one has an interest in something”. What he means is that when considering learners interest in Science, we should be looking to create interest in specific content. A key factor to interest seems to be that it engages the affective and cognitive domains (ibid). This seems significant, as our feelings, attitudes and values are called into play. These are aspects of ourselves which are very personal and which we all take as significant and meaningful, as discussed earlier. When they are linked to cognitive content, it seems likely that the content will become more personally significant and therefore more likely to become more than just *triggered situational interest* and more readily move into the domain of *personal interest*, the higher levels of interest as laid out by Hidi (Hidi, 2006).

As much as it is the intention of my research to capture or trigger interest in the content being covered, I also hope that this interest may become personally significant for the learners in the long run. I have only researched the initial change in the learners’ interest levels.

### 2.2.2 **Holistic education**: *A simple dish of sautéed, diced beef and broccoli served on a bed of rice*

Holistic education has been a catch phrase used by many schools in South Africa for the last twenty or so years. By this they often mean that they address the developmental needs of our human faculties of “head/thinking, heart/feeling and hands/doing” (Easton, 1997). The difficulty with this undefined term is that all schools already do this through content subjects for the head, arts and languages for the heart, and physical education and sport for the hands, and so can claim to be holistic education providers.

In education centres that claim to be child-centred, holistic education becomes a more meaningful term. This usually implies that in any one activity all of our faculties are engaged, so that the faculties not only develop in their own way, but with overlapping connections and integrity. In Montessori type education the child is often allowed to direct their own learning time and programme and so the child’s mind remains in charge, intact and not fragmented into separate parts (Kahn, 1990). One type of holistic education that takes the term to a whole new level is Waldorf education.

### 2.2.3 **Steiner / Waldorf education**: *A meal for four of roast chicken served with a variety of seasonal vegetables, herbs and fruit.*

Waldorf Education was introduced by Dr Rudolf Steiner in the early 1900’s. His ideas are too broad and deep to explore here other than to give a few key ideas and their application in Waldorf schools around the world today.

#### The main-lesson:

At the start of each day for about 3 weeks, the learners have the same subject lesson for between one and two hours each day called the main-lesson (Richter, Rawson & Fellowship, 2000). The daily rhythm of this time enables the learners to focus on the topic in greater depth and with greater continuity than in a more conventional, annual timetable. The teacher structures the lessons to involve many different activities each morning and continues to create threads of connection between the work covered on successive days. By the end of the roughly three-week block, the content should become a story which the learners will have captured in book form. This book is called a main-lesson book, filled with the learners’ copied and self-created content and art works, logically ordered with other artefacts all done by the learners themselves. The learners usually have a practical project that they will do, which will be connected to the content covered but be chosen and executed out of the learner’s own interest, independently of the teacher, but often in collaboration with other learners. A holistic approach is evident here that goes beyond the usual use of the term.

Selection of content:

Another very important aspect of Waldorf as well as Montessori education is the selection of approach and content for each age group. This is now common practice in most curricula, but the notion of needing to develop certain capabilities before working on others has a fundamental place in Waldorf (Richter, 2000). The best example to show this is in learning to read and write. Steiner says that although a child can learn to read and write at an early age, it is best to wait as long as possible due to the child using the same biological forces that are used to read and write, for building up the bodily organs when younger. His most famous example of this shift in the function of biological forces is the emergence of adult teeth known as the *change of teeth* that happens at this age, as one of several indicators, that the child is school-ready (ibid). For many years these associations of changing bodily and mind building forces have been viewed as unscientific and nonsense. It is doubtful that even "critical theory" activists, who reject the dominating world view of rationalistic science, would support this approach [see chapter 3.1 where paradigm is discussed]. This is because they see social change from a political perspective rather than a metaphysical one (Bohman, 2005).

Before Rudolf Steiner set up the first Waldorf school he gave a two-week workshop with the future teachers. As a part of this training he gave 14 lectures called "Study of Man" (Steiner, 1966). In these lectures, he presents the human being to the teachers in such a way that it will encourage them to think about the effect of their teaching on the whole organism of the child. Much of the early chapters focus on showing the difference between the nerve and blood systems in the human being and the type of knowing that is derived from each system.

He says how our nerve/sense-system, in which we are very conscious and awake, separates us from the world through antipathy, through pushing the world away from us so we can be objective and create strong mental images, concepts and memories. This is the common approach to most modern education and is the focus in the Science classroom. Educating this system is well known and developed in modern education. More important for this research and for establishing holistic education is the balance for this nerve-system, the blood-system, which is mostly overlooked in Science education.

The blood-system he describes is what he calls *will*, which he differentiates from *thinking* which is centred in the nerve/sense-system, and *feeling* which comes about through an overlap or meeting of the nerve and blood systems. He says that in the blood-system we are asleep and unconscious, but this does not mean that we do not gain any knowledge from it. This is the knowledge that wells up from the body in the form of imaginations, inspirations and intuitions, is a type of knowing that has a personal and intimate nature. We experience it

ready formed, with multiple associations and impulses. It is also, in its more unconscious form, our *gut instinct*, the basis on which we make many decisions like in selecting a toothpaste in the supermarket or in choosing a romantic partner.

### How blood-knowledge arises:

Steiner explains how it is that these imaginations become conscious for us, despite originating in our unconscious will.

> "Just as our thinking depends on antipathy, so our willing depends on sympathy. Now if this sympathy is sufficiently strong – as strong as the antipathy which enables mental picturing to become memory – then out of sympathy there arises imagination… And if your imagination is sufficiently strong [which only happens unconsciously in ordinary life], if it is so strong that it permeates your whole being right down into the senses, then you get the ordinary picture forms through which you make mental pictures of outer things. This activity has its starting point in the will." (Steiner, 1966, pg 32; 33).

Here he is describing how the nerve/sense-system is activated through the will, creating the same clear picture experience as a sense image, but arising from within our body rather than from outside through our physical senses.

### Steiner's sympathy and modern Psychology's empathy:

The interesting distinction between nerve and blood-knowledge is that these imaginations that well-up from within will have a more personal and intimate nature because they have been formed from a base of what Steiner calls sympathy, what modern Psychology would probably call empathy (Sassen, 2012). Georgia Sassen, who is involved in mental health, has used poetry and drums to encourage empathic connection, an experience of being at one with someone or something, in 7 to 9-year olds to help them overcome violent and bullying behaviour. By strengthening what Steiner calls sympathy, these negative behaviours can be transformed into healing and healthy forces instead. I was greatly pleased to see poetry being used in this way as it is the intention of my research to use poetry to help learners develop empathic connections to Science. Such empathic connections are made conscious in the way Steiner describes, and can be quite *awake* in one who has strengthened their ability to sympathise, or what modern Psychology calls empathise.

In a later chapter, Steiner comes back to this two-fold way of knowing when he says,

> "In other words, you will understand how everything that awakens an intense interest in the child also contributes to a very great extent towards making his memory strong and efficient. For the power of memory must be derived from feeling and will and not from mere intellectual memory exercises." (Steiner, 1966, pg 114).

In this chapter, he shows that although memory is created through antipathy, to develop "power of memory", we need to awaken "an intense interest" in the learner which happens through feeling and will. Here he clearly indicates the importance of interest in the entire of the learning process. Therefore, in my research, the cognitive/thinking, affective/feeling and will relationship of the learners to the work was tested in order to determine their overall interest-level changes.

In chapter nine, Steiner develops the idea of will-knowledge which arises into consciousness from the blood-system by giving further tips as to how we can educate the child.

> "In teaching, we must not make definitions but rather must endeavour to make characterisations. We characterise things when we view them from as many standpoints as possible… A right kind of teaching will aim, from the outset, at characterisation rather than definition… make it your constant and conscious aim not to destroy anything in the growing human being, but to teach and educate him in such a way that he continues to be full of life, and does not dry up and become hard and ridged. You must distinguish carefully between mobile concepts which you give the child and such concepts as need undergo no change… [give] concepts which will develop with him organically." (Steiner, 1966, pg 132).

What is interesting in this quote is how Steiner implies that concepts created out of pure rote learning and not approached from multiple perspectives are harmful for the learner. That by only educating through the nerve-system with rigid definitions and methods, we bring about a hardening of the growing human being, by which he does not only mean only the hardening of the body, but also the inner-being and their ability to learn. In my research, the focus was clearly addressing this concern by approaching the topic of acids, bases and salts through metaphor and poetry. The multiple images and characterisations that the poem and video included, hopefully enabled the learners to form concepts of the topic that can evolve in the future as they gain more experience and knowledge.

In 1923, after the first Waldorf school had been open for some years, Steiner gave lectures on how to address specific subjects, including Science. His emphasis for Science is that it should enable the children "to acquire really practical ideas of their environment." and "connect the children with the creations and inventions of the human mind. This will enable them to understand and find their right place in social life." (Steiner, 1972; pg 171). His concern was that people use modern technology without knowing how it works or even the principles that make it operate. With the technological explosion since that time the situation is much worse, making it more essential that we find ways of increasing learner interest in Science and bringing the subject over in such a way that more learners continue studying Science. Science should become more focussed on helping the learners to understand the applications of scientific theory in technology. Here we see again the holistic nature of

Waldorf education in keeping all aspects of life and learning working harmoniously together. The work of Steiner led to the Waldorf/Steiner school movement which is operating successfully in many countries around the world, in a wide range of cultural and religious settings. Although he does not use the word *holism* in any of his work, he clearly thinks holistically. It was after all, one year after Steiner's death that the word *holism* was first coined; and it was given to us by a South African who lived just a few kilometres from where this dissertation was written.

### 2.2.4 **Holism**: *Salmon steaks, baked to perfection on layers of spinach and subtly flavoured sauce*

Holism is arguably the most ignored idea in Science. Smuts who gave us the word in his work "Holism and Evolution" (Smuts, 1926), worked thoroughly through many ideas that show how the principle of holism works in evolution. It is the only principle that can be applied to the evolution of living species as well as to the evolution of matter and mind. He carefully works through the idea first brought by Plato and Aristotle, that "the whole is always more than the sum of the parts" to show how the new *whole* will contain an element that was not there before, hence deducing a creative element in evolution; and yet this new whole will always behave in a manner that reflects the behaviour of lower levels, of the *parts.*

Once a whole has reached its evolutionary perfection, it joins with other *wholes* of the same kind to become the *parts* which give birth to a new *whole,* one level above the old one. Using this notion of a growing set of levels of existence, he works through the layers of development of matter into the development of life, from life to mind / consciousness and then to the *highest* level at which evolution is operating, the level of the human personality.

Smuts is also at pains to show how each level tends to manifest the same type of behaviour as other levels. So, the analogy of our human experience of attraction being used to describe the behaviour of a magnetic force could be a true reflection of the same impulse acting out on different levels. Unfortunately, holism is still not a generally accepted or used paradigm or lens through which to view scientific ideas, but it would not be unthinkable to find real pathways through holism to logically link Steiner's idea of the early years' biological forces with the forces of thinking required for school-readiness.

*An unexpected bite of clove*

When we look at the human being through the lens of holism we see that each human being is a single or *whole* personality, made up of the parts of mind, life and body. If we recognise that the ultimate role of education is to encourage the evolution of the personality, then we

will feel the necessity to educate holistically. The validity of all *parts* of the mind must be acknowledged and treated with equal respect. As Kravchenko notes, “The ousting of the ideology of holism from scientific research, and the persisting infatuation with analytism have led to an extreme fragmentation of our knowledge of the world” (Kravchenko, 2015, pg 1). His contention is the same as mine, namely that our analytical faculties alone cannot create a synthesised whole. It requires other faculties, ones which can most readily be found in our will and feeling life, to unite everything into meaningful wholes. If we accept that Kravchenko is right, and that our knowledge is fragmented, then by holistic extrapolation, this fragmentation will be extended to the fragmentation of the elements of mind, hence forming a fragmented personality.

## Religion and Science:

Jonathan Sacks, a former chief Rabbi of England, wrote a book on the importance of Science and religion working together called “The Great Partnership” (Sacks, 2011). On page 6 he prepares his readers for the main thread of his argument by saying,

> “Science is about explanation. Religion is about meaning, Science analyses. Religion integrates… Science practices detachment. Religion is the art of attachment.”

On page 7 he goes on that in religion we,

> “sometimes use poetry and song, and rituals that bind us together, and stories that gather us into a set of shared meaning“ (ibid).

On page 123 he continues with…

> “First, there is something intrinsically dehumanising in the left-brain mentality. The scientific mind lives in detachment, analysis, the breaking down of wholes into their component parts. The focus is not on the particular – this man, that woman, this child – but on the universal. Science per se has no space for empathy or fellow feeling… when Science is worshipped and religion dethroned, then a decision has been made to set aside human feelings for the sake of something higher, nobler, larger. From there it is a short distance to hell.” (ibid).

On page 289 he elaborates on this point with,

> “Those civilisations built on the abandonment of God and the worship of Science- the French revolution, the Soviet Union, the Third Reich and Chinese Communism- stand as eternal warnings of what happens when we turn a means to an end. Science as humility in search of truth is one thing. Science as sole reality is another. It can then become the most pitiless and ruthless of gods.”

A Christian priest, Friedrich Benesch (Benesch, 1983), uses the biblical quote of “Man does not live by bread alone, but also from every creative word which proceeds from the Godhead into the human being” (Benesch, 1983, pg 22) to say that the Science of “turning stones into

bread", which we all must do to survive, needs to be accompanied by the word of God; religion. On page 26 he quotes Klaus Muller, saying

> "…Science seems to be a realm of clarity, soberness and unimpeachability. But it is just Natural Science itself … that totally lacks enlightenment about its own premises, goals and motives" (Benesch, 1983, pg 26).

Benesch goes on to say that Science should examine its "inner state" and set up a higher forum to oversee Natural Sciences itself. Towards the end of his booklet, Benesch, like Rabbi Sacks, warns that

> "… mankind will inevitably plunge into the most terrible catastrophes if, as has been the case up to now, materialism alone continues to dominate as a mental attitude, or even as the solely valid, dogmatic ideology, and prevents the rising of man out of matter… materialism as ideology, as a fixation of consciousness on matter, sets a limit on the growth of the human spirit" (Benesch, 1983, pg 38).

Neither Rabbi Sacks nor priest Benesch speak badly of Science, but they both come to the same conclusion that, on its own, without the balancing force of religion, not just their own religions of Judaism and Christianity but any religion, classical, materialistic Science will bring devastation and an undermining and limiting of the human spirit. Steiner and Smuts would agree with the sentiments of these men. Both are men of science, with deep spiritual intuitions, who frame the religious needs of the human being in a different way. It is Steiner's description of blood-knowledge that seems to me the best description for the way of keeping our intimacy with ourselves, others and the world strong.

My research has its focus on learner interest and not religion, and yet it is often through religious or spiritual men and women that the need for the inclusion of a more holistic and human approach to our world view is so poignantly expressed; an approach where our experiences of knowing and belonging unite.

Our modern use of Science has caused many problems that will take many generations to solve, including the cleaning-up, processing and safe-keeping of nuclear waste, pollution of the environment, destruction of species, natural habitat and environments as well as disruption and destruction of communities, cultures and social values. We must however, believe that the positive of Science outweighs the negative. It has enabled us to overcome diseases, improve transport and communication, liberate and empower citizens, democratise society, transform and deepen our understanding of ourselves and our world. Advances in our military capability has also led to an unprecedented period of world peace over the last sixty years (Harari, 2014, pg 416). It is the scientific paradigm that took us out of a mythological and fatalistic relationship to life in the old cultures, and liberated the individual to empowerment and self-determination. Barriers to knowledge, education, work, travel and

a broader social-life have crumbled before its immense power. But it is just this immense power that needs to be held in check by what Steiner calls will-knowledge and by introducing what priest Benesch calls a “higher forum” to examine Science’s “inner state” to prevent its excesses and one-sidedness. Once these are in place, Feynman’s scientific age will surely begin.

A clear indication that nerve-thinking is dominating our approach to life is seen in how we allow ourselves to raise farm animals. Industrial agriculture has developed to supply the market with meat for human consumption. To do this, they use the economic principal of least cost and maximum profit. This has led to chickens being kept in cages and pigs in small pens; even cows in closed cages (Harari, 2014). Their physical needs of food, medication and even reproduction are catered for by the farmer. Their need to exercise all and any behaviours that have evolved to enable them to develop their social relationships in their natural environment have been denied to them. The emotional and personal stress that these animals experience seems to be of no concern to the farming industry (Harari, 2014, Pg 385). Here, clearly demonstrated, our inhuman treatment of animals proves the concerns of Benesch and Sacks and shows the desperate need for us to educate holistically in order for our ideas and relationship to the world to include will-knowledge; knowing gained through sympathy and intimacy with ourselves and the world.

*All flavours now harmonise into a full, satisfying whole, spreading warmth and comfort through the whole body.*

Rabbi Sacks’ theme (Sacks, 2011) is that religion and Science should be kept separate as they are contrasting and complementing principles. His contention is that Science should not be treated as the *whole*, but as a *part*, that requires another *part*, religion, to make a balanced *whole*. Rabbi Sacks sees religion as the bringer of the arts into society. When he speaks of religion he includes a humanistic relationship to the world where the imaginations, inspirations and intuitions that well up from within, and make us feel connected to the world, are joined with religious revelation. Unfortunately, schools in South Africa are not able to promote religion to balance the picture, hence the contention in my research that Science itself should take up the challenge to bring its content to learners in a balanced way that makes space for our personal intimacies within this *universal Science*. The solution to this challenge is to invite the teachers and learners to bring their own imagination and personal feelings of intimacy with their world into the Science classroom. By weaving the facts of Science into a meaningful story the inner experience of holism can be achieved and the learning process can be enhanced at the same time.

## Education challenges:

That Science and story, song and poetry should unite is what Feynman declares will bring the birth of a truly scientific age (Feynman, 1955). Science began its journey united with human intimacy and what can be called, will-knowledge or religious feeling; surely in its maturity these elements should join again.

I wrote the following piece shortly after Barack Obama implemented his programme of “No child left behind” to improve the state of education in the United States of America. Because the world of education still does not understand the developmental needs of children and focusses primarily on academic “nerve” knowledge, I felt the need to express this in poetry.

*No Child left behind*

*There sits a child upon the shelf forgotten, left behind.*
*What should we do to get the child to come and join the crowd?*
*Loud noises, sad songs and fancy cars; 2 seconds every scene,*
*Social pressure, tests, exams; the challenge to succeed.*

*20 Years of this grand plan has made the child a man*
*Who’s been so sucked out himself there’s nothing left behind.*
*To fill the void where once there was a quiet shelf to find*
*Is sex and drugs and rock n roll; panacea for the mind.*

*So what real substance do we have to do a proper job?*
*So that the child, full in itself, extends it all around.*
*It just so happens the child itself has exactly what we need,*
*With wish to play and learn; a searching love to feed.*

By ignoring holism, we will never solve our educational challenges and meet the needs of our developing personality, or our global and social challenges. Without a means to understand the relationships between different aspects and levels of ourselves and our world, we will remain ignorant of our true nature and prevent a growing intimacy with the world. Science, the study of the nature of our world, can reveal great insights into our human nature when we use the lens of holism.

There are many scientists who have given credit for their findings to their intuitions, and many others who have tried to analyse how this intuitive process has helped in scientific discoveries (Koestler, 1964; Langley, 1987). Albert Einstein is often quoted as having said

that “The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honours the servant and has forgotten the gift.” It seems to be a misquote that originated from a book by Bob Samples (Samples, 1976). It none the less shows the immense respect Einstein had for intuition. The most famous example of a scientist giving credit to his intuitive faculties is the German scientist August Kekule, who credits a dream of a snake curled in a circle eating its own tail that gave him the insight that the shape of benzine, which he had been wrestling with, was ring shaped (Rothenberg, 1995; Strunz, 1993).

What is clear from these intuitive discoveries is the process of how the intuitive and rational mind cooperate to make these discoveries valid (Koestler, 1964). It is the same process that I used to write the poem for my research. In each case, it seems that the scientists immerse themselves in the scientific content being investigated. Wrestling with the experimental evidence, the ideas already known and those associated with the work are explored and experienced with a strong mental focus. It is this immersion, coupled with a strong affinity and personal connection, that allow the content to sink down into our unconscious mind, our will. From here it later rises in imaginations, inspirations or intuitions. The best description I have found for this process is given by Rudolf Steiner, as described earlier in this chapter. From experience, it is not the objective rationalising that gives rise to the inspired harmony between fact and imaginary picture, but the personal “sympathy” or connection that is felt with the ideas and substances involved. Steiner emphasises the difference between objective, rational thought, which is borne out of pushing the world away from us, and personal, subjective will, which arises though uniting ourselves with the world. When this will is strong enough, the intuitive knowledge arises, but it is only the well-developed reasoning mind that has immersed itself in the subject matter that can make full sense of that which arises.

### 2.2.5 **Quantum mechanics**: *Penne pasta served with a variety of seasonal vegetables in cream with an unexpectedly full flavour.*

Quantum mechanics is a branch of Science which looks at the nature and behaviour of sub-atomic particles. What it has revealed to us has required a truly post-modern mind to comprehend. Many physicists have been inspired to question the reality of our world because of its extraordinary findings. It is as though quantum mechanics is showing universal truths which can be found to be harmonious with Christian (Davies, 1984), Jewish (Schroeder, 2011; Schroeder, 2009) and Eastern religious (Capra, 2010) perspectives. Of these religious authors, it is Dr Fritjof Capra who I would like to draw on here.

Fritjof Capra, then a researcher in theoretical high-energy Physics, begins the preface of his book, “The Tao of Physics” (Capra, 2010) with a personal story of how he combined his knowledge of particle Physics with his imagination while,

> “sitting by the ocean on a summer’s afternoon, watching the waves roll in and feeling the rhythm of my breathing, … I suddenly became aware of my whole environment as being engaged in a gigantic cosmic dance… I ‘saw’ cascades of energy coming down from outer space… I felt its rhythm and I ‘heard’ its sound, and at that moment I *knew* that this was the dance of Shiva, the Lord of Dancers worshipped by the Hindu’s (ibid).”

Capra is showing, in this magnificent story, the power and life-changing capacity of bringing nerve and blood knowledge together. His previously developed concepts and ideas from particle Physics and his in-the-moment sensory experience, fill his imagination and inspirational experience, blood-knowing, with a sense of “seeing, hearing and knowing” that had a life-changing effect. This experience changed his understanding of the world and his place in it. Further in his book he relates how the Cartesian view of the world that influenced classical Newtonian Science by causing a separation of mind and body, has “alienated us from nature and from our fellow human beings.” (Capra, 2010, pg 22). He adds that,

> “Today we know that the Newtonian model is valid only for objects consisting of large numbers of atoms, and only for velocities which are small compared to the velocity of light (Capra, 2010, pg 42).”

Having placed classical Science in its place, he goes on to say,

> “In modern Physics, the universe is thus experienced as a dynamic, inseparable whole which always includes the observer in an essential way.” (Capra, 2010, pg 86) and “It has come to see the universe as an interconnected web of physical and mental relations whose parts are only defined through their connection to the whole.” (Capra, 2010, pg 147).

On page 303 he puts his point more clearly by saying that physicists now see the laws of physics as “creations of the human mind; properties of our conceptual map of reality, rather than reality itself.” Fritjof Capra has used his expertise in Physics and his interest in Eastern mysticism to show a meaningful relationship between physics and spiritualism. That he starts his book with a moving personal experience where he felt the relationship between science and spirit, is not surprising to understand. His aim was to show a meaningful relationship between objective Science and our subjective human inner-life. Fritjof gives us a clear indication that understanding quantum mechanics requires both nerve and blood knowledge.

One of the founding fathers of quantum mechanics, Werner Heisenberg, [1901 to 1976] once said,

> "The first gulp from the glass of Natural Sciences will turn you into an atheist, but at the bottom of the glass, God is waiting" (as quoted by Dimitrov, 2010) and
>
> "Natural Science, does not simply describe and explain nature; it is part of the interplay between nature and ourselves." (as quoted by Cavallo, 1982)

It is well known that many physicists are, or were, deeply spiritual or religious (Dimitrov, 2010), including the famous Albert Einstein (Einstein, 1949). This does not prove anything in itself. What it does suggest is that the ideas embedded in quantum mechanics are easily holistically integrated into a deeply personal relationship with the world.

Quantum mechanics shows that matter and energy are interchangeable manifestations of particles. Photons of light and electrons behave as waves as much as particles, indicating that they can be energy or matter. More unexpected is that they will take the form that scientists are looking for in their experiments. The two experiments which show this are well known in Science as the photo-electric effect (Clauser, 1974) which only works if light is a particle, and the single and double-slit diffraction patterns using single photons (Tonomura, 1989) which only works if light is a wave.

It was further realised that in cases when an electron took on a particle form we could still not know everything about it; we can either know where it is or how fast it is moving, never both! This is known as Heisenberg's Uncertainty principle (Busch, 2007). Matter itself shows that it is inherently unknowable and will only show one aspect of itself at a time. More than this, on an individual level of humans and particles, there is little or no predictability of behaviour, but on a mass scale of particles and humans, there is predictability. This shows one aspect of the holistic relationship between humans and particles.

Quantum mechanics shows that striving for objective reality through the accepted form of positivist Science is not possible within certain levels of evolution. We influence the way basic particles behave and we can only know certain aspects of reality at any moment in time. Through these findings the scientific paradigm was shaken to its core. The history of the events around the time of this monumental shift is a moving story that is tragically rarely told. The stories of how Werner Heisenberg and Albert Einstein developed their uncertainty principle and relativity theories respectively, are further indications of how imagination, inspiration and intuition, knowing gained through *blood knowledge*, have been essential in the development of Science.

To continue teaching Science in the old classical paradigm is counter to the logical inference of quantum mechanics within a world governed by holism. This has been addressed in my research by allowing for multiple stimuli in the research intervention, enabling learners to be stimulated on different levels by what catches their personal interest.

## A taste of wholesomeness

I wrote the following piece to bring home to us how modern, Western education is not what the great minds of politics, Science, education or religion would have wanted.

*Organic, free-range education*

*The fertiliser of our time*
*Driving progress and efficiency*
*Appeals to our small and self-centred mind…*
*To compete and to win and be better than the rest.*

*In schools' we've devised ways to make this quite fair.*
*With moderated test and exam results we compare*
*One child to another and sort them with care*
*So that...Umm? We can sell the best fruit at the fair?*

*Despite the rhyme I don't feel it this time.*
*Are we really so small that it's the best we can do?*
*Is this the highest our humanity can stretch?*
*And does this really bring out our best?*

*Did Mohammed, Srivastava, Jesus or Buddha*
*Einstein, Faraday, Pascal or Newton*
*Educationists Hahn, Montessori or Steiner*
*Advocate this way to make all life finer?*

*Was it then Moses, Pythagoras, Confucius or Plato*
*Mandela, King, Lincoln or Gandhi?...*
*All these leaders saw something higher and deeper*
*For up-skilling humanity and working together.*

*Life is long and our roots must grow deep*
*In soil with good nutrients and water that's sweet,*
*Breathing air that is fresh with bird-song and more*
*And in light, warm and clear, from just beyond our reach.*

*Then the being that we are is the being we shall be*
*[Not a mass-produced, monocultural uniformity, but]*
*Growing in harmony with all human diversity*
*And the fruit we will bear when our season is right*
*Will be given in freedom, owned by all with delight.*

We see from quantum mechanics that the version of Science taught at schools is only valid for certain aspects of Science and that it needs to be complimented with the most up-to-date understanding of our world which includes a recognition of the relationship between our world and ourselves.

### 2.2.6 **Story**: *Bell peppers filled with lamb and beef mince. Subtly different flavours with every bite.*

Everyone loves a good story. It captures our imagination as it takes us into its world. It gives us characters in context. It creates dynamic and moves us on a deep level just because we are not looking at the events from the *outside*, objectively, but from the *inside*, subjectively. It is a powerful tool for engaging the full human being, enabling us to see things from the fresh perspective of the various characters.

Every song, book, short story, poem or painting; every scene of nature, conversation or art work; even every Science lesson is a potential story. Stories encapsulate parts into a whole as a well-known and loved expression of holism. It conveys information factually and yet the listener accompanies the events with their sympathies and antipathies shaped by their inner moral landscape which in turn receives shaping. Since Science has as its basic challenge to convey unfamiliar and challenging content to the uninitiated young teenager, it makes sense to use a tool as powerful as story. It knits the parts of information into a meaningful context that results in a comprehensive whole in a form that can be revisited by the learner without being a dull and dry experience.

All parents know that little children will ask for stories to be retold ad-nauseam and will even *help* you when you do not repeat it correctly. They experience an extraordinary range of emotions, questions and ideas as they live it again and again until they have completely absorbed it into themselves. Imagine Science capturing young learners' attention with the same completeness and life shaping investment? For this we would need to give learners the opportunity to form their own relationships, questions, ideas and conclusions and not enforce a uniform definition for everything. If we do not encourage independent experience and thinking we do our learners and Science an injustice; we no longer do Science.

Neuroscience has done many experiments looking at brain activity while doing various activities (Eagleman, 2015). In 2012, Annie Paul published an article in the New York Times on how listening to a story affects our brains (Paul, 2012). It seems that when we are talking about food or music or a picture, the parts of our brain that are active when we eat, listen and see respectively, are activated as though we are doing the activity ourselves. This mimicry of real activity that our brains do, activates old and new neural pathways including motor, or movement, paths. In Annie Paul's article, she promotes stories as a way of awakening ourselves on multiple levels and thus with the possibility of giving a full human mental, emotional, active and creative stimulation. Most interesting is the realisation that we make even small decisions, for example which peanut butter to buy at the supermarket, with both our affective and rational parts of our brain (Eagleman, 2015).

Young teenagers fall in love with books, music and movies, with characters, actors and pop-stars; they fall in love with goodness, beauty and truth (Steiner, Adams & Darrell, 1972). With the onset of puberty, the teenage brain undergoes many changes (Blakemore, S., Burnett, S., Dahl, R. E., 2010), one of which is that they explore their inner lives independently for the first time at this stage. Accompanying this change, they seek stories to expand their horizons. Science is well positioned to bring its stable and reliable findings into what can easily become chaotic; their inner life. Young teenagers should be flocking thirstily for the depth, breadth, insights and sanity that Science brings. Yet they are not choosing it because Science has positioned itself aloof to this inner life; the very inner life that rose up for the fruits of Science in a previous era and gave it birth.

A greater tragedy is hard to find.

### 2.2.7 **Lifelong learning**: *Char-grilled sirloin steak, rare, with al dente large-diced seasonal, organic vegetables.*

Lifelong learning is based on *well-developed personal interest* (Hidi, 2006) as well as the notion that we all should keep our interest levels in learning high and never be satisfied with what we already know. Lifelong learning is not assessed, just as we do not assess and evaluate our own children in the home. It forms part of what we bring to others and what others bring to us. That we all see the world differently is what enriches life and makes us enjoy each other's company. To seek only those who are the same as ourselves is what leads humanity into so much trouble [think apartheid and xenophobia], and is indicative of souls who believe that what they have is all that they need; one devoid of a love for lifelong learning.

Art, story, quantum mechanics, holism and lifelong learning all ask of us to allow a degree of freedom-of-choice to the learner in the learning process to find their own path to the learned content and to even select the content itself. In the current education system where specific content is needed and the rest ignored, this is a challenge, but at least we have the possibility to use some of these tools to enliven the learning process.

*Feeling satisfied, and stimulated by the many heart-warming and soul-expanding flavours, the diners put down their knives and forks and talk openly of their deepest work.*

2.3 **Portraiture**: (Lawrence-Lightfoot, 2005; English, 2000)

*One of our dinner guests is…* Sara Lawrence-Lightfoot, a MacArthur prize-winning sociologist, currently the Emily Hargroves Fisher Professor of Education at Harvard University, where she has been on the faculty since 1972 (Lawrence-Lightfoot, 2017). On her personal web-page she shares the key ideas that stand behind her life-work, and of particular interest is her idea of portraiture.

Portraiture is what she calls the process of creating a portrait of a person's life using our analytical and emotional faculties. A research method that "bridges the realms of aesthetics and empiricism" (Lawrence-Lightfoot, 2017). The key elements to portraiture are context and the ability to hear the voice of the subject to create an "aesthetic whole", a portrait, which captures the essence of the subject's reality.

*In discussion, the guests realise how close Sara and our dinner theme are in spirit.*

"In creating the text, the portraitist is alert to the aesthetic principles of composition and form, rhythm, sequence, and metaphor" (ibid). Sara has found the same wish, to tell a full *story*, using all our human observational, analytical and creative faculties to do it justice. In her field of Sociology, she has awoken to the same impulse as I have in the field of teaching Science. To do justice to anyone or any body of work we need to gather all the information available to us and allow our inner life to form it into an *aesthetic whole*. For her work, each human life is the subject. For my research, it is the section of acids, bases and salts. Beyond the poem used in my research I have written poems for many sections of the Science syllabus, striving to create portraits or *aesthetic wholes* for each.

The poem used for my research was written after over 25 years of teaching. My knowledge and experiences amalgamated into coherent pictures, a portrait if you like, which showed the substances as characters, and the relationships between the substances as an unfolding

story. Using the elements of metaphor and rhythm in the form of a story-poem, the portrait is created as a living whole. This done, it was the task of my research to show that such a portrait enhances learner interest in the topic.

*The diners remain at the table sipping their drinks and nibbling at the remaining side dishes while discussing some of the realities of life.*

## 2.4 **The current state of Science education**:

### 2.4.1 **Text books**:

To determine how much artistic, aesthetic, biographical and historical information there is in the Science text books, I examined the grade 12 texts of “Doc Scientia” (just the Physics book), “Physical Sciences” by A. Olivier (all three books), “Physical Sciences” by the Answer Series and the internet available “Everything Science” by Siyavula. These books all have diagrams, pictures, sometimes in colour, and graphs. They also use questions which are story-like, to give a context for doing some calculations and showing understanding of application of theory. In some cases, real historical situations are given as the context for a question. These books varied in the number of date references that they gave, from 20 in “Everything Science” to less than 10 in the “Answer Series” book. The total number of quotes in all the books combined was one, by Albert Einstein, at the start of the “Doc Scientia” book. In each book, the total space given to historically contextualising the work amounted to less than half a percent. “Everything Science” had a side column in which it placed between 30 and 40 short features of interesting facts related to the content, giving context and history to the development of Science as well as some technological applications.

These findings, of limited context and application, do not surprise me as the curriculum demands the knowledge of specific content and the texts would naturally reflect this. There are only a few sections in the CAPS syllabus that require any real-world application knowledge or environmental impact understanding. Teachers and learners alike are focussed on the transfer of skills and knowledge required for the exam. Everything else is regarded as a distraction. The focus in all the books is on the transfer of curriculum-specific content and skills to the learners.

An interesting review of Science text books was done in South Africa by Whitfield Green, (Green, Naidoo, 2008) who says, "textbooks are not neutral... they are conceived, designed and authored by real people with real interests." They then quote Apple (2000) who said, "all too often legitimate knowledge does not include the historical experiences and cultural expressions of labour, women, people of colour, and others who have been less powerful”

(Green, 2008, pg 239). His socio-political view on text books reminded me of the attempts in South Africa during the 1980's to produce texts that would be more inclusive of a broader representation of humanity in the world of Science (Walshe, 1985; Christie, 1985; Mazel, 1987). From my experience in Science teaching since then, such attempts have been reduced to giving the names of people in examples and questions, a broader cultural, racial and gender base. Everything else remains the same.

Attempts are being made to include traditional, indigenous knowledge which arose mostly out of intuition. These are still few in number and included only where Science can give its authoritative approval to such knowledge.

### 2.4.2 **The arts in Science education**:

A search for research done on the use of the arts, in any form, being used in Science education did not yield many results. One significant finding was a widespread movement in Germany, the United Kingdom and the United States of America, often referred to as the "Romantics". For over a hundred years, from around the time of Goethe in the early nineteenth century, they strove in vain to have Science include a vision of the world which was filled with vitality as well as laws (Harrington, 1999; Tauber, 2009: Zajonc, 1998). These great thinkers recognised, while it was happening, the shift from a human-based knowledge to an objective, abstract one. William Wordsworth's poem [in Chapter 1] spoke strongly of this feeling of lost intimacy with the world. He, together with many others, tried to ensure that Science would not remove all the depth of the old *classical* education which taught us our true and intimate relationship with ourselves, others and our world. Perhaps the time will soon come where we will have *drunk deeply* enough from Heisenberg's *glass* of Natural Science (Dimitrov, 2010) to find our deepest selves reflected in it.

Some researchers focussed on the attitude of learners and teachers and how it affected their interest levels and therefore their engagement in the subject [see 1.6] (Denessen, 2015; Gal, 1994). The Western Cape Education department (Western Cape Education Department, 2015) did some fine research into the state of Science education over the last few years and identified that learner "stimulation and motivation" needs addressing. They even propose that teachers should make the lessons more interesting and they put forward dates for training, but nowhere do they stipulate how this should be done. Due to the non-specific manner of the intervention, the teachers will probably remain doing the same things as before with perhaps more teacher knowledge, skill and enthusiasm if they are lucky.

The closest finding I made to the use of art or "story" in Science is the use of analogy (Orgill, 2013). Science is full of the use of analogy and metaphor to explain the working of nature

and so a study of its usefulness is still well within the current parameters of Science. Other methods looked at, that motivate learners in Science, included problem solving and inquiry-based learning (Hmelo-Silver, 2004) which would give a problem to be solved and allow learners to create their own pathway to solutions. This method would be highly compatible with child-centred learning as the learners create their own *story* towards solving the problem, but with the current CAPS syllabus there would not be the class time and their work would probably not be syllabus compatible. Our current exam system would not reward their efforts.

I found a good article on art-infused education (Lorimer, 2011) which indicated significant benefits for learners, but they were referring to posters, graphs and the other usual tools. The use of visual art and the dramatic arts were also mentioned but not in Science education. It seems that there is a real divide between the Mathematics-Science world and the rest of education when it comes to including the arts (Daugherty, 2013).

Someone who has done much to bring children from disadvantaged backgrounds in urban United States of America into Science is Christopher Emdin (Emdin, 2010). His valuable work created a positive connection to Science through rap music, a genre which is often used to articulate beliefs and attitudes towards learning. Encouraging learners to create their own lyrics to their own rap beat was a successful way to enable learners to become more positive towards Science. Although the lyrics used by the learners did not incorporate a high level of Science content, and focussed rather on the learners' feelings, it seems to have had the overall effect of making Science more acceptable to learners. The emphasis in his research is to portray scientific content artistically. The Natural Science topics that he used with his learners fall under Life Science in the South African syllabus and not Physical Science. My research will only look at a part of the Natural Science syllabus that becomes Physical Science in the later educational phase.

The community where Christopher worked would probably resemble more closely the township community in South Africa, where learners' relationship to Science education is possibly more negative. If my research were being conducted in the townships it would be meaningful to see how his approach would work. An assumption in my research is that the learners' parents have chosen these ex-model C schools because they already have a positive attitude towards education and value the education given.

## 2.5 **Chapter summary**:

This chapter has shown how Science in general, as well as Science education in the Grade 9 classroom, has placed itself separate from the concerns of the human inner-life. Modern

Science, through quantum mechanics, shows us the appropriateness of including the concerns and consciousness of the workings of the mind into the Science class. By not including the human inner-life into the Science classroom we are perpetuating a falsehood as to the real nature of our world as it is understood by post-modern Science. The dangers of not doing this are not just in a loss of learner interest but of far greater concern for the future of humanity if Steiner, Sacks and Benesch are to be believed. Several perspectives that show how the human being needs to be taught holistically, by allowing for objective and subjective knowledge, to create a healthy balance in our knowledge and relationship to ourselves and the world as well as improving interest and engagement in Science have been shown.

It has also been shown that by introducing story [in the form of poetry in my research], holism and holistic educational practices into the Grade 9 Chemistry class we have a chance to not only rectify this current error, we also open the door for greater learner engagement and interest that may lead to more learners feeling that Science has something to teach them about themselves, and may lead to more learners studying Science in the future.

In the next chapter, the current curriculum context for the section of acids, bases and salts that will be used for my research intervention will be examined. Details of the intervention content and process as well as the questionnaire that will be used as matched-pairs in the pre-test and post-test will be given.

*Having satisfied their need for real nourishment, the guests prepare themselves for the sweet taste of action. They think to themselves, "What will our host do to make manifest these thoughts and intentions?"*

# Chapter 3: Research method and details: *Dessert menus arrive*

**Paradigm**: *Chocolate truffle*

**Curriculum context**: *Four-layer sponge and cream cake with raspberries and pistachio nuts*

**Artistic, holistic devices used in this research**: *Strawberries dipped in Fairtrade chocolate*

**Ethical considerations**: *Cream filled chocolate éclair*

**Controlling the research environment**: *Gluten free Homemade Tiramisu with mascarpone cream filling*

**Selection of the research tool**: *Red wine poached pear*

**Statistical significance**: *Fruit salad*

**Implementing the research**: *Peach-berry frozen dessert, diabetic friendly*

## 3.1 **Paradigm**: *Chocolate truffle*

Being quantitative in the data collection and analysis, and qualitative in this investigation of Science education and learner interest, it was a clear choice to look at the mixed - methods research approach.

In selecting the paradigm the contents of the book “Research Methods in Education” (Cohen *et al.*, 2007) were examined. My research holds the position that the learner’s perceptions and attitude to learning makes all the difference. Lifelong learning is born out of the individual’s interest in life and the world, and is also the fuel for enjoying school subjects which will hopefully lead to improved school results. This led away from positivism, with its objectivity and wish to remove the subjective influence of the individual from the research. [The research questions ask the learners and teachers for their personal views.]

The positivist approach, which dominates quantitative research, was developed by a French philosopher called Auguste Comte, who lived from 1798 till 1857. Comte saw,

> “the evolution of human thinking as a process that must pass through three stages. The first two stages of this trinity, the theological and metaphysical, were signs of immaturity and merely precursors of the third and most desirable positive stage” (Barrow, 2005, pg 45).

In the opening few pages of Comte’s work “Introduction and Importance of Positive Philosophy” (Comte, 1976), he outlines these three stages of thinking. The first two stages are varying degrees of attributing the causes of all things to one or more supernatural beings. In this he includes all mythological and religious beliefs.

Reaching the third stage, Comte’s final stage of the development of human thinking, the human abandons the hope of,

> “obtaining absolute truth, gives up the search after the origin and hidden causes of the universe… It endeavours now only to discover, by a combined use of reasoning and observation, the actual laws of phenomena” (Comte, 1976, pg 3).

Comte sees the attempt to find absolute truth as futile and a primitive activity. The mature stage of thinking was to limit oneself to sense observation and reasoning. The positivist approach is undoubtedly useful for Science as long as it is remembered what its self-imposed limits are. My research will need to go beyond this not because I want to make use of one of his first two stages of thinking, but because I want to look at a fourth stage, that of an integration of positivist thinking and imaginative and intuitive ways of knowing. This does

not require mythological or religious beliefs, just a recognition that it is not only our senses and reasoning faculties that can bring us knowledge.

One paradigm which Cohen proposes is critical theory, which is very political in its approach (Cohen, 2007). Critical theory proponents see our current view of reality as twisted by our scientific, positivistic outlook which does not respect *life or mind*. In many ways, this reflects my views in this dissertation, and the wish to broaden and humanise Science through a holistic approach which engages as many of our faculties as possible. However, the scientific paradigm or positivist approach has its place. The book “Sapiens” (Harari, 2014) has a chapter titled “The discovery of ignorance” where the author explains how it is our awareness that we do not know everything, that stimulated the modern scientific approach of asking questions and searching the world for answers. The humility to acknowledge our ignorance is what has led to so much security and confidence in scientific knowledge that has been tested and re-tested. The fact that this positivist approach is being over-emphasised as the almost exclusive way to view our world, is not the fault of the scientific paradigm itself. It is the fault of those who use it to dominate and limit our understanding of ourselves and the world [as extensively discussed in chapter 2]. A rejection of this positivist approach is not, however, helpful. It is needed to lift our understanding out of being purely subjective without any objective referencing or reasoning. The fruit of our positivist approach has been the force that took human thinking out of the dark ages. The positivist approach, like anything else that is not the *whole* but only a *part*, needs the other *parts* for it to find its right place.

The interpretive approach seemed like a good fit for my research because it looks to the meaningful nature of people’s participation in life. This will not always lead to the universal ideas that Science discovers but for the purposes of my research, will be the ground for seeing how important it is that each learner develops their own relationship to the content so that their interest is felt, as well as thought. The interpretive approach has its focus on “interpreting the world through its actors” to find “meanings and interpretations” (Cohen, 2007; pg 26) through the way in which we make sense of the bits of information. This is important if each learner is to take Science into their lifelong learning. The holistic way that meaning is created clearly resonates with the focus of this research.

In selecting interpretivism as the paradigm, my research needs to give it some holistic context. Holism, as put forward by Jan Smuts (Smuts, 1926) shows how our world is constructed of layers, with each layer needing to go through an evolutionary stage to reach maturity. Maturity is a state where the layer will possess a high degree of perfection, consistency and predictability. He shows how the world of atoms and molecules is so

evolved that it now behaves in uniform and predicable ways; therefore, we can study it in a positivist manner. The newest levels of evolution, of mind and personality have not yet reached such perfection and if we address the individual human we simply cannot do it in a positivist manner due to each personality needing to process the information from their own standpoint. Different paradigms would be suitable for studying different levels of our world as viewed through holism. For this study, with its emphasis on trying to awaken an interest in Chemistry in the learners, we are observing the effects of learning on the evolutionary level of personality. Although school Science studies *lower levels*, which are fully evolved and can be studied positivistically, I am here addressing the level of personal engagement and interest when engaged in scientific studies.

What may seem to be a conflict is that all my data and analysis of data is done in a positivistic way. This is because the findings of this research will be judged on its ability to objectively show that my holistic intervention did cause an increase in learner interest. The motivation for my research and the interpretation of the results are qualitative as they try to find the human dynamics for the changes in learner interest levels. Therefore, I stay with my decision to call my paradigm an interpretive approach to mixed methods.

## 3.2 **Curriculum context**: *Four-layer sponge cake with raspberries and pistachio nuts*

My research took place during the study of acids and bases in the Grade 9 Science syllabus in term 2.

Young learners often struggle to identify with the content of the Natural Science course. This is partly because it is very challenging for some learners to understand the unfamiliar and abstract nature of the content. No one has seen individual atoms or their constituent parts. The learners are expected to imagine these. The syllabus then requires learners to understand chemical formulae of compounds and their use in chemical reactions. These abstract symbols have little that will initially identify them with the properties of acid or base or salt. Not until they are a good way into the work will the learners form much of an idea of the substances. From my teaching experience, by this time many learners who are not already lost, will be losing interest due to an approach that is counter to one of the governments aims for education.

From the Senior Phase CAPS Natural Science document:

General aims of the South African curriculum point 1.3 c on page 4 of the Natural Science CAPS document states we need to promote “Active and critical learning: encouraging an

active and critical approach to learning, rather than rote and uncritical learning of given truths" (Education, 2007).

In CAPS, Grade 7 learners are introduced to the categories of acids and bases without their relationship to metals and non-metals or how they fit into a broader Chemistry context. It is a very practical and experiential start to the topic but gives no context to the work beyond the kitchen. It is a good way for the learners to get a preliminary identification of acids and bases. The topic then skips Grade 8 and returns in term 2 of Grade 9.

At the start of the section in Grade 9, the syllabus looks at the periodic table and where the metals and non-metals are found. The work then moves quickly [too quickly to develop more than a basic grasp] to chemical formulae. These are then used in chemical equations to show how substances change in a chemical reaction. From there the focus is on reactions of metals and non-metals with oxygen to form acids and bases. This sequence is highly sensible and is an excellent way to bring learners to a greater context of how acids and bases are formed. The problem lies in the amount of time spent in developing the learners' confidence and competence with the periodic table, elements and their symbols, compounds, formulae, equations and reactions before beginning the work on acids and base. At the start of the acid-base section they are introduced to the pH scale and neutralising of acids and bases. Only then do they proceed with the specific reactions of acids and bases.

It is at this point that the research intervention took place with the poem (Addendum D), video and class discussion.

This description of the detailed background to the topic at Grade 9 level would be enough to put most people off unless they had previously formed a developing or well developed interest (Hidi, 2006) in acids and bases. A good teacher will continuously refer back to the covered concepts in order to help the learners maintain an integrity in their understanding.

## 3.3 **Artistic, holistic devices used in my research**: *Strawberries dipped in Fairtrade chocolate*

### 3.3.1 **The poem**:

I wrote this poem after teaching Chemistry for about 25 years. I encountered the alchemists' idea that acid displayed masculine traits and base feminine, many years ago. Since then I have used and played with the idea to stimulate learner interest in the section of work despite never being able to find any proof that this idea really comes from them. I used the

male/female theme in the poem to allow for a dynamic story to unfold. I do not support gender stereotyping and the class discussion and video addressed this.

*Acid Man and Lady Base*

*Of these the ancient Alchemists spoke*
*Who knew them both as active folk.*
*Base, born of metal and acid her mate*
*Have needs that only the other can sate.*

*To find their nature, for what they strive,*
*We place in sets of test-tubes five*
*Magnesium, milk and copper sulphate,*
*Crushed chalk and oil; our sacrifice, our bait.*

*Acid brighten, dissolve and boil*
*To lift from solid its heavy toil*
*In one quick act his halide sword*
*Or brimstone fire has form destroyed.*

*Slower working, to hold and bind,*
*Our Lady's fruits though soft in kind,*
*Take what is loose, unbound and free*
*And ground it, give it presence to be.*

*When together these two we place*
*The drive, the need, the hot embrace*
*Seems like a fight to dominate the lover.*
*Inanimate opposites attracting each other.*

*Then left to cool and crystallise,*
*As children born of their parents' demise,*
*Small shining beads; salt crystals delight,*
*To fructify the Earth as solidified light.*

This poem describes two experiments using acids and bases. The first experiment involves 10 reactions. Acid is placed into five test tubes which contain five different substances and base is then put into five different test tubes with the same five substances to observe how they each react to see their different chemical nature. The second experiment involves reacting acid with base directly as indicated in verse 5. By using a specific, concentrated acid and base together, the reaction gives rise to the formation of a salt which will crystallise within an hour. This shows the learners the nature of acid-base reactions and how salts are formed.

The use of the metaphor of man and woman giving birth to children through their death was originally inspired by hearing that this was how the alchemists saw them. Over the years this way of looking at them has given rise to many difficulties, not the least of which is gender stereotyping of the different sexes. What resolves this is the experience in the experiment that these two imbalanced substances find their resolution in the overcoming of their one-sidedness in becoming salt. Salts may lack the drama of the polarity but unite the best of acid and base in becoming “solidified light”, which has the capacity to bring about new life as nutrients for plants. The drama of the metaphor more than justified its use despite the obvious danger of stereotyping.

A Science teacher may object in that the modern definition of acid and base, as proton donor and proton acceptor respectively, is not addressed in the poem or experiments. In answer to this I say, firstly, that this is not part of the Grade 9 curriculum, and secondly, this does not contradict the use of the metaphor and that this metaphor may well assist the learners in their relationship to the topic when they integrate this new information into their existing understanding of the work.

### 3.3.2 **The video**:

The video can be viewed on my Deep Science Education Facebook page at https://www.facebook.com/Deep-Science-Education-Science-Poetry-Holism-and-Education-in-harmony-334924460228786/

For my research intervention, we made a 15-minute video of myself performing the reactions in relation to the poem. My wife, Tessa, filmed while I performed the experiments and explanations. Later, to film the time-lapse crystal growing and do the final editing, Andre du Plessis, senior video producer of the Department of Education Innovation at the University of Pretoria, turned the video into a more professional product.

The video, being visual and showing what happens in the various experiments in relation to the poem, was expected to be the most important stimulus for most learners. What would be interesting is to see was how the interest of the learners in the other stimuli, of the poem and class discussion, would compare to the influence of the video. This intervention directly addressed only visual and auditory learners, and not kinaesthetic learners, or learners who learn by doing (Gilakjani, 2011). The poem and class discussions were used to engage the interest of the auditory learners. The experiments in the video were used to engage the kinaesthetic learners indirectly, as brain functioning imitates what we closely observe as though we are doing it (Eagleman, 2015; Paul, 2012).

In the video, inquiry-based learning was used where the poem was presented as something the learners needed to critically evaluate using the experimental evidence shown.

It was initially hoped that the teachers would perform the experiments themselves, but several factors made this challenging. For one, the experiments would take at least two full lessons to perform and ten test-tubes of reactions would need to be preserved overnight for each class doing the experiment. Secondly, there are a total of eleven reactions that would need to be performed for each class and the preparation for each would require a lot of teacher time and commitment. The teachers are trained to perform experiments, but these experiments could be dangerous if done with the wrong concentrations of acid and base and so, also for safety sake, the video option was chosen. From my experience, video is not as effective in engaging the learners with experiments but practical, time and safety concerns resulted in the use of the video. [See addendum C for the full, final lesson plan.]

### 3.3.3 The c**lass discussion**:

After the video was shown, the class discussion was guided by a set format of questions that needed to be addressed. This was to enable the learners to revisit the content of the poem and video and to give them the opportunity to raise questions or share their thoughts. The questions for the discussion were given in addendum C, step 4, and copied here.

Step 4: Once the video is over, discuss the poem and video with the learners, using the following questions, until the last five or so minutes of the lesson.

*Questions for class discussion after watching the video.*

*<u>Questions on the acid and base separate reactions in the test tubes:</u>*

*Do you think that the poem's description of acids is accurate?*
*Do you think that the poem's description of bases is accurate?*
*Do you think the alchemists were right to describe acids as male and bases as female?*
(Please help to break gender stereotypes.)

*Questions on the reaction where the acid was put into the beaker with the base:*

*Was the poem's description of the reaction of concentrated, strong acid and base accurate?*
*Did you see how the salt crystals grew? (That they grow in all directions, free of gravity.)*
*Do you think the poem's description of salts is accurate?*
*Did the story of a mother, father and child help you to relate to acids, bases and salts?*
*Are you now able to understand acids and bases better?*
*Are you now more ready to learn further details about acids and bases?*

During the class discussion, it was important for the learners to feel that the aspects that they related to most were valid, even if they could not yet formulate why they felt the way that they did. The inquiry-based learning involved asking questions of what was observed in both the poem and the experiments to determine the validity of the poems metaphor and story.

## 3.4 **Ethical considerations**: *Cream-filled chocolate éclair*

Because the intervention was taking place in government and private schools with minors as a captive audience, it was necessary to obtain consent for the research from the University of Pretoria Education Research Ethics committee, the Gauteng Department of Education (GDE), the principal of each school, the teacher of each class, the parents of each learner and from each learner who would take part. The first step was to get approval from the university ethics committee which was gained in the middle of 2016. GDE approval followed in 2017 and the schools' permissions were gained shortly before the intervention took place.

The intervention was covering curriculum content relevant for the learners and at a time when they should be covering the content. It was presented in a familiar environment with their teacher present. The lesson involved no health and safety risks. All the learner responses on the pre- and post-tests were anonymous, to protect their identities. The learners' teachers did not know how any learner responded in the tests which gave the learners the freedom to respond without fear or favour. The only personal information learners indicated on their questionnaire [Addendum 1] was whether they are boys or girls. Teachers were further asked for their age, years of teaching experience, years of teaching Science and their highest qualification.

The poem uses gender to describe specific behaviour of acids as male and bases as female. In order to address possible gender stereotyping of the sexes from this characterisation as originally used by the alchemists, the video had a graphic representation of acid and base as both being female. The point was further raised during the class discussion where it was emphasised that these characterisations were the way the alchemists saw them and should be challenged by our own experiences.

## 3.5 **Controlling the research environment**: *Gluten-free homemade tiramisu with mascarpone filling*

My research relied on controlling many variables in the different schools where the intervention took place, by keeping as many aspects of the research the same as possible.

The choice of schools was made where the main variable was the focus of the type of learner that they attract. The metropolitan district, district 4, that was selected draws learners from similar economic backgrounds. The government schools were all large, co-educational institutions in an urban, residential setting. The one school that did not fit the profile was the private school, which is more rural in setting, has far fewer learner numbers, and draws learners from a wealthier background. This school was chosen as a deliberate variable to get a small indication of the breadth of applicability of my research.

The teachers in each school were all women of Afrikaans background with enough experience to be confident in the subject. They had also brought their classes to the same place in the syllabus. Chance had it that none of the teachers had done any experiments on the topic with their classes. The research intervention covered experiments that are not normally done at school. Had a teacher done some of the usual experiments it would have been a variable to see if this would have influenced their interest responses. As it turned out, I did the intervention which brought a uniformity to the implementation.

The class sizes differed greatly from over thirty in schools 3 and 4 to around 20 in schools 1 and 2. The number of classes per school that took part in my research also varied enormously. This helped to find a better average in the schools with more classes than was possible for the smaller sample sizes. This difference in sample size for each class and school was accounted for by weighting the averages for each school when calculating the overall averages.

The main, independent variable of my research was the different schools with their different areas of focus. Other independent variables were the learners and teachers gender and home language. The dependent variable was the change in interest levels created by the multi-stimulus, holistic intervention of poem, video and class discussion, [determined by the post-test], and the interest levels created by the usual teaching methods of the teacher prior to the intervention, [determined by the pre-test]. The change in interest levels was easy to determine as the pre-test and post-test questions were identical so their different responses could be measured as matched pairs.

Because of these variables, differences in the interest level changes were compared between government schools with different focus points as well as between the private and government schools. I was also able to compare the results between the sexes within each class and school as well as between the schools and overall. Home language trends were compared between the learners from different schools as well as between the teachers and myself because I did the intervention.

## 3.6 **The selection of the research tool**: *Red wine poached pears*

The greatest challenges with using questionnaires come from sending them by post or allowing for a choice in completing them (Cohen, 2007). Bias can be caused by only a certain sector of the population being inclined to complete and return them. I chose to use questionnaires because the sample in my research was captive, and in the presence of their teacher when the pre-tests and post-tests will be administered, this bias was avoided. It was therefore important that the selection of schools be carefully considered as this defined the sample. Even with the teacher there, it was still possible that the learners would not complete the questionnaires faithfully. The culture of discipline and compliance to teacher initiated tasks in the selected schools was relied on to overcome this.

The use of matched pair questions, where the pre-test questions are identical to the post-test questions was used here. These results were easily compared and the statistical tests of the t-test and Wilcoxon test were run to determine whether the results were statistically significant or not.

Interviews are useful for qualitative research but can be very time consuming to undertake and to interpret. It is also challenging to avoid interviewer influence on the interviewee especially as the interviewer will be adult and the learners may feel influenced to give answers that they think the adult would like to hear. In order to avoid such bias, it is important to ensure that the learners feel comfortable and so the interviewer may engage the learners in order to build a rapport that would result in more authentic responses, but this would result in less valid results. It would seem that the degree of authenticity and validity of interview results can be inversely proportional. This idea was formulated by Kitwood (1977) as mentioned by Cohen (2007). I decided to not use interviews because the focus of my study was an initial look at whether holistic devices would increase learner interest. Interviews would be useful to find the learners' individual experiences of the holistic devices and would be useful for further research should my research prove to be helpful in creating and improving learner interest.

Testing the learners on the work covered would be suitable if the desired outcome was the assimilation of a body of knowledge or ideas. In my research, the intention was simply to test for learner interest and engagement with the work. It would not be any direct indication of their interest levels to assess their accumulated knowledge or understanding. What was tested were the learners perceived cognitive, effective and personal relationship to the content being covered as these factors affect lifelong learning. Lifelong learning does not lead to the universal acquisition of specific knowledge. It leads rather to the accumulation of individually desired knowledge and understanding which naturally differs from one learner to the next. I chose to not test learners on the content covered in the intervention.

### 3.6.1 **The Questionnaire**:

The questions chosen were to determine the learners' perceived confidence in their understanding of the content, their feelings towards the content and subject and their sense of its personal relevance for themselves.

The learner questionnaires asked 9 questions using a five-point Likert scale. The questions of the pre-test and post-test were identical so that the changes in response to the questions could be determined as matched pairs as mentioned earlier in this chapter.

To process and analyse the results, the responses of each sex, class and school were gathered separately.

The following table is the learner questionnaire that was used.

| | Grade 9 Learner Post-Test Questionnaire | School: | | | | |
|---|---|---|---|---|---|---|
| | Indicate with a cross if you are a Boy ◯ Girl ◯ | Home language is English ◯ | | English and Other ◯ | | Other ◯ |
| | Place a cross in the appropriate space provided | Strongly disagree | Disagree | Neither Agree or Disagree | Agree | Strongly Agree |
| 1 | I understand what acids and bases are. | | | | | |
| 2 | I know how acids and bases are formed. | | | | | |
| 3 | I know how salts are formed. | | | | | |
| 4 | I enjoy learning about acids and bases. | | | | | |
| 5 | I want to know more about acids and bases. | | | | | |
| 6 | I find Chemistry interesting. | | | | | |
| 7 | I love Chemistry | | | | | |
| 8 | I enjoy learning about Chemistry. | | | | | |
| 9 | I think that Chemistry can teach us about ourselves. | | | | | |
| | | | | | | |
| 10 | Which aspect of the lessons did you enjoy most? | Poem | Video | Class | Own | |
| | (You may include more than one option) | | | Discussion | Learning | |
| 11 | Further comment. (Optional) | | | | | |
| | | | | | | |
| | | | | | | |

I ran a pilot study with my own class at the start of the year to fine-tune the questions and process. After analysing the results, the questions were refined. The breakdown of each question in the questionnaire follows.

### 3.6.2 **The questionnaire questions**:

Questions 1, 2, and 3: Learners confidence in their grasp of the work

These questions addressed the learners' perception of their grasp of the content covered in the intervention. Here, I expected the greatest increase in response from start to finish if the learners engaged well during the intervention. The ideas conveyed in the intervention should enable the learners to feel confident that they understand the content conveyed if their engagement was good. What would also emerge from their response to these questions is whether the metaphorical association of acids, bases and salts to male, female and child helped them to make sense of the substances themselves. Their responses to these questions would indicate how well the holistic devices engaged the learners' cognitive interest during the lesson.

The curriculum had already covered the conventional ideas of these substances and their pre-test response therefore indicated how confident they were in their understanding from this perspective. The difference between this initial response and the post-test response was a strong indicator of how the use of the holistic devices gave them more [or less] confidence in their understanding of the work. If the use of holistic devices were distracting and confusing, we would see a decrease in their post-test responses. Should the use of these devices help the learners to integrate their earlier knowledge into a form that makes more sense to them, we would see an increase in their post-test responses.

Questions 4, 7 and 8: Learners emotional relationship to the work

These questions asked the learners if they enjoyed or loved learning the content covered and if this extended to the topic of Chemistry in general. These questions were intended to see if the holistic devices influenced their emotive relationship to the subject. Question 4 asked about their enjoyment of learning acids and bases directly but questions 7 and 8 asked about their love and enjoyment of learning Chemistry in general. The change in the learners' responses to these questions indicated whether the holistic devices influenced their emotions or affective domain.

We know from Adam Ferrier (Ferrier, 2014), who worked in advertising, that the best way to affect behaviour change is to get people active and involved. This breaks down perceived barriers and imagined fears to the subject. This was not possible in this research so the next best option was to improve the feelings of the learners towards the subject. Alexander

looked at how the cognitive and affective domains were good predictors of participant's knowledge, interest, and recall (Alexander, 1995). The combination of the results of the first three questions with these three questions is therefore a good indicator of the overall improvement or decline of learners' interest.

Question 5: Learners' wish for further learning

Improvement in the learners' responses to this question would have indicated the lowest level of interest, *triggered situational interest* (Hidi, 2006), if any form of emotive sensationalism was used in the intervention. Since all forms of sensationalism had been consciously avoided, even in the experiments performed, the learners change in response would indicate a change of the most advanced level of interest, one which would show a *developed personal interest*. A single intervention of this sort would probably not result in much improvement in the learners' wish for further learning but such a change would be expected to require a longer-term intervention (Hidi, 2006).

Question 6: Learners' expressing cognitive interest in chemistry

This question asked the learners directly what their interest is in learning Chemistry. This was intended to see how they extended their interest in the section of work covered, onto the subject in general. An improvement in the learners' confidence in the topic of acids, bases and salts [for questions 1, 2 and 3] would be interesting to compare with the changes to their response to this question as this would show how related they feel the topic is to the subject overall.

Question 9: Learners' perceived relevance of Chemistry for their lives

This question was included as it showed to what extent the learners perceived that their previous exposure to Chemistry was relevant to their lives in the pre-test, as well as to see whether the holistic devices improved their perceptions of its relevance.

This question was a good indicator of the start of development of what Hidi calls *personal interest*. When people feel something is relevant to their lives they are more likely to become motivated to learn (von Goethe & Eastlake, 1840). This is particularly true for previously unmotivated learners (Hidi, 2000; Schraw, 1994).

A significant increase in the learners' responses to this question, would be most encouraging for the use of holistic devices in assisting learners to develop the higher levels of interest, interest which is personal and internally motivated; the basis for lifelong learning.

Question 10: The stimulus most effective in capturing learner interest

This question was only in the post-test as they only experienced the stimuli during the intervention and there was no comparison to be made with previous stimuli. It was expected that the video would make the biggest impact as it showed the experiments. Of significance would be whether the poem and discussion would feature as significant stimuli. The number of learners who found their own learning as the most enjoyable would be probably have been learners with *developed personal interest* or *developing personal interest*.

## 3.7 **Statistical significance**: *Fruit salad*

The statistical significance of the intervention was determined by the results from the t-test and the Wilcoxon test. These tests checked for the significance of the intervention by using the null hypothesis. The null hypothesis assumes that the intervention is not significant in creating a change in the learner responses. If the results to these tests, given as p values which can be easily converted into a percentage, are less than 5 percent then the results will be regarded overall as statistically significant. This is because it will show that there is less than a 5 % chance that the intervention did not cause the change in learner responses. Sometimes a 10% significance value is used to determine significance but the statistician recommended that we use the more demanding 5% limit. I used both the Wilcoxon and t-tests and compared the results to ensure validity.

These tests used the increase or decrease of the post-test results compared to the pre-test results. Assuming that the intervention showed an increase in interest levels, these tests do not include any indication of the percentage increase from the amount of increase that would have been possible. This means that if the learners interest levels were low in the pre-test it would require a smaller increase in interest levels to show that the intervention was statistically significant. If the learner initial interest was already high, the amount of possible increase would be smaller and so obtaining the greater increase required to get a 5% significance would be considerably harder. Because of this, the results are also given as a percentage increase of the amount of increase available and not just the overall percentage increase.

## 3.8 **Implementing the research**: *Peach-berry frozen dessert; diabetic friendly*

The details for how the research intervention would take place underwent an evolutionary process. The initial idea, in 2016, was that the teachers in each school would conduct the research with their own classes. This would require three lessons where…

The first lesson would have been used to…

1. Hand out the pre-test questionnaires and collect the responses.
2. Hand out the poem, read through it and discuss any confusing words or meanings with the learners.
3. Perform the first experiment which involves putting acid and base into the 5 different substances in the test-tubes as described in the poem.
4. Observation, discussion and getting the learners to record the experiment would fill the rest of this lesson.

The second lesson would…

1. Observe the changes in the test-tubes from day one.
2. Record these changes in their experiment write-up.
3. Perform the second experiment with strong, concentrated acid in strong, concentrated base. [This is the most dangerous experiment requiring great care and proper protective clothing etc.]
4. Observe the reaction and allow the solution to cool quietly to see the growing of salt crystals.
5. Begin the write-up of the second experiment.

Lesson three would…

1. Observe the final crystals from experiment two.
2. Discuss the questions given for the research [Addendum C].
3. Conclude the experiment write-ups.
4. Hand out and fill in the post-test questionnaires and collect.

When the four selected schools were approached for the research, their initial responses were very positive. When follow-up contact was made, the two schools that responded said that they could not do the research as they were preparing for exams and could not afford to devote three lessons to this. The other two schools chose not to respond despite several attempts to contact them. This led to the research not being done in 2016.

This made it necessary to try something simpler. The schools and teachers would only be prepared to offer one lesson towards the intervention. For this to take place in 2017, a video with the experiments would be needed.

The one-lesson intervention would be presented by the teacher of the learners.

1. The teacher would hand out the pre-test questionnaire and collect their responses.
2. The teacher would hand out the poem, read through it and discuss any confusing words or meanings with the learners.

3. The teacher would show the video to the learners.
4. The teacher would discuss the questions given for discussion [Addendum C].
5. The teacher would hand out the post-test questionnaires and collect the responses.

This time all four schools were very positive and planned to conduct the research. However, three days before the first school was to do the intervention the teacher informed me that her projector had been stolen from her class and that she no longer felt confident to do the research. The third school informed me on the night before their intervention that all their Grade 9 learners were going on an outing that day and only the learners who could not afford to go and those with discipline issues who were not allowed to go, would remain at school. Not being a usual class, she too no longer felt confident to implement the intervention. The fourth school teacher informed me on the morning of their research that the police were there doing an impromptu search of all the learners and that their lessons would therefore be shortened to 30 minutes and felt that she should no longer do the research.

Before the research was abandoned at school one I made an emergency call to my supervisor, informing her of the situation and saying that the only way this would be done is if I go in myself. I would take all the equipment needed to show the video and present the research myself. Further, by me doing all the interventions I would be eliminating one variable, of different teachers conducting the research.

As a result, the actual research was conducted by myself under the conditions and limitations mentioned earlier. At this point it was important to realise that the effect of a novel *guest teacher* would generally give rise to improved interest levels. The fact that I am very experienced in the field of teaching Science and that I am passionate about the topic would also have an impact. What helped to overcome these influences was the design of the intervention. The pragmatic handing out and collecting of materials and simply reading through of the poem before the playing of the video, required almost no interaction with the learners which might have influenced their interest levels. The main point of interaction was in the class discussion which depended on the learners' responses to the questions and not the researcher. In school 4 the class discussions did not happen or happened very briefly and in a rushed manner so it was interesting to see their interest levels changes. In short, the manner of the interaction required by the intervention was designed to allow the presenter to have a minimal influence on the process and that the poem, video and learner input in the class discussion should stand as the main source of influence. If the results showed this, then we could assume that the influence of the researcher doing the intervention was minimal.

Actual implementation:

The schools had already received the permission slips for the learners' parents. These had been handed to the learners and collected prior to the intervention as required. Each school intervention was a different experience so are related in the order of implementation.

School 1: We had 40 minute lessons so there was more than enough time to conduct the research in a relaxed atmosphere. The class sizes varied from 20 to 25. The research was conducted with four classes over two days in their usual classroom, a laboratory, with their teacher present. The light in the laboratory was very bright from outside so the video was not easy to see clearly. This led to many learners moving to the front of the class during the video presentation.

School 2: We had 45 minutes with a class of 20 learners. The lesson was conducted in the school's media centre and not the Science laboratory, their usual classroom. Their teacher was present. The process was conducted as required. The sound and picture were easy to follow.

School 3: This was conducted with the learners of Grade 9 that did not go on the outing, all 35 of them. These learners were not from the same class and arrived at the laboratory with a discernible, negative attitude at not going on the outing with the rest of the grade. That they were going to have a Science lesson did not receive a warm response. The teacher was present but she was not the usual teacher for all the learners in the room. The lesson was conducted as with school 1 and 2. The video, sound and picture were easy to follow except for the little distractions and disruptions from some learners. This was the only group where discipline measures were needed for the full intervention to happen smoothly, which it did.

School 4: The research was conducted in their usual classroom, a laboratory, with their teacher present. The shortened lessons meant that the discussion part of the intervention was very brief with the second and third of the three classes and not done at all with the first class. The speakers did not work, so only the sound produced by the lap-top was used. This meant that it was hard to hear the sound so the learners from the back needed to move to the front of the class. Other than this, the research was conducted as in the three other schools.

*Dessert, having been consumed, brings the diners an unexpectedly warm aftertaste.*

*A range of small, low-calorie nibbles are placed on the table.*

## 3.9 **Calculating initial and final interest levels**:

The five-point Likert scale which was used had all the low interest responses on the left, and the high interest responses on the right. The lowest interest level column was assigned a value of one, and the highest interest level column, a value of five, with the others the values in between. The number of learner's responses in each column was multiplied by the value of the column it was in to, calculate the score for that column. The scores for each column were then added to find the total score for that question. The score was then divided by the total number of learners who answered that question, giving the average response for that question.

The table that follows illustrates the calculations mentioned above where a, b, c, d and e represent the number of learners who put their response in the respective columns. The total number of learners who responded to the question will therefore be a + b + c + d + e. The average response for each question, out of 5, is then given by the calculation,

$$T = [a + 2b + 3c + 4d + 5c] / [a + b + c + d + e]$$

| | 1 | 2 | 3 | 4 | 5 | Average |
|---|---|---|---|---|---|---|
| Question 1 | a | b | c | d | e | T |
| Calculation | 1xa | 2xb | 3xc | 4xd | 5xe | T |

An average mark of 3 would indicate a neutral interest level, as indicated on the questionnaire; above three and the interest level is higher and below three, less than neutral. This was done for the pre-tests to calculate the initial interest-level mark, and for the post-tests to calculate the interest-level mark after the intervention lesson.

From each question's interest level mark, the percentage interest was then calculated. This was done by subtracting one from the average interest mark for the question, making the highest possible mark 4 instead of 5. The middle mark of 2 was then equivalent to 50% [2/4 x 100] of the maximum mark of 4. If the original assigned values had been used, with the neutral interest value of 3 and the maximum value of 5, the neutral value would be calculated at 60% [3/5 x 100], and not 50% as it should be. The new average mark was then multiplied by 25, as the maximum mark is now four, [25 X 4 = 100], or [[T-1] x 25] and the result was the percentage interest level for the question. By finding the average for all the questions, the average interest level for each class as a percentage was obtained.

The interest level percentages for the boys and girls of each class, school, and all schools combined, was then calculated. These were weighted for the number of learners in each

case, so that a class or school with more learners was given the correct relative-weighting against a class or school with fewer learners.

### 3.10 **Determining the percentage change in interest levels**:

By subtracting the post-test interest level percentage from that of the pre-test percentage, the change in interest level was obtained. A positive value would indicate an increase in interest level and a negative value indicates a decrease in interest level. This method gave the increase or decrease in interest as an overall percentage. It is these values that were used in the t-test and Wilcoxon test.

To accommodate for the fact that the initial interest levels were not neutral or equal, the amount the interest levels changed *relative to how much change was still possible*, was calculated. To do this, the amount of possible increase available was determined from the pre-test percentage. By converting this percentage increase available into a total of 100%, the percentage increase was then calculated as a percentage of the amount of increase possible. This value was much higher than the actual percentage increase. This was done because a school with an increase in interest of around 10% would be more significant if the initial interest levels were around 65% [where only 45% increase is available] than if they were only 45% [where 65% increase is available]. Here the increase would be 22,2% and 15,4% of the respective available increase. This was needed to make a fair comparison between schools whose initial interest-levels differed.

| Our example: | Pre-test % | Actual % increase | % inc. of amount available |
|---|---|---|---|
| School 1 | 45 | 10 | 22.5 |
| School 2 | 65 | 10 | 15.4 |

### 3.11 **Reliability and validity of the research tools and data**:

The reliability of the questionnaire was determined in the pilot study. This was done by identifying and comparing each learners' pre- and post-test responses, which showed a high degree of correlation. Further reliability was gained in that the questions relating to cognitive learning all showed a similar pattern and those that related to the feelings of the learners showed a similar correlation (Cohen, 2007).

The questionnaires were taken seriously by most learners. Less than 20 of the 220 learners left out some questions or did not hand in one of their questionnaires. Less than 10 of the 220 learners filled out all, or almost all, of their answers in only one column. Those that put their responses in only the first column were similar in number to those whose answers were

only in the last column. All learners' responses were used in the data processing despite the possibility that some of the questionnaires mentioned may have not been properly answered. This small number of potentially spoiled questionnaires gave a high degree of validity to the results.

Analysis of the results was done using the T-test and the non-parametric Wilcoxon test. This was done because the number of questions asked was only 9 and the T-test requires more questions to be regarded as valid. Fortunately, the results of the two tests were very similar, giving a great degree of reliability to the use of the tests and validity to their results. All instruments of this research can therefore be regarded as reliable.

## 3.12 **Chapter summary**:

In this chapter, we looked at the details outlining my research intervention which included the selection of research tools, schools, the poem, video and discussion questions used as well as the actual process for the intervention and the processing of results.

In the following chapter, the data from the research will be presented with all their details and discussion.

*The full meal and dessert now consumed, the guests settle back to allow the meal to settle and to feel the glow of comfort both physically and spiritually.*

# Chapter 4: Presentation and discussion of data: *Hiatus*

*The diners sit back and analyse how the ideas have worked.*

*First, the big picture.*

## 4.1 Statistical significance of results

Whole sample results:

Table 1: Summary of results for the entire sample of 222 learners from all four schools, 122 boys and 100 girls

| | Wilcoxon test | | T test | |
|---|---|---|---|---|
| | Test statistic | P value | Test statistic | P value |
| Entire sample | 56 | 0.0078 | 2.98 | 0.0088 |
| Boys | 54 | 0.004 | 3.20 | 0.0084 |
| Girls | 58 | 0.0142 | 2.73 | 0.0148 |

- All p values < 0.05, [ < 5%] thus the intervention has a significant effect on the entire sample.

Both the Wilcoxon and T test results show, with p values indicating less than one percent correlation for the whole sample; that there is less than 1% chance that the intervention did not cause a significant improvement in learner interest. The same is true for the boys overall. This shows a rejection of the null hypothesis to a 1% level, more significant that the 5% value recommended by the data analyst.

The girls show a statistical correlation of less than 1.5%, slightly less significant than the overall results and those of the boys, but still considerably under the 5% threshold, thus rejecting the null hypothesis for the girls.

The null hypothesis is thus rejected for the sample overall, for the boys and for the girls.

## 4.2 Preliminary answer to research questions:

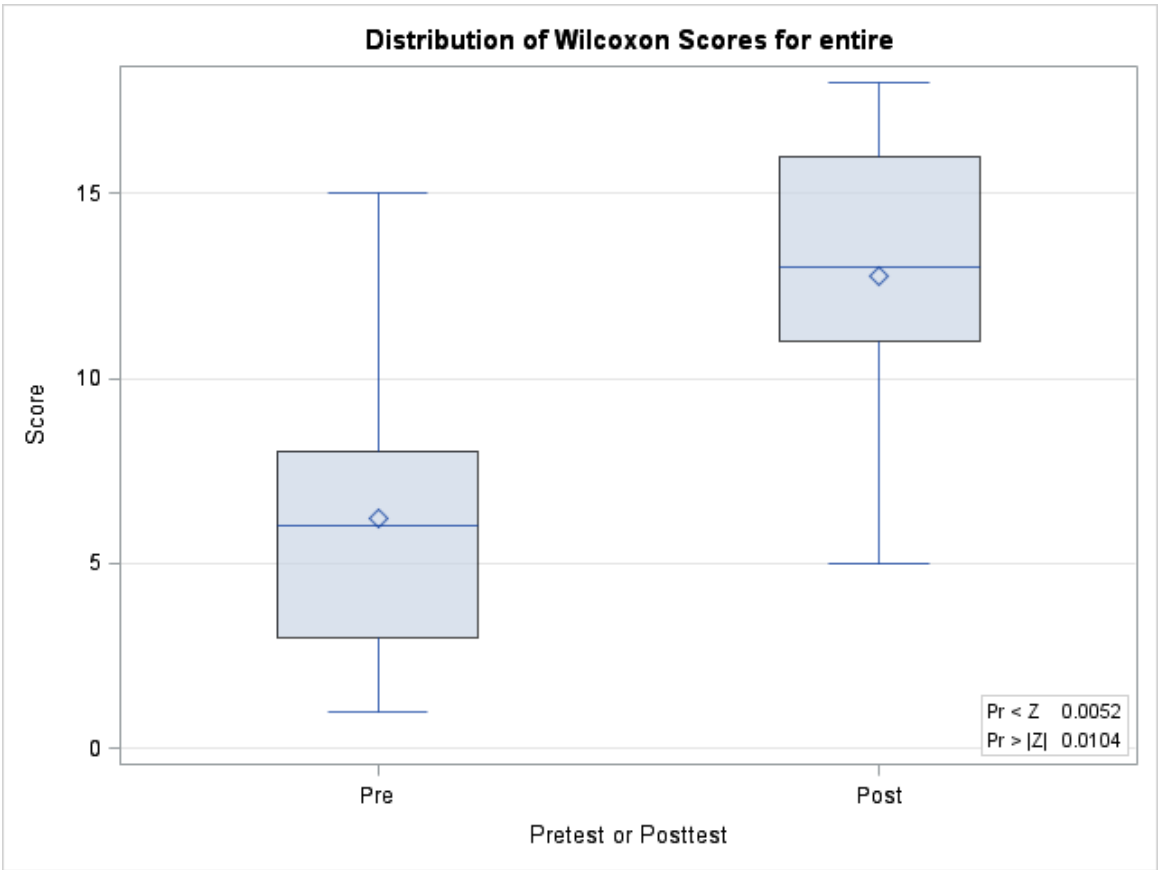
We can answer the primary question for my research, “To what degree can learner interest in Grade 9 Chemistry be engaged by holistic, artistic devices?” with “Holistic, artistic devices caused a statistically significant increase in learner interest levels to a very high degree”.

To answer, “How effective are each of the used holistic devices at engaging learner interest?” and “How will the holistic devices influence learners’ cognitive and effective domains as well as their perception of how relevant Chemistry is for their lives?”, the detailed results of each sex and school will be looked at in reference to the learners’ home language and their initial interest levels.

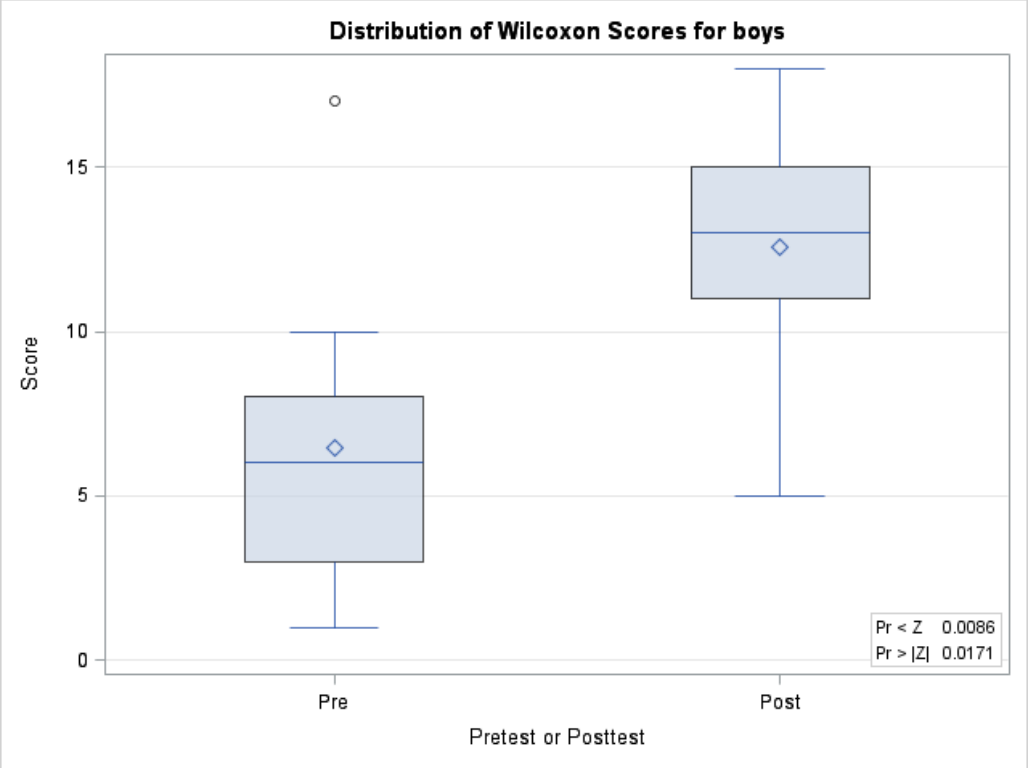
## 4.3 **Graphic representation of overall results**:

The following box and whisker plots have been generated to show the spread of pre- and post-test results for the whole sample as well as for all the boys and girls. The box represents the middle 50% of data with the middle line showing the central median. The lines, or whiskers, indicate the top and bottom 25% of scores. The lack of overlap of the boxes shows the extraordinary degree to which the pre- and post-test responses differ.

Graph 1: The distribution of the Wilcoxon scores for the whole sample of 222 learners.



Graph 2: Distribution of the Wilcoxon scores for the whole sample of 122 Boys.




Graph 3: Distribution of the Wilcoxon scores for the whole sample of 100 girls.

## 4.4 **Statistical significance of the results from the four schools**:

In this section only the main results will be given. The box and whisker plots for each school are in addenda E to I at the end of each school's data analysis. It is important to recognise that the significance of the results depended largely on the sample size in each school, with the larger the sample allowing more easily for a greater statistical significance.

Taking a significance level of 5% [p < 0,05].

Table 2: School 1: A government school with a focus on the arts

| | Wilcoxon test | | T test | |
|---|---|---|---|---|
| | Test statistic | P value | Test statistic | P value |
| Entire sample | 52 | 0.0019 | 3.95 | 0.0011 |
| Female | 51 | 0.0012 | 3.97 | 0.0011 |
| Male | 51 | 0.0012 | 3.8 | 0.0016 |

- All p values < 0.05, [< 5%]
- The intervention has a significant effect on school 1.

Table 3: School 2: A private school with a focus on the arts

| | Wilcoxon test | | T test | |
|---|---|---|---|---|
| | Test statistic | P value | Test statistic | P value |
| Entire sample | 75.5 | 0.3994 | 1.25 | 0.2283 |
| Female | 82 | 0.7686 | 0.93 | 0.368 |
| Male | 76 | 0.4191 | 1.01 | 0.3298 |

- All P values are above 0,20 [ > 20%]
- There is no significant effect from the intervention.

Table 4: School 3: A government school with no particular focus on arts, sports, academic or practical.

| | Wilcoxon test | | T test | |
|---|---|---|---|---|
| | Test statistic | P value | Test statistic | P value |
| Entire sample | 62 | 0.0382 | 2.65 | 0.0174 |
| Female | 64 | 0.0588 | 1.96 | 0.0681 |
| Male | 62 | 0.0376 | 2.78 | 0.0135 |

- P < 0,05 for the whole sample and for the boys; P < 0,10 [<10%] for girls.
- There is a significant effect of the intervention for the entire sample and for the boys – but no significant effect for the girls.

Table 5: School 4: A government school with a practical, and science, focus.

| | Wilcoxon test | | T test | |
|---|---|---|---|---|
| | Test statistic | P value | Test statistic | P value |
| Entire sample | 65 | 0.0770 | 2.03 | 0.0595 |
| Female | 69 | 0.1615 | 1.74 | 0.1132 |
| Male | 63 | 0.0503 | 2.10 | 0.0592 |

- No significant effect after interventions – no p values are smaller than 0.05.

Table 6: The statistical significance can be summarised as follows

| | Whole school | Boys | Girls |
|---|---|---|---|
| Overall | Yes | Yes | Yes |
| School 1 | Yes | Yes | Yes |
| School 2 | No | No | No |
| School 3 | Yes | Yes | No; Yes to 10% |
| School 4 | No; Yes to 10% | No; Yes to 10% | No |

Reassuringly, the T test and Wilcoxon test results agree on the significance or non-significance of results in each instance. The results show that the intervention was

- highly significant for all learners in the government school with an arts focus
- totally insignificant for all learners in the private school with an arts focus
- generally significant for learners in a non-focus government school
- not significant to a 5% level for all learners but significant to a 10% level for the overall learners and the boys at the practical focus school.
- marginally more significant for boys than girls in every school except school 1.

## 4.5 **Detailed breakdown of results for each participating school**:

### 4.5.1 **School 1**: A government school with an arts-focus

The following table shows the summary of the pre-test and post-test results for each of the four classes in which the research was conducted in school 1.

Total sample size of 84 with 26 boys and 58 girls.
Home language: 23% English, 70% English and other; 7% other language.

Table 7: Boys results

| School 1: Boys | Class 1 | | | Class 2 | | | Class 3 | | | Class 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Question | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference |
| **1** | 3,71 | 4,14 | **0,43** | 3,75 | 3,75 | **0,00** | 2,90 | 3,60 | **0,70** | 3,60 | 4,00 | **0,40** |
| **2** | 3,29 | 3,71 | **0,43** | 2,75 | 4,00 | **1,25** | 2,40 | 3,90 | **1,50** | 3,00 | 4,00 | **1,00** |
| **3** | 2,43 | 4,14 | **1,71** | 2,75 | 4,00 | **1,25** | 2,22 | 3,50 | **1,28** | 2,40 | 3,40 | **1,00** |
| **4** | 3,71 | 4,14 | **0,43** | 2,25 | 3,75 | **1,50** | 3,00 | 3,60 | **0,60** | 3,40 | 4,20 | **0,80** |
| **5** | 3,86 | 4,14 | **0,29** | 3,50 | 3,75 | **0,25** | 3,20 | 3,60 | **0,40** | 4,00 | 3,80 | **-0,20** |
| **6** | 3,71 | 4,29 | **0,57** | 2,75 | 3,50 | **0,75** | 3,60 | 3,70 | **0,10** | 4,00 | 4,00 | **0,00** |
| **7** | 3,43 | 4,00 | **0,57** | 2,00 | 2,75 | **0,75** | 2,40 | 2,73 | **0,33** | 3,40 | 3,40 | **0,00** |
| **8** | 3,43 | 4,00 | **0,57** | 2,50 | 3,50 | **1,00** | 3,10 | 3,30 | **0,20** | 3,80 | 4,00 | **0,20** |
| **9** | 3,57 | 3,14 | **-0,43** | 2,50 | 3,25 | **0,75** | 2,50 | 3,22 | **0,72** | 3,00 | 4,00 | **1,00** |
| | | | | | | | | | | | | |
| **Average** | 3,46 | 3,97 | **0,51** | 2,75 | 3,58 | **0,83** | 2,81 | 3,46 | **0,65** | 3,40 | 3,87 | **0,47** |
| **% average** | 61,51 | 74,21 | **12,70** | 43,75 | 64,58 | **20,83** | 45,34 | 61,53 | **16,19** | 60,00 | 71,67 | **11,67** |

Table 8: Girls results:

| School 1: Girls | Class 1 | | | Class 2 | | | Class 3 | | | Class 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Question | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference |
| **1** | 3,29 | 3,86 | **0,57** | 3,77 | 4,08 | **0,31** | 3,40 | 4,07 | **0,67** | 3,38 | 4,19 | **0,81** |
| **2** | 2,64 | 3,79 | **1,14** | 2,62 | 4,15 | **1,54** | 2,13 | 3,53 | **1,40** | 2,63 | 3,63 | **1,00** |
| **3** | 2,57 | 4,07 | **1,50** | 3,31 | 4,54 | **1,23** | 2,20 | 4,20 | **2,00** | 2,79 | 3,94 | **1,15** |
| **4** | 2,86 | 3,57 | **0,71** | 4,00 | 4,00 | **0,00** | 3,46 | 4,14 | **0,68** | 3,20 | 4,06 | **0,86** |
| **5** | 3,00 | 3,50 | **0,50** | 4,46 | 4,23 | **-0,23** | 3,80 | 4,27 | **0,47** | 3,50 | 3,53 | **0,03** |
| **6** | 3,93 | 3,86 | **-0,07** | 3,69 | 4,08 | **0,38** | 3,73 | 3,93 | **0,20** | 3,06 | 3,93 | **0,87** |
| **7** | 2,29 | 2,71 | **0,43** | 3,31 | 3,31 | **0,00** | 2,67 | 3,27 | **0,60** | 2,75 | 3,13 | **0,38** |
| **8** | 2,93 | 3,43 | **0,50** | 3,31 | 3,86 | **0,55** | 3,40 | 3,87 | **0,47** | 3,00 | 3,94 | **0,94** |
| **9** | 2,64 | 3,14 | **0,50** | 3,46 | 3,85 | **0,38** | 3,00 | 3,93 | **0,93** | 2,94 | 3,50 | **0,56** |
| | | | | | | | | | | | | |
| **Average** | 2,90 | 3,55 | **0,64** | 3,55 | 4,01 | **0,46** | 3,09 | 3,91 | **0,82** | 3,03 | 3,76 | **0,73** |
| **% average** | 47,62 | 63,69 | **16,07** | 63,68 | 75,24 | **11,57** | 52,21 | 72,80 | **20,60** | 50,66 | 69,00 | **18,34** |

Comparing the data of the 4 classes in school 1.

- The initial interest levels, as determined by the pre-tests, vary between 43,75% and 61,51% for the boys and 47,62% and 63,68% for the girls in different classes.
- The differences in initial interest levels differ between the boys and girls in each class with the smallest difference of 6,87% in class 3 and the biggest difference of 19,93% in class 2.
- In two of the classes the boys have the greater initial interest and in the other two classes the girls have the greater initial interest.
- With the exception of class 3, the sex group with the lower initial interest level in the class, showed the greatest increase in interest after the intervention lesson.
- Two class sex groups, class 2 girls and class 4 boys, showed the lowest increase in interest of just over 11,5 %. Two class sex groups, class 2 boys and class 3 girls, showed the greatest increase of interest of just over 20,5 %.

Table 9: School 1 overall results

| | School 1: Average increase | | |
|---|---|---|---|
| Question | **Boys** | **Girls** | **Average** |
| **1** | 0,38 | 0,59 | 0,49 |
| **2** | 1,04 | 1,27 | 1,16 |
| **3** | 1,31 | 1,47 | 1,39 |
| **4** | 0,83 | 0,56 | 0,70 |
| **5** | 0,18 | 0,19 | 0,19 |
| **6** | 0,36 | 0,35 | 0,35 |
| **7** | 0,41 | 0,35 | 0,38 |
| **8** | 0,49 | 0,61 | 0,55 |
| **9** | 0,51 | 0,59 | 0,55 |
| | | | |
| **Ave inc.** | 0,61 | 0,67 | 0,64 |
| **% inc.** | 15,35 | 16,64 | 16,00 |

Despite the enormous variation between the boys and girls in each class, the overall differences between the responses of the boys and the girls is negligible, with the girls showing a slightly greater increase in interest than the boys.

The questions that show the greatest increase in interest overall, questions 2 and 3, as well as the question which shows the least increase in interest, question 5, are the same for each sex group.

School 1 shows a highly significant increase in interest levels overall.

### 4.5.2 **School 2**: A small private school with a focus on the arts.

The table that follows includes the average results for the pre-tests, post-tests and overall for the single class that experienced the intervention.

Total sample size of 20 with 13 boys and 7 girls.
Home language: 16% English, 84% English and other, 0% other language

Table 10: School 2 overall results

| School 2 | Boys | | | Girls | | | Whole school | | |
|---|---|---|---|---|---|---|---|---|---|
| Question | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference |
| **1** | 3,00 | 4,00 | **1,00** | 3,00 | 3,57 | **0,57** | 3,00 | 3,85 | **0,85** |
| **2** | 2,69 | 3,62 | **0,92** | 2,29 | 3,71 | **1,43** | 2,55 | 3,65 | **1,10** |
| **3** | 3,00 | 3,85 | **0,85** | 3,43 | 4,00 | **0,57** | 3,15 | 3,90 | **0,75** |
| **4** | 3,38 | 3,23 | **-0,15** | 3,57 | 3,57 | **0,00** | 3,45 | 3,35 | **-0,10** |
| **5** | 3,77 | 3,31 | **-0,46** | 3,71 | 3,71 | **0,00** | 3,75 | 3,45 | **-0,30** |
| **6** | 3,46 | 3,17 | **-0,29** | 4,14 | 4,57 | **0,43** | 3,70 | 3,66 | **-0,04** |
| **7** | 2,62 | 2,62 | **0,00** | 4,14 | 3,71 | **-0,43** | 3,15 | 3,00 | **-0,15** |
| **8** | 3,31 | 3,38 | **0,08** | 4,17 | 3,43 | **-0,74** | 3,61 | 3,40 | **-0,21** |
| **9** | 3,23 | 3,00 | **-0,23** | 3,86 | 4,00 | **0,14** | 3,45 | 3,35 | **-0,10** |
| | | | | | | | | | |
| **Average** | 3,16 | 3,35 | **0,19** | 3,59 | 3,81 | **0,22** | 3,31 | 3,51 | **0,20** |
| **Average %** | 54,06 | 58,80 | **4,74** | 64,75 | 70,24 | **5,49** | 57,80 | 62,80 | **5,00** |

There is a lot of variation between the boys and girls, much as we saw from each individual class in school 1. With the overall average increase however, the difference between the boys and girls becomes negligible, and is very close to the class average difference of 5% increase in interest overall.

As with school 1, questions 2 and 3 are among the questions with the greatest increase in interest and question 5 has the lowest increase of interest; in this case it has the greatest decrease in interest. Because school 2 had such a big increase in their responses to question 1 it is possible that this class had not covered the required work in acids and bases to be ready for this intervention.

The last six questions all suffered a decrease in interest. This indicates that the intervention made the learners less interested in science on two levels, in their feelings towards Science and their sense that Chemistry can teach them about themselves. The intervention did not create a significant change in their interest levels. It would be speculation at this stage as to why this lack of change occurred. If their previous exposure to Science, and their

expectations of what Science is, clashed with what they were exposed to in this intervention, this would explain the drop in this type of interest.

The first three questions did experience an increase in interest because of the gaining in perceived confidence in understanding the content covered. This indicates a good engagement with the lesson content. The increase from these three questions was enough to give the group an overall increase in interest. This indicates that the holistic devices gave rise to a positive increase in the learners perceived grasp of the content but that this did not lead to a positive impact on their feelings towards Science or towards their feelings of the relevance of Science to helping them understand their lives.

Further investigation would be needed to understand the results from this school. A larger sample size would be needed to obtain better results. I did not gain clearance to interview the learners or teacher further and so this could be a focus for a further study.

### 4.5.3 **School 3**: A Government school with no specific area of focus.

The table that follows includes the average results for the pre-tests, post-tests and overall for the single group that experienced the intervention. It is important to remember that this group was not one where the learners were used to being together as a class. They had been forced together by virtue of circumstances where they had not been allowed to attend a school outing.

Total sample size of 33 with 23 boys and 10 girls.
Home language: 4% English, 81% English and other, 15% other language.

Table 11: School 3 overall results.

| School 3 | Boys | | | Girls | | | Whole school | | |
|---|---|---|---|---|---|---|---|---|---|
| Question | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference |
| **1** | 3,46 | 4,04 | **0,58** | 3,27 | 3,80 | **0,53** | 3,40 | 3,97 | **0,57** |
| **2** | 2,13 | 3,43 | **1,30** | 2,00 | 2,90 | **0,90** | 2,09 | 3,27 | **1,18** |
| **3** | 2,33 | 3,58 | **1,25** | 1,91 | 3,20 | **1,29** | 2,20 | 3,47 | **1,26** |
| **4** | 2,68 | 3,59 | **0,91** | 2,92 | 2,60 | **-0,32** | 2,75 | 3,29 | **0,54** |
| **5** | 3,56 | 3,48 | **-0,08** | 3,09 | 3,30 | **0,21** | 3,42 | 3,42 | **0,01** |
| **6** | 3,48 | 3,48 | **0,00** | 3,09 | 3,30 | **0,21** | 3,36 | 3,42 | **0,06** |
| **7** | 2,52 | 2,73 | **0,21** | 2,36 | 2,50 | **0,14** | 2,47 | 2,66 | **0,19** |
| **8** | 2,80 | 3,17 | **0,37** | 3,00 | 3,33 | **0,33** | 2,86 | 3,22 | **0,36** |
| **9** | 2,56 | 3,35 | **0,79** | 2,73 | 3,20 | **0,47** | 2,61 | 3,30 | **0,69** |
| | | | | | | | | | |
| **Average** | 2,84 | 3,43 | **0,59** | 2,71 | 3,13 | **0,42** | 2,80 | 3,34 | **0,54** |
| **Average %** | 45,90 | 60,72 | **14,81** | 42,70 | 53,15 | **10,45** | 44,93 | 58,42 | **13,49** |

Here the initial interest levels of the boys and the girls were similar, and very low, below 46% for both. The girls' initial interest levels were the lowest of any class or sex group in my research, at under 43%. These initial low interest levels were indicative of the context on the day and the way in which this group was formed. Even with these low initial interest levels, the increase in interest levels were fairly significant, showing that learners with an underdeveloped interest in Science will experience an increased interest with holistic devices.

The post-intervention results for the girls is also the lowest set of post-test results of any group in this research, at just over 53%, and this was after an increase of interest of over 10%. Only the boys of school 2 also had post-test results of under 60%, at 58,8%.

The learners in school 3 showed their greatest increase of interest in questions 2 and 3, and least increase, in question 5.

The boys in this school showed the greatest increase in their response to question 9, the question which indicates whether they feel that Science can teach them about themselves. They showed an increase of exactly 20% in this question. It was the question which showed the forth greatest increase after content related questions.

The girls and boys showed a great difference in their changed responses to question 4, the question asking them if they enjoy learning about acids, bases and salts. The boys showed a great increase and the girls showed a very strong decrease. More investigation would be needed to find the cause for this. My speculation is that this is due to the class discussion being generated a lot by the boys with some degree of silliness. This resulted in me needing to occasionally discipline the group as mentioned in the data collection process. Perhaps the whole discussion process served as enlightening for the boys and the opposite for the girls.

### 4.5.4 **School 4:** The Government school with a focus on the practical and with Science and technology

The following table shows the summary of the pre-test and post-test results for each of the three classes in which the research was conducted in school 4. This is the school where the learners had experienced a school drug search at the start of the day. Class 1 arrived straight after the drug search for the intervention. The lessons were also shortened so that class 1 had not even finished the video when the bell for the end of the lesson went, forcing a very rushed and premature completing of the post-test. In the next classes, some very brief class discussion was possible but the whole process was rushed.

Total sample size of 85, with 60 boys and 25 girls.

Home language: 4% English, 75% English and other, 21% other language.

Table 12: School 4: Boys results

| School 4: Boys | Class 1 | | | Class 2 | | | Class 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Question | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference |
| **1** | 3,26 | 4,22 | **0,96** | 3,93 | 4,13 | **0,20** | 4,08 | 4,38 | **0,31** |
| **2** | 2,53 | 4,00 | **1,47** | 2,87 | 3,60 | **0,73** | 3,19 | 4,04 | **0,85** |
| **3** | 2,84 | 3,61 | **0,77** | 2,79 | 3,60 | **0,81** | 3,19 | 4,08 | **0,88** |
| **4** | 3,84 | 4,28 | **0,44** | 3,93 | 4,27 | **0,33** | 4,19 | 4,31 | **0,12** |
| **5** | 4,47 | 4,44 | **-0,03** | 4,53 | 4,33 | **-0,20** | 4,62 | 4,50 | **-0,12** |
| **6** | 3,74 | 4,00 | **0,26** | 4,13 | 4,33 | **0,20** | 4,08 | 4,31 | **0,23** |
| **7** | 3,26 | 3,67 | **0,40** | 3,53 | 3,67 | **0,13** | 3,62 | 4,00 | **0,38** |
| **8** | 3,95 | 4,22 | **0,27** | 3,93 | 4,07 | **0,13** | 3,88 | 4,15 | **0,27** |
| **9** | 3,75 | 4,33 | **0,58** | 3,64 | 3,93 | **0,29** | 3,54 | 3,85 | **0,31** |
| | | | | | | | | | |
| **Average** | 3,52 | 4,09 | **0,57** | 3,70 | 3,99 | **0,29** | 3,82 | 4,18 | **0,36** |
| **% average** | 62,90 | 77,16 | **14,26** | 67,49 | 74,80 | **7,31** | 70,51 | 79,49 | **8,97** |

Table 13: School 4: Girls results

| School 4: Girls | Class 1 | | | Class 2 | | | Class 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Question | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference |
| **1** | 3,00 | 3,86 | **0,86** | 3,40 | 4,30 | **0,90** | 4,14 | 4,17 | **0,02** |
| **2** | 2,00 | 3,75 | **1,75** | 2,70 | 3,50 | **0,80** | 3,14 | 4,67 | **1,52** |
| **3** | 2,00 | 3,38 | **1,38** | 2,20 | 3,00 | **0,80** | 2,57 | 4,67 | **2,10** |
| **4** | 4,43 | 4,13 | **-0,30** | 4,20 | 4,20 | **0,00** | 3,86 | 5,00 | **1,14** |
| **5** | 4,13 | 4,13 | **0,00** | 4,78 | 4,40 | **-0,38** | 4,14 | 4,67 | **0,52** |
| **6** | 4,50 | 4,38 | **-0,13** | 3,90 | 3,90 | **0,00** | 4,57 | 4,83 | **0,26** |
| **7** | 4,13 | 3,88 | **-0,25** | 3,30 | 4,00 | **0,70** | 4,14 | 4,33 | **0,19** |
| **8** | 4,38 | 4,00 | **-0,38** | 3,70 | 4,30 | **0,60** | 4,57 | 4,67 | **0,10** |
| **9** | 4,63 | 4,25 | **-0,38** | 3,20 | 3,80 | **0,60** | 4,29 | 4,50 | **0,21** |
| | | | | | | | | | |
| **Average** | 3,69 | 3,97 | **0,28** | 3,49 | 3,93 | **0,45** | 3,94 | 4,61 | **0,67** |
| **% average** | 67,16 | 74,26 | **7,09** | 62,16 | 73,33 | **11,17** | 73,41 | 90,28 | **16,87** |

Comparing the data of the three classes of school 4.

- The initial interest levels, as determined by the pre-tests, vary between 62,90% and 70,51% for the boys and 62,16% and 73,41% for the girls. These initial interest levels were the highest of all the schools in my research.
- The differences in initial interest levels between the boys and girls in each class had the smallest difference of 2,90% in class 3 and the biggest difference of 5,33% in class 2.
- In one of the classes the boys had the greater initial interest and in the other two classes the girls had the greater initial interest.
- The sex with the lower initial interest level in the class, showed the greatest increase in interest after the intervention lesson except for class 3, which showed the greatest increase of interest of any other class sex group, despite having the highest initial interest of any sex group in my whole study.
- Two class sex groups showed the lowest increase in interest of just over 7%, class 1 girls and class 2 boys. Two class sex groups showed the greatest increase of interest of over 14%, class 1 boys and almost 17%, class 3 girls.
- Class 1 girls showed a similar set of results to the class from school 2, the private school with a focus on the arts, while the boys of the same class showed results similar to those of school 1, a government school with a focus on the arts. School 1 and school 2 had the greatest difference in their change of interest of the four schools researched.

Table 14: School 4 overall results

| | School 4: Average increase | | |
|---|---|---|---|
| Question | **Boys** | **Girls** | **Average** |
| **1** | 0,49 | 0,59 | **0,54** |
| **2** | 1,02 | 1,36 | **1,19** |
| **3** | 0,82 | 1,42 | **1,12** |
| **4** | 0,29 | 0,28 | **0,29** |
| **5** | -0,11 | 0,05 | **-0,03** |
| **6** | 0,23 | 0,05 | **0,14** |
| **7** | 0,31 | 0,21 | **0,26** |
| **8** | 0,23 | 0,11 | **0,17** |
| **9** | 0,39 | 0,15 | **0,27** |
| | | | |
| **Ave** | 0,41 | 0,47 | **0,44** |
| **% Ave** | 10,18 | 11,71 | **10,95** |

The differences between the results of the girls and the boys is negligible, with the girls having a slightly greater increase in interest than the boys. The fewer number of girls led to lower statistical significance in the t-test despite them having a greater increase in interest level. The questions with the greatest increase due to the intervention are questions 2 and 3, and the question that showed a decrease in interest in the boys and overall, with the smallest increase in interest in the girls, is question 5.

This school had the highest levels of initial interest with all sex groups having an initial interest level of over 60% and with two groups of over 70%. Even these class sex groups who had the highest initial interest levels in Science still showed a significant increase in interest. This shows that holistic devices improve interest levels of learners with an already developed interest in Science.

## 4.6 **Further breakdown of schools and questions results**:

Addenda E to I show the tables of the collation of responses per learner, school, question and sex, as well as the initial calculations and results.

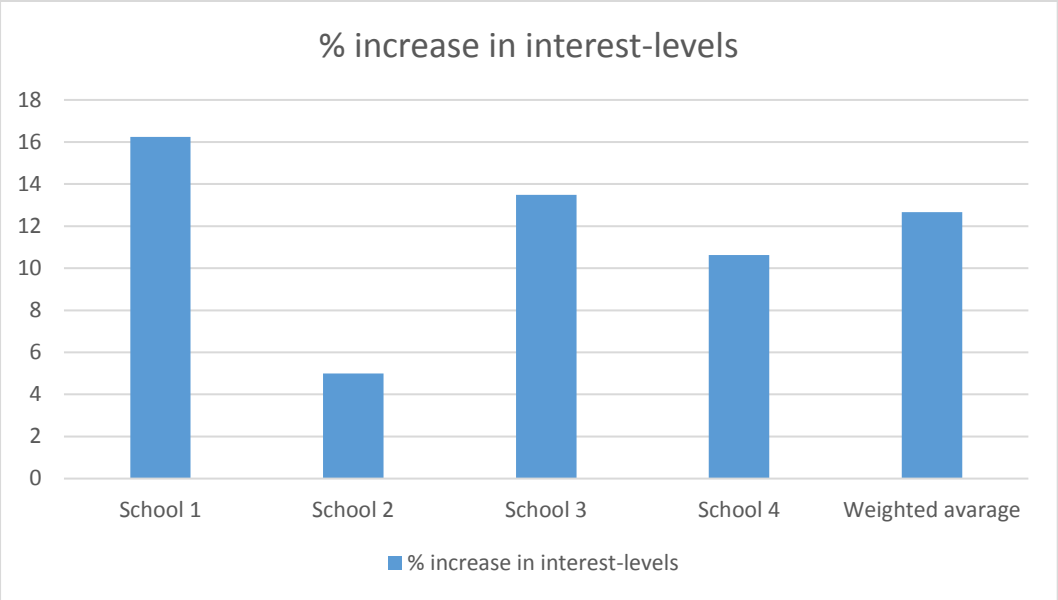
### 4.6.1 **Initial interest levels**:

The initial interest levels were the highest in school 4 at 67.15 %, the school with a more practical-focus, and the lowest in school 3 at 44.93%, the school with no special focus but where the learners present were the ones who were not given permission to go on the Grade outing. School 1, the school with an arts-focus, had an initial interest level of 53.27% and the private school with an arts-focus had an initial interest level of 57.80%.

### 4.6.2 **Change in interest levels**:

The school with the greatest increase in interest levels was school 1 with an increase of 16.24% and the school with the smallest increase was school 2 with an increase of exactly 5%. School 3 had an increase of 13.49% and school 4 had an increase of 10.63%. The overall weighted increase in interest levels is 12.67%.

Graph 4: The percentage increase in interest levels per school.



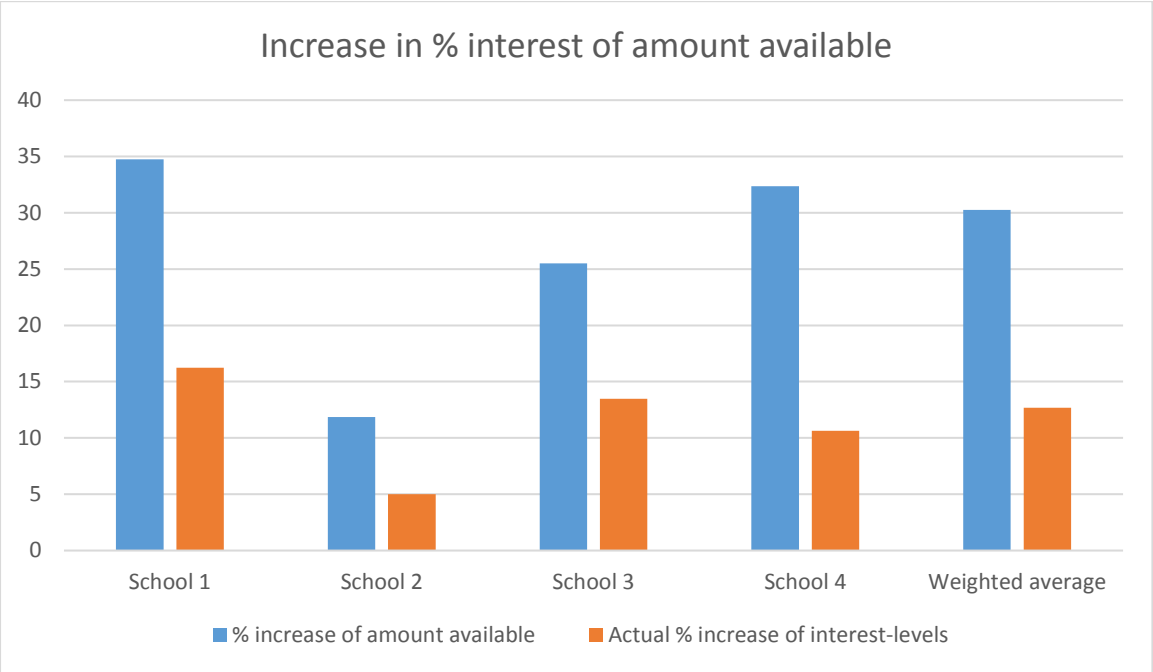

### 4.6.3 **Change in interest levels as a percentage of the amount available**:

This value tells a different story to the change in interest level as it shows how much of the increase is relative to the possible amount that it can increase. Here school 1 and 4 had increases of over 30% of the available increase, with school 1 at 34.75% and school 4 at 32.36%. This is an important observation as school 4 did not show a statistically significant increase in interest using the t-test or the Wilcoxon test. Its increase of amount of increase available is however very comparable with that of school 1, which showed a highly statistically significant increase of interest. This is because school 4 learners had begun the lesson with a very high level of interest in Science.

School 2 had the lowest relative increase at 11.85% and school 3 had a 24.5% increase. The overall, average increase of the amount available, weighted for the number of learners in each school, is 30.25%, almost one third of the possible increase in interest.

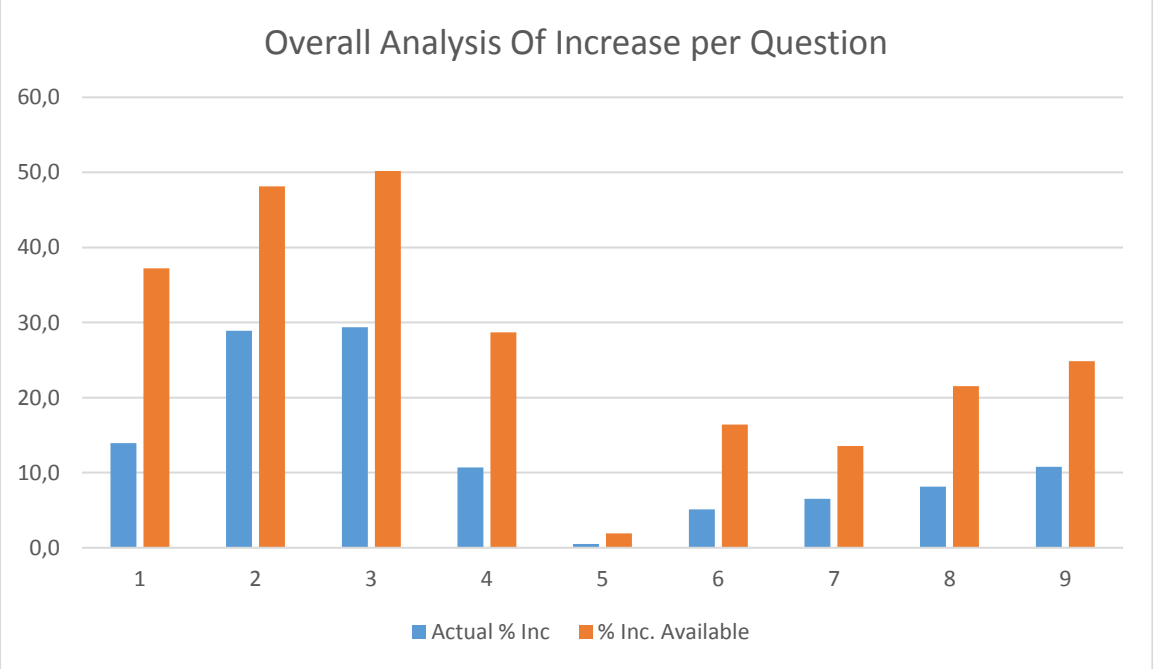
In the graph below, school 4 blue column can be seen to increase greatly from the brown because of their very high initial interest levels.

Graph 5: The percentage increase in interest levels of the amount of increase available.




### 4.6.4 **Analysis per question**:

Graph 6: Analysis of each question, comparing the actual increase to the increase of the amount available. [See Addendum I for full numerical details.]



The graph above shows the breakdown of the increase in the value of the learners' responses per question. The discussion that follows uses the percentage increase of the amount available. This is due to the enormous variation in the pre-test values between schools.

Questions 2 and 3 show the most marked increase. These questions indicate the learner perceived knowledge on the topic. The classes had all already learned the textbook work but the use of metaphor within the poem and experiments gave them the confidence to say that they now understand the content almost 50% better. In school 2 the post-test responses to the first three questions were the only questions where they scored higher than in their pre-test.

Questions 4, 7 and 8 showed an increase of between 13% to 28%. The 28% increase was related to their enjoyment of learning the specific topic of acids, bases and salts, and the transference of this enjoyment onto the larger section of Chemistry resulted in improvement of only 13% and 21%. This improvement in their emotional relationship to the work is most encouraging.

Question 5 was the question which yielded the lowest increase from the pre-test to the post-test. What is interesting to note is that question 5 gave the highest percentage of all the pre-test questions, of just over 73%. The post-test result of just over 74% was now the question with just the second highest percentage interest shown; second only to question 1 [see addendum I for full details]. This lack of raised interest in wanting to know more about the topic could be due to a satisfaction with how much they have already learned. That their interest was so high from the start shows that their usual manner of teaching this section had kept their love of learning alive.

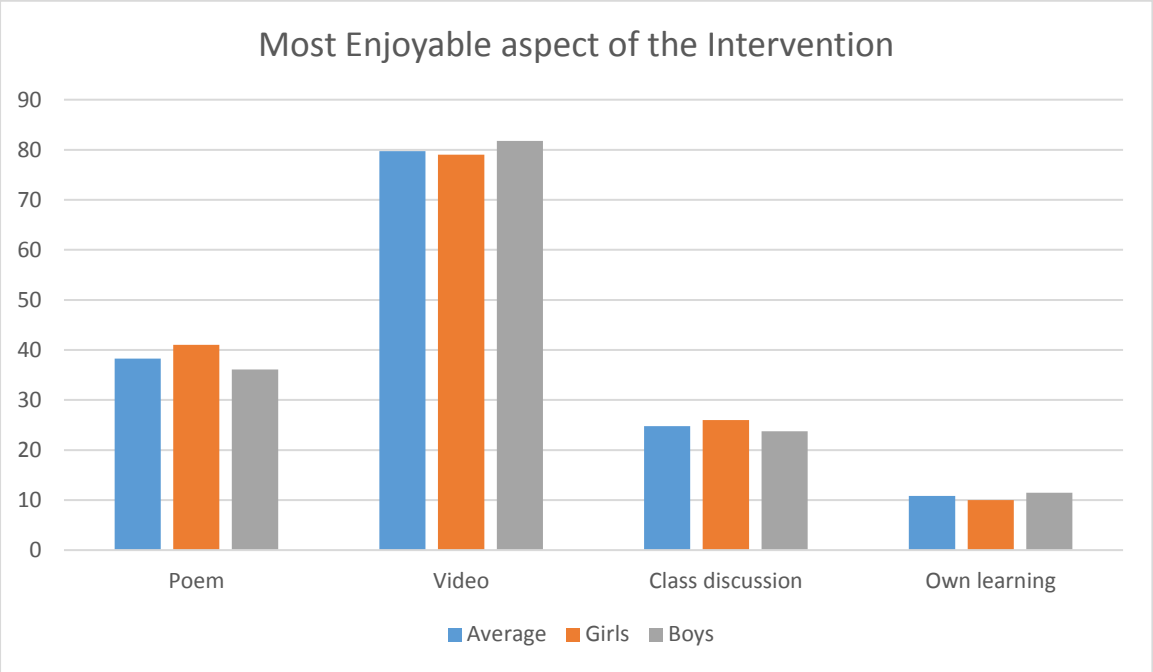
Question 6 addressed a higher level of interest, of personal interest and showed an increase of 16%. These learners expressed an increase in the degree to which they find Chemistry interesting as a result of their exposure to the topic covered.

Question 9 showed an increase of around 25%. This is significant as it is the indicator of whether the learners find that Chemistry can teach them about themselves. This personal relevance was one of the indicators that Goethe held to be significant in a person retaining sustained interest in something (Seamon, 1998), and which Hidi (2006) would describe and a factor that leads to higher levels of interest.

### 4.6.5 **Most significant stimuli for the learners**: Post-test question 10.

The learners could give more than one response here so the total was greater than 100%. The total of around 150% means that the average learner marked one and a half stimuli.

Graph 7: Most enjoyable aspect of the intervention overall, for the girls and for the boys.




Although all stimuli indicate the first stage of interest, namely *triggered situational interest* (Hidi, 2006), the "own learning" category was included to indicate towards the *personal interest* categories which lead to lifelong learning.

The differences between the boys and girls preferences are negligible. The strongest *trigger* of *situational interest* was clearly the video, which showed the experiments within the context of the poem, with almost 80% of the learners finding this as the most enjoyable stimulus. Just fewer than half this, just less than 40% of the learners, found the poem itself to have been a significant stimulus. Almost one quarter of the learners found the class discussions to be the most significant. This is significant, as the three classes of school 4 did not have time for the post-intervention discussions. Just over 10 percent of learners found their own learning to be the most significant stimulus. These learners are showing an inner activity in relation to the intervention that led them to inner experiences that superseded what occurred outwardly. Such learners may have had new rational or *nerve* learning or creative *blood* imaginations or revelations that resulted in their perceived significant learning. Due to the content of the intervention where both types of knowledge are addressed it would only be possible to know why these learners responded as they did with further research. If individual learners who responded to this question could be identified and interviewed or

given a further questionnaire, to the type of independently-obtained knowledge they gained could be known.

The average response from learners was that every second learner marked 2 stimuli as most interesting. This, in itself, justifies the use of multiple devices in engaging and improving learner interest.

## 4.7 **Teachers data**:

Although this is a sample size of four it is important in understanding the context for the different schools.

- All four schools had a female Natural Science teacher with an Afrikaans background.
- None of the teachers had already done any experiments on the topic with their classes.
- All had a minimum of 5 years' experience teaching Chemistry; three had 10 years or more.
- Three had a degree as their highest qualification and one had an honours degree.
- Three teachers found they related most to the poem and video; the fourth related most to the class discussion and their own learning.
- Among the teachers there was very little improvement in interest levels. The teacher from the private school had marked all her responses in column 5. The only area of improvement was with two teachers wanting to know more about Smut's principal of holism and wanting to know more about holistic education. One teacher had an improved perception that Chemistry could teach us about ourselves.

Two teachers mentioned to me in conversation a week after the intervention, that they kept referring to the poem and video observations to remind the learners of specific learning.

All 4 participating teachers expressed a sincere enjoyment and warm appreciation for exposure to the research. What seems clear from these teachers' responses is that the use of holistic devices will not be possible for teachers who are not trained and committed to their use. As Science teachers are not accustomed to this, nor have they chosen this for their job, much work will need to be done to implement the use of such devices in Science education.

## 4.8 **Research findings on influences surrounding the intervention**:

Although the analysis of the data clearly shows that the use of holistic stimuli improves learner interest in Grade 9 Chemistry, there is now more detail that can be added to give a greater context to this finding.

### 4.8.1 **The background preparation and initial interest levels of the learners**:

The three government schools were following the CAPS syllabus but the private school, school 2 was not. In conversation with their teacher it became clear that the teacher did not follow the CAPS syllabus and had brought the learners to the point of intervention with a different background of knowledge and experiences. It is hard to determine the extent to which this impacted the results, as the teacher and I had consulted as to the best time to do the research, and the intervention was done on the day that she had deemed best, with enough time for the full intervention.

The overall increase in learners' confidence of knowledge and belief in the ability of Science to inform them about themselves tells us that a holistic approach to teaching Science is clearly beneficial for learner interest on more than just the lowest level of *triggered situational interest* which enabled greater engagement during the lesson.

The schools had learners with a wide range of initial interest in Science. Although the increase in interest was often less for learners with an initial high level of interest, all learners interest levels increased. This implies that the use of holistic devices is effective for engaging learners who have not yet developed, or have already lost their interest in Science, as well those with a developed interest, and all those in-between.

### 4.8.2 **The influence of the conditions and timing of the intervention**:

What is important to recognise in this research is the timing of the intervention for the learners. As with all learning, it is important to bring the right material and experiences to the learners at the right time and in the right way. As hard as we tried to ensure that this was done, practical constraints meant that each school was a different experience, with some schools having the full intervention at exactly the right time as with school 1 and 2. School 4 on the other hand had the right timing for the intervention but, due to the police doing a search first thing in the morning, the lessons were shortened so the class discussion was hardly done or not done at all. The outing in school 3 meant that many of the learners who would have participated did not, the group that had the intervention was not a single class but the group of learners who were not allowed to go and who were not pleased about the idea of having a Science lesson while everyone else was having fun.

Although this would have impacted the results, the fact that school 1 and 2 had the best and the worst improvement in learner interest respectively, despite the best timing for both, shows that other factors must have been a greater influence.

The influence due to me having done the intervention seems to have had a negligible effect. The main place where the person implementing the research would have influenced interest levels would have been in the class discussion and the learners showed this as only the third most interesting factor, of the four options available. Further, school 4, where the discussions did not take place or took place very briefly and in a rushed manner, had the second highest improvement of available interest levels, of over 30%, while school 2, which had the full intervention with plenty of class discussion time, showed the lowest increase of available interest.

### 4.8.3 **The influence of gender and home-language on the data**:

In each class and in each school the overall interest levels of the learners increased, both for the boys and the girls. In schools 1, 2 and 4 the girls had a slightly greater increase in interest than the boys and in school 3 the boys had a slightly greater increase in interest. The greater statistical significance of the boys' results is due to the greater number of boys who took part in my research. Had there been more girls in my sample, their results would have been shown to be more statistically significant with the current percentage increases. We can conclude that the effect of the intervention on the different sexes is negligible.

The home language profiles of the learners in all the schools was similar with over 70% speaking English and another language. Schools 1 and 4 had the greatest difference in home language of their learners with school 1 having the most only-English speakers and school 4 having the most other-language speakers, and yet they both had the greatest improvement in the percentage increase of the available interest, of over 30% each [see 4.6.4]. If home language did influence the learners, this was not noticeable in the results.

The teachers all had Afrikaans as their home language. The intervention was done in English and was prepared by me, a native English speaker. This may have resulted in some of the improvement of interest. As all the sample schools used are English medium schools my assumption was that the teachers would be English, as a result I did not have any measures in place to determine the influence this difference could have.

### 4.8.4 **The influence of the school type**:

School 1 had an arts-focus and school 4 had a practical-focus with an emphasis on Science and Technology. These two schools had the greatest improvement in the percentage increase of the available interest. School 3, the only other government school in the

research, had a similar but slightly smaller improvement, although their results showed a greater statistical significance than school 4's.

It was the private school whose results were significantly different. From this study, it is not possible to tell which factor, or factors, may have created this difference. The private school was a semi-rural, non-CAPS compliant, small school with one class per grade and ended with Grade 9. The government schools were all urban, following CAPS, large schools with many classes per grade and all ended with Grade 12, the last year of formal schooling in South Africa. Further research would be needed to determine which factors created the lack of significant change of interest.

## 4.9 **Answering the research questions**:

The primary research question: "To what degree can learner interest in Grade 9 Chemistry be engaged by holistic, artistic devices?"

Answer: The use of artistic, holistic devices has shown to statistically significantly engage learner interest in Chemistry on multiple levels. Their improved interest ranged from the simplest level of helping the learners engage better with the content and with a more confident grasp of the content being covered, through improved feelings towards the subject to an improved sense that Chemistry can teach them more about themselves. This improvement took place whether the learners had an initial high or low level of interest in Science, or whether they were already in a school which focusses on the arts, the practical or neither, and was independent of their home language and sex.

The degree to which the devices successfully influenced learners in my research was limited to the large, urban government schools who were following the CAPS curriculum and who were at the right point in syllabus for the intervention. This was true irrespective of the circumstances surrounding the intervention, which varied greatly.

Research question 2: "How effective are each of the used holistic devices at engaging learner interest?

Answer: 80% of learners indicated that the video showing the experiments was the most effective device at engaging their interest, almost 40% indicated that the poem was the most effective and 25% marked the class discussion as the most effective. The visual stimulus was always expected to be the most significant. What is significant is to see how effective the poem was, as the inner activity required of a learner to process the story and images of the poem requires a more active engagement than simply witnessing visual or auditory events. By stimulating the learners appropriately both visually and auditorily and by giving them the poem to unite these stimuli into an imagination filled story, the harmony of the

combined stimuli must have helped in increasing the effectiveness of each device. The holistic combination of devices was therefore significant in engaging learner interest.

As the average learner indicated more than one device as their most interesting, and others not indicating any devices, it is hard to say how important it was that the specific combination of devices was used in improving learner interest. What is clear is that each device engaged certain learners interest and that combining them was a strong contributor to improved learner engagement and interest.

Research question 3: “How will the holistic devices influence learners’ cognitive and affective domains as well as their perception of how relevant Chemistry is for their lives?”

Answer: We know that a visual stimulus can give rise to an awakening in the auditory part of the brain and that an auditory stimulus awakening the visual part of the brain is even more likely (van den Hurk, 2017). In a like manner, the affective and cognitive domains affect each other. The cognitive domain was mostly engaged in my research so it was not surprising to see the greatest increase in interest and engagement here through the responses to questions 1, 2 and 3, which averaged around a 45% increase of the amount if increase available. The affective domain questions showed an average improvement of around 21% of available increase. The ratio of difference between the cognitive and affective domains is very similar to the ratio between the interest taken in the video and the poem. Although there is no way this research can show that these two ratios are connected, it is likely that a holistic connection exists between visual stimuli and our cognitive domain, and auditory stimuli and our affective domain (Hanser, 2013). If this is so, then visual stimuli could be more effective at influencing our cognitive domain and auditory stimuli may be more effective at stimulating our affective domain.

The learners’ responses to question 9 gave us the answer to whether holistic, artistic devices increased learner’s personal relationship to, and feeling of relevance of Science for their lives. Their responses to this question increased by almost 25% of the amount of increase available showing an increase of more than that shown in their affective domain. This is significant as this response must therefore be because of some level of integration between their affective and cognitive domains, one of the great intentions of my research.

*Intrigued by the enormous amount of information and variety of different conclusions, the guests urge our host to condense the findings and explain how they are related to the hors d’oeuvres, main meal and dessert.*

# Chapter 5: Significance and implications of this study:

## Port is served

*The full-bodied port is served as the guests move to the lounge, mingle and converse on the evenings experience. An extraordinary mix of feelings begin to filter through the group as they internalise their impressions from the evening. As they talk freely, the multitude of events and experiences now begin to reveal the bigger picture.*

### 5.1 **A personal moment**:

I love Science. I love its relentless, disciplined challenging of reality to reveal itself. Our understanding of ourselves and our world have been immeasurably enriched through the findings of our well-trained rational and intuitive mind. But in the Science classroom, because of the demands of assessments, only the logical/rational mind and memory are predominantly educated. This is only a part of our mind. Our search for meaning and our need to feel connected to ourselves and our world requires more. If we only recognise one way of looking at our world and of gaining knowledge as valid, we split ourselves and all forms of error then open to us.

Richard Dawkins is an example of a tireless campaigner for the rational mind (Dawkins, 2006). He is well known for his distaste of those who do not base their relationship to life on Science. He is right that Science is and should remain primarily in the domain of the rational mind. It is this reasoning mind that can moderate our thinking and actions and bring objectivity to life. That Richard Dawkins is not always reasonable and disciplined in his fight against religion should not dissuade us of this.

Religion has served humanity in building social structures, values and knowledge that created stability and enrichment for communities. Its intuited knowledge, often called revelation, has been tested in its ability to maintain and improve life for all, and has proved itself over a far longer time than has Science. In its short lifespan, Science has caused more damage to our social life and natural world than religion ever did, despite religions' irrational [having gained its insights through intuition rather than reason, would be a more accurate description] origins.

We have seen from our look at quantum mechanics that Science and religion are not mutually exclusive. Many of our greatest scientists have been men and women of deep spirituality just as many spiritual leaders have been great scientists. What is needed is to

recognise that our rational mind needs to be balanced by our imaginative, intuitive mind; the part of our mind that builds intimacy and meaningful connections to ourselves and our world.

The solution lies in holism. All true holistic education involves activities that engage us on multiple levels; objective rationality with subjective intuitions and artistic inspirations. And as much as the current study of Science disciplines and trains our reasoning, rational mind, so too, our intuitive, inspired and imaginative mind requires training and discipline. It is this disciplined, working together of these two parts of mind, mediated by feeling-life, that gave birth to the poem used in this research. To write this poem the ideas of Science gave rise to imaginative images which I tested against further scientific knowledge which in turn stimulated my imagination and so on. The poem was formed by ideas and imaginations going back and forth between objective and subjective knowledge until I was satisfied that it was true to both. This process is little different from the usual scientific process for testing knowledge except that it embraced subjective intuitions and imaginations as valid knowledge. The thrust of my research was to show the need for this in Science education.

This research has shown that Grade 9 learners in the greater Tshwane region respond very positively, in their thinking, feeling and willing, to the use of such holistically produced knowledge when presented in an artistic, holistic way. A true scientific age, as viewed by Feynman, will surely be born when we acknowledge the real value of the holistic union of these two parts of our mind in Science education.

## 5.2 **Preparing the feast, the banquet of body and mind**:

My dissertation was thinly layered as a meal with many courses and moments of pause and conversation. The use of this metaphor gave you, the reader, an experience unique to yourself.

The ideas in my research are designed to be followed by everyone. If this dissertation has done its job correctly, everyone who reads this should end up with the full picture of the ideas presented and the same conclusion from the results. Because of the meal metaphor layer over it, you, the reader, will have had a unique experience, different from every other reader. You have been through your individualised journey just because of your own relationship to food and dining.

You may have thought the meal to be a very clever use of a holistic device to bring a direct experience of metaphor, imagination and story to emphasise the point my dissertation is trying to make. You may have thought it a distraction which took your attention away from the main ideas; perhaps you sensed that some of the courses did not reflect the content they represented? Certain courses may have caught your attention and filled you with the very

tastes and experiences of eating while you read further. Only you will know, because only you had your unique experience.

The universal ideas of the Science were coupled with your individual experience of the artwork I tried to create. This dissertation is like a great meal or a story, potentially filled with rich, personal meaning. If there is a true relationship between the meal metaphor and this dissertation, some part of your imagination will hopefully have found it, with or without your rational or emotional permission or enjoyment. This only you will know because here you stood alone with the opportunity to attach yourself through your unconscious forces of sympathy, of will, as opposed to your very awake forces of antipathy, of thinking. Hopefully this enabled you to experience the use of this holistic device in the process, and that, like the results of my research, your interest levels were improved.

## 5.3 **The current state of Science education**:

Doing this research has been very interesting for many reasons. Among the significant experiences along the way has been the response of the University of Pretoria Science Education department and Science teachers. The Science Education department did not accept my proposal to do research under them as they did not feel confident to assist me because of the use of poetry in the research. It was Humanities Education that accepted me as a student for this research.

The Science teachers in the schools where the implementation took place did not feel comfortable to do the implementation themselves due to the poetry aspect of the intervention. We can therefore safely assume that the results of this research, that leaner interest in Grade 9 Chemistry in the greater Tshwane metropolitan area can be significantly improved with holistic devices which use a combination of poetry, experimentation, video and class discussion, will not be welcomed by all in Science education. The first and major concern of all involved in Science education is the current examination results of learners which are not yet satisfactory. Although many factors contribute to this, one of the greatest challenges in improving results is in improving the scientific knowledge of teachers. This must be priority number one, getting teachers confident and competent in knowing and teaching scientific knowledge.

Science and Science education is dominated by the positivist paradigm. This is not new. That those involved in Science education have shown this as a real limiting of interest and confidence in dealing with anything outside of this paradigm has been a new experience for me. It appears that the use of imagination, inspiration and intuition, the upwelling of knowledge from within that is developed as an individual and personal synthesis of the

experiences and knowledge gained through the positivist paradigm, is not readily welcome in the Science classroom. The living, personal relationship to the world that we study in Science is tangibly not commonly found in the Science classroom. It is Science educators that enforce this accepted but unspoken rule as a result of their training and perceptions.

This should not be surprising, considering that these educators were trained under the same conditions and chose it as their path in adult life. The reliability, security and consistency of the positivist paradigm gives its adherents a solid ground of ideas. Followers of this paradigm are offered good pay and status in society. They can follow many branches of application, from medicine and dentistry to the design, development, building and maintaining of all manner of products. It is a very safe and secure paradigm in providing for many of our needs. But it is a paradigm that excludes the creative inner-life of the human being. The discomfort of its adherents in dealing with my research has been a tangible expression of this. And yet, when the teachers and learners were exposed to the intervention they enjoyed it and showed a growth in positivity towards holism and the use of holistic devices in the Science classroom.

## 5.4 **Gaining a broader perspective**:

> *"Nobel laureates in the sciences are 25 times as likely as the average scientist to sing, dance or act, 17 times as likely to be an artist, 12 times more likely to write poetry and literature, eight times more likely to do woodworking or some other craft, four times as likely to be a musician, and twice as likely to be a photographer. Many connect their art with their scientific creativity (Root-Bernstein, 2011)", as quoted by (Daugherty, 2013).*

These very interesting statistics tells us as much about the average scientist as it does about Nobel laureates. It shows a high correlation between the arts and Science at the highest level. By reverse implication, it also shows that average scientists rarely partake in arts activities. My research shows that general learner interest is increased through holistic devices. Those learners who retain interest in Science, and pursue Science as a career, seem to be those with an almost exclusive interest in the positivist paradigm. Only those geniuses who get to the top in the field of Science have the capacity to keep their artistic inner-life active within their scientific work.

The capacity of the arts to stimulate us in multiple ways and to open us to heights of thought and feeling seems to verify holism as a reality and be a source for the types of insights that lead to ground-breaking scientific work. Would the practice of Science not benefit if we could

attract more learners to remain in Science by showing them that their inner creativity and insights have a place in the subject; that the subject is singularly significant in its ability to inform them about, and bring greater intimacy between, their lives and the world?

## 5.5 **Summary of reflections**:

Many people who are looking for predictability, order, security and structure in life find comfort and support in the scientific, positivist paradigm. This is a good thing. This has been called *left-brain* or *nerve* thinking and is clearly an important part of our human faculties and functioning. This is the type of learning that is emphasised in much of our modern schooling and used almost exclusively in the Grade 9 Science classroom. Holism shows that this is one-sided and ultimately unhealthy for people trying to create a personal intimacy with themselves and their world. For a fully developed human, we need to integrate the creative *left-brain* activity with *right-brain* activity. Steiner referred to the rational left-brain activity as *nerve thinking*, and creative *right-brain* activity as *blood knowledge* (Steiner, 1966). This idea shows a clear distinction between the two types of thinking or knowledge, and why the latter has been so easily rejected by the positivist paradigm.

My research shows that holistic devices which include an integration of left and right-brain activity significantly increase learner interest in Science at a crucial time in their learning; when they are being introduced into the subject and when they need to decide if they will take Science into the next phase of their education.

If our ideal in education is to educate holistically so that young people can feel their own significance and place in their world, then using all our faculties to create an intimacy between our objective knowledge and our personal, inner experiences is a must. The significance of the results of my research show us a first step in this direction.

## 5.6 **Implications of my research**:

My research has shown that the use of holistic devices has a statistically significant effect on learner interest in the specific context of Grade 9 Chemistry in the greater Tshwane region. The combination of poetry, which uses drama, metaphoric characterisation, rhythm and rhyme to describe the observable behaviour in Science experiments significantly increases learner interest.

### 5.6.1 **Implications for policy**:

The existing policy already encourages creative, problem solving rather than rote learning (Education, 2007).

My, or similar, research should now be done in other cities and in rural areas to test its effectiveness. Where significant increases in interest are replicated, policy for the training of teachers in holistic Science education should be put in place, implemented and introduced into the classroom.

Should it be found that the results are similar in a multitude of environments then new policy should be made to change the training of Science teachers in trusting and using their own intuitive and inspired knowledge to enrich their relationship to Science, and to include the use of holistic devices in presenting scientific content. Curriculum and assessment policy changes would also need to be made to accommodate this.

Finding the limits of the effectiveness of this approach would be a first step. In South Africa, we have many different types of schools in many different areas. Private schools, city schools, township schools and rural schools are just the broad categories of school, with each urban and rural area having its own specific reality. My research showed results ranging from highly significant to moderate significance in state schools and zero significance in one private school. Further research should be undertaken to see if it will be effective in other types of private schools as well as township and rural schools.

As a researcher, I assumed learners to have a basic belief in the value of Science, education and learning and if the learners in a school do not have this, my research could possibly be ineffective. Getting learners to create their own rap, poetry or other artworks after being exposed to experiments and learning on a topic could also be the basis of testing the use of holistic devices in improving learner interest (Emdin, 2010). It would be important for policy to acknowledge and accommodate that the holistic devices should include existing interests of the learners within the learning of Science and that this will differ in different contexts.

### 5.6.2 **Implications for practice**:

Steps should be undertaken to train Science teachers in the Senior phase, in the types of schools where the research is shown to be effective, in the use of holistic devices to increase learner interest in Science. Because of the current, almost exclusive belief in the positivist paradigm, it will take some powerful evidence to create a shift in Science, for those involved in Science education to embrace a more holistic approach. A start could be made by helping Science teachers-in-training to develop confidence and trust in their own imaginations and intuitions. Training and disciplining our intuitive life would need to follow, as it needs as much training as our rational life to produce valid knowledge.

Science educators, and those who train them, would need to be the first to make the shift to the use of more holistic and artistic devices. If further research shows that teachers-in-training have improved interest levels if taught using holistic, artistic devices then the implementation of it in teacher training would lead over to teachers using them in the Science classroom. Developing a suitable training will require broad and strong evidence of the effectiveness of holistic devices in increasing learner interest and confidence, to convince Science teachers and lecturers that it is meaningful. It would be helpful if Science first embraced holism as a scientific, acceptable model for understanding our world. Research into the application of holism in Science would broaden its acceptance of valid ways of viewing our world and could open the way for the arts and intuition to be more accepted in scientific practice than in just the few who get Nobel recognition.

Science teachers are not naturally drawn to the artistic, *blood-knowledge* way of working. Trusting our intuitions and imaginations to hold valid knowledge is not an easy thing to develop once our trust in them is broken; not that this is the case with those involved in Science and Science education. An alternative to introducing this knowledge into the Science classroom would be to emphasise education in the arts for all Science learners and educators. This would already be a great help in strengthening the confidence Science practitioners have in their own blood-knowledge. That this type of knowledge is needed in Science is what my research has shown is needed for learners to relate better to Science. Hopefully over time we Science practitioners will become confident in trusting our own blood-knowledge to strengthen our relationship to our work and help in overcoming a fragmented relationship to ourselves and our world.

## 5.7 **Closing**:

The answers to my research questions have been to stress that holistic devices are needed in the Science classroom to improve and possibly develop a sustained interest in Science. That it works well in urban Tshwane is not a guarantee that it will work everywhere. Where and how it will work best has yet to be established.

There is a danger that if we do not introduce holistic knowledge and practice into Science, the harmful applications of Science that lead to pollution and destruction on multiple levels will continue without the wholesome balancing effects of our inner relationship to what we are doing. By introducing holistic, artistic thinking and practice into Science we open the possibility of having more young people becoming scientists who will be among the top of

their profession, making the cutting-edge findings, and making use of Science with a well-developed trust and engagement in their personal relationship to life.

In history, the scientific age began with detailed experimentation accompanied with poetry. This study imitated this approach and gave statistically significant results. Could this be the path to a re-establishing of a truly scientific age?

## 5.8 **Farewell**: *Our host calls our attention for a farewell address*

*Dear examiner and reader.*

*Thank you for sharing this meal with me.*

*We have shared so many thoughts, pictures and stories from so many beautiful human lives; so much food for thought that my research findings stand as a small egg laid in the vast basket of nourishing experiences of reality and knowledge.*

*What you believe should be done with this egg has possibly not changed since you started reading my dissertation; such is the nature of blood knowing and its power over rational thought. Yet, if this egg of experience has been laid in your heart as much as in your mind, there is a chance that new ideas and inspirations will be born in you, shaped by your own inner moral landscape which will receive shaping in return.*

*And should it be that this leads you to a dialogue of such integrity and trust between heart and mind that you create your own hearty meal, and write a story, dramatically enact a poem or give life to rational knowledge in some other artistic form, then we shall stand together on Wordsworth's "pleasant lea" and not feel forlorn, but like Fritjof Capra, feel enlivened. We shall stand as brothers and sisters with some of the greatest hearts and minds of humanity at the birth of a truly scientific age.*

*May your journey home be blessed with sobriety and love.*

*Philip*

**References**: After dinner mints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Hors d’oeuvres smoked salmon picture gained from the internet from the website:

http://www.taste.com.au/recipes/smoked-salmon-lettuce-cups/126359e2-6131-4ca2-953a-a118737b6fd6

Dinner pictures were gained from the internet from the following websites:

Curry: http://chesterboat.co.uk/themed-cruises/curry-n-quiz/

Beef and broccoli: http://www.food.com/ideas/all-time-best-dinner-recipes-6009
Stuffed bell peppers: http://www.food.com/ideas/all-time-best-dinner-recipes-6009
Steak: http://www.philstar.com/food-and-leisure/2014/03/21/1303548/pyromusical-dinner-highlands-prime-steakhouse
Baked salmon: https://www.pinterest.se/eika974/cuisine/
Penne pasta: http://www.flavoreddelights.com/2013/04/good-healthy-foods-to-eat-for-dinner/
Roast chicken: https://es.dreamstime.com/fotograf%C3%ADa-de-archivo-libre-de-regal%C3%ADas- el-d%C3%ADa-de-fiesta-as%C3%B3-el-pavo-relleno-image15959637

Dessert pictures were gained from the internet from the following websites:

Chocolate truffle: http://www.taste.com.au/recipes/chocolate-truffle-dessert/d15acff1-db36-4d51- b7d9-679b67747d2f
Four-layer sponge and cream cake with raspberries and pistachio nuts: http://www.taste.com.au/recipes/raspberry-honey-dessert-cake/1c073ecf-ff98-4f40-888c- 5e3bb9376dc5
Strawberries dipped in Fairtrade chocolate: https://bgcater.com/index.cfm?fuseaction=order&product_group_id=17
Cream filled chocolate éclair: http://cowbird.com/story/46481/The_Eclair/
Gluten free Homemade Tiramisu with mascarpone cream filling: https://dessertswithbenefits.com/tiramisu/
Red wine poached pear: https://www.finedininglovers.com/blog/food-drinks/vegan-dessert-recipes/
Fruit salad: http://www.toptenz.net/top-10-international-desserts.php
Peach-berry frozen dessert: diabetic friendly: http://www.diabeticlivingonline.com/diabetic-recipes/dessert/fruit-dessert-recipes

## **Addendum A**: **Ethical clearance to proceed with the research**:

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

**Ethics Committee**
**01 August 2016**

Dear Mr Mirkin

**REFERENCE: HU 16/06/04**

Your application was carefully considered by the Faculty of Education Ethics Committee and the final decision of the Ethics Committee is:

Your application is approved.

This letter serves as notification that you may continue with your fieldwork. Should any changes to the study occur after approval was given, it is your responsibility to notify the Ethics Committee immediately.

**Please note that you will have to fulfil the conditions specified in this letter from the Faculty of Education Research Ethics Committee. The conditions include:**

1) The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment (Section E) for approval by the Committee.
    - Any amendments to this approved protocol need to be submitted to the Ethics Committee for review prior to data collection. Non-compliance implies that the Committee's approval is null and void.
    - Final data collection protocols and supporting evidence (e.g.: questionnaires, interview schedules, observation schedules) have to be submitted to the Ethics Committee before they are used for data collection.

2) The researcher should please note that this decision covers the entire research process, until completion of the study report, and not only the days that data will be collected.
3) Should your research be conducted in schools, please note that you have to submit proof of how you adhered to the Department of Basic Education (DBE) policy for research.

4) The Ethics Committee of the Faculty of Education does not accept any liability for research misconduct, of whatsoever nature, committed by the researcher(s) in the implementation of the approved protocol.

Please note that this is not a clearance certificate.
Upon completion of your research, you need to submit the following documentation to the Ethics Committee:

- **Integrated Declaration Form (Form D08),**
- **Initial Ethics Approval letter and,**
- **Approval of Title.**

On receipt of the above-mentioned documents you will be issued a clearance certificate. Please quote the reference number **HU 16/06/04** in any communication with the Ethics Committee.

Best wishes

Prof Liesel Ebersöhn
Chair: Ethics Committee
Faculty of Education

Dr Maitumeleng Ntho-Ntho
Ethic Assistant

## **Addendum B**: **Questionnaires**:

| | Grade 9 Teacher Pre-Test Questionnaire | School: | | | | |
|---|---|---|---|---|---|---|
| | Place a cross over your correct answer | | | | | |
| | Age in years | 20 - 25 | 26 - 30 | 31 - 35 | 35 - 40 | 41 + |
| | Years of teaching experience | 0 -4 | 5 - 9 | 10 - 14 | 15 - 19 | 20 + |
| | Years of teaching Grade 9 Chemistry | 0 -4 | 5 - 9 | 10 - 14 | 15 - 19 | 20 + |
| | I have already done …?.. acid/base experiments with this class | no | One | Two | Three | 4 or more |
| | Gender and Home language | Male | Female | English | Partly English | Other |
| | Highest Qualification (may circle more than one) | Diploma | Degree | Honours | Masters | PhD |
| | Place a cross in the appropriate space provided | Strongly disagree | Disagree | Neither Agree or Disagree | Agree | Strongly Agree |
| 1 | I enjoy teaching chemistry. | | | | | |
| 2 | I am looking forward to doing the intervention with my class. | | | | | |
| 3 | It will be a waste of valuable class time. | | | | | |
| 4 | It will help my learners to understand acids, bases and salts better. | | | | | |
| 5 | I know what holistic education is? | | | | | |
| 6 | I know of Jan Smuts's principle of Holism? | | | | | |
| 7 | I think that chemistry can teach us about ourselves. | | | | | |
| 8 | I want to know more about acids and bases. | | | | | |
| 9 | Further comment (optional): | | | | | |

| | Grade 9 Teacher Post-Test Questionnaire | School: | | | | |
|---|---|---|---|---|---|---|
| | Place a cross over your correct answer | | | | | |
| | Age in years | 20 - 25 | 26 - 30 | 31 - 35 | 35 - 40 | 41 + |
| | Years of teaching experience | 0 -4 | 5 - 9 | 10 - 14 | 15 - 19 | 20 + |
| | Years of teaching grade 9 Chemistry | 0 -4 | 5 - 9 | 10 - 14 | 15 - 19 | 20 + |
| | Gender and Home language | Male | Female | English | Partly English | Other |
| | Highest Qualification (may circle more than one) | Diploma | Degree | Honours | Masters | PhD |
| | Place a cross in the appropriate space provided | Strongly disagree | Disagree | Neither Agree or Disagree | Agree | Strongly Agree |
| 1 | I enjoy teaching chemistry. | | | | | |
| 2 | I enjoyed doing the intervention with my class. | | | | | |
| 3 | It was a waste of valuable class time. | | | | | |
| 4 | It helped my learners to understand acids, bases and salts better. | | | | | |
| 5 | I would like to know what more about holistic education. | | | | | |
| 6 | I would like to know more of Jan Smuts's principle of Holism. | | | | | |
| 7 | I think that chemistry can teach us about ourselves. | | | | | |
| 8 | I want to know more holistic science ideas. | | | | | |
| 9 | Which aspect of the lessons did you relate to the most? (You may tick more than one option) | Poem | Video | Class Discussion | Own Learning | |
| 10 | Further comment. (Optional) | | | | | |

| | Grade 9 Learner Pre-Test Questionnaire | School: | | | | |
|---|---|---|---|---|---|---|
| | Indicate with a cross if you are a Boy ◯ Girl ◯ | Home language is English ◯ | | English and Other ◯ | | Other ◯ |
| | Place a cross in the appropriate space provided | Strongly disagree | Disagree | Neither Agree or Disagree | Agree | Strongly Agree |
| 1 | I understand what acids and bases are. | | | | | |
| 2 | I know how acids and bases are formed. | | | | | |
| 3 | I know how salts are formed. | | | | | |
| 4 | I enjoy learning about acids and bases. | | | | | |
| 5 | I want to know more about acids and bases. | | | | | |
| 6 | I find chemistry interesting. | | | | | |
| 7 | I love Chemistry | | | | | |
| 8 | I enjoy learning about Chemistry. | | | | | |
| 9 | I think that Chemistry can teach us about ourselves. | | | | | |
| 10 | Further comment (optional): | | | | | |

| | Grade 9 Learner Post-Test Questionnaire | School: | | | | |
|---|---|---|---|---|---|---|
| | Indicate with a cross if you are a Boy ◯ Girl ◯ | Home language is English ◯ | | English and Other ◯ | | Other ◯ |
| | Place a cross in the appropriate space provided | Strongly disagree | Disagree | Neither Agree or Disagree | Agree | Strongly Agree |
| 1 | I understand what acids and bases are. | | | | | |
| 2 | I know how acids and bases are formed. | | | | | |
| 3 | I know how salts are formed. | | | | | |
| 4 | I enjoy learning about acids and bases. | | | | | |
| 5 | I want to know more about acids and bases. | | | | | |
| 6 | I find Chemistry interesting. | | | | | |
| 7 | I love Chemistry | | | | | |
| 8 | I enjoy learning about Chemistry. | | | | | |
| 9 | I think that Chemistry can teach us about ourselves. | | | | | |
| 10 | Which aspect of the lessons did you enjoy most? (You may include more than one option) | Poem | Video | Class Discussion | Own Learning | |
| 11 | Further comment. (Optional) | | | | | |

**Addendum C**: **The intervention: Lesson plan**:

A one lesson intervention of poem, video and teacher-led class discussion with a pre- and post-intervention questionnaire being administered to the teacher and the learners.

Step 1: Hand out the pre-intervention questionnaires to the learners and do your own questionnaire. Once completed, please collect and seal in envelope provided.

Step 2: Distribute the copies of the poem to the learners. Then read through the poem with them and answer any questions they may have.

Step 3: Play the video for the learners. Please stop to highlight aspects or do other teaching if this is what you naturally feel like doing. The video is available on the internet at https://www.facebook.com/Deep-Science-Education-Science-Poetry-Holism-and-Education-in-harmony-334924460228786/

Step 4: Once the video is over, discuss the poem and video with the learners, using the following questions, until the last five or so minutes of the lesson.

*Questions for class discussion after watching the video.*

*Questions on the acid and base separate reactions in the test tubes:*

*Do you think that the poem's description of acids is accurate?*
*Do you think that the poem's description of bases is accurate?*
*Do you think the alchemists were right to describe acids as male and bases as female?* (Please help to break gender stereotypes.)

*Questions on the reaction where the acid was put into the beaker with the base:*

*Was the poem's description of the reaction of concentrated, strong acid and base accurate?*
*Did you see how the salt crystals grew? (That they grow in all directions, free of gravity.)*
*Do you think the poem's description of salts is accurate?*
*Did the story of a mother, father and child helps you to relate to acids, bases and salts?*
*Are you now able to understand acids and bases better?*
*Are you now more ready to learn further details about acids and bases?*

Step 5: Distribute the post-test to the learners and do your specific teacher post-test. Place in the package and seal ready for collection.

Step 6: Call or message me to collect

Thank you for your and your class time. It is much appreciated.

**Addendum D**: **The Poem used in the intervention**:

Acid Man and Lady Base

Of these the ancient Alchemists spoke
Who knew them both as active folk.
Base, born of metal and acid her mate
Have needs that only the other can sate.

To find their nature, for what they strive,
We place in sets of test-tubes five
Magnesium, milk and copper sulphate,
Crushed chalk and oil; our sacrifice, our bait.

Acid brighten, dissolve and boil
To lift from solid its heavy toil
In one quick act his halide sword
Or brimstone fire has form destroyed.

Slower working, to hold and bind,
Our Lady's fruits though soft in kind,
Take what is loose, unbound and free
And ground it, give it presence to be.

When together these two we place,
The drive, the need, the hot embrace
Seems like a fight to dominate the lover.
Inanimate opposites attracting each other.

Then left to cool and crystallise,
As children born of their parent's demise,
Small shining beads; salt crystals delight,
To fructify the Earth as solidified light.

<u>Glossary:</u>

| | |
|---|---|
| Alchemists | Early experimental scientists who looked for the qualities and properties of materials which related to human nature. |
| Folk | People |
| Sate | Satisfy |
| Toil | Burden or to work hard |
| Halide | A reacted halogen, eg: Fluoride, Chloride, Bromide or Iodide |
| Brimstone | An old name for Sulphur |
| Ground it | To make it solid and to take a form of its own |
| Inanimate | Not able to move of their own accord |
| Demise | Death |
| Fructify | To bring new life or ideas |

**Addendum E**: **School 1 results**: 4 Classes, 84 learners: 58 girls and 26 boys.

4 Classes Boys pre-test Data

| School 1 | 26 Boys | | Group 1 | | | | | | | Group 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre-tests | 1 | 2 | 3 | 4 | 5 | Total 1 | Ave | 1 | 2 | 3 | 4 | 5 | Total 2 | Ave |
| 1 | 0 | 0 | 2 | 5 | 0 | 26 | 3,714 | | | 1 | 3 | | 15 | 3,75 |
| 2 | 0 | 1 | 3 | 3 | 0 | 23 | 3,286 | | 2 | 1 | 1 | | 11 | 2,75 |
| 3 | 1 | 3 | 2 | 1 | 0 | 17 | 2,429 | | 2 | 1 | 1 | | 11 | 2,75 |
| 4 | 1 | 0 | 1 | 3 | 2 | 26 | 3,714 | | 3 | 1 | | | 9 | 2,25 |
| 5 | 0 | 1 | 2 | 1 | 3 | 27 | 3,857 | | 1 | | 3 | | 14 | 3,5 |
| 6 | 0 | 1 | 2 | 2 | 2 | 26 | 3,714 | | 2 | 1 | 1 | | 11 | 2,75 |
| 7 | 0 | 1 | 3 | 2 | 1 | 24 | 3,429 | 1 | 2 | 1 | | | 8 | 2 |
| 8 | 0 | 1 | 3 | 2 | 1 | 24 | 3,429 | | 2 | 2 | | | 10 | 2,5 |
| 9 | 1 | 0 | 2 | 2 | 2 | 25 | 3,571 | 2 | | | 2 | | 10 | 2,5 |
| | | | | | | | | | | | | | | |
| | | | | | | 218 | 3,46 | | | | | | 99 | 2,75 |

| | | Group 3 | | | | | | | Group 4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | Total 3 | Ave | 1 | 2 | 3 | 4 | 5 | Total 4 | Ave |
| | 3 | 5 | 2 | | 29 | 2,90 | | | 2 | 3 | | 18 | 3,6 |
| 1 | 6 | 1 | 2 | | 24 | 2,40 | | 1 | 3 | 1 | | 15 | 3 |
| | 7 | 2 | | | 20 | 2,22 | | 3 | 2 | | | 12 | 2,4 |
| 2 | | 5 | 2 | 1 | 30 | 3,00 | 1 | | | 4 | | 17 | 3,4 |
| 2 | 1 | 3 | 1 | 3 | 32 | 3,20 | 1 | | | 1 | 3 | 20 | 4 |
| 2 | | 2 | 2 | 4 | 36 | 3,60 | 1 | | | 1 | 3 | 20 | 4 |
| 4 | 1 | 2 | 3 | | 24 | 2,40 | 1 | | 1 | 2 | 1 | 17 | 3,4 |
| 1 | 2 | 3 | 3 | 1 | 31 | 3,10 | 1 | | | 2 | 2 | 19 | 3,8 |
| 4 | | 4 | 1 | 1 | 25 | 2,50 | 1 | 1 | 1 | 1 | 1 | 15 | 3 |
| | | | | | | | | | | | | | |
| | | | | | 251 | 2,81 | | | | | | 153 | 3,4 |

| Total boys | |
|---|---|
| Total | Ave |
| 88 | 3,49 |
| 73 | 2,86 |
| 60 | 2,45 |
| 82 | 3,09 |
| 93 | 3,64 |
| 93 | 3,52 |
| 73 | 2,81 |
| 84 | 3,21 |
| 75 | 2,89 |
| | |
| 721 | 3,11 |

School 1: 4 Classes Girls pre-test Data

| School 1 | 58 Girls | | Group 1 | | | | | | | Group 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre-tests | 1 | 2 | 3 | 4 | 5 | Total 1 | Ave | 1 | 2 | 3 | 4 | 5 | Total 2 | Ave |
| 1 | 1 | 2 | 6 | 2 | 3 | 46 | 3,286 | 1 | 1 | | 9 | 2 | 49 | 3,769 |
| 2 | 1 | 7 | 2 | 4 | | 37 | 2,643 | 2 | 5 | 3 | 2 | 1 | 34 | 2,615 |
| 3 | 1 | 7 | 3 | 3 | 0 | 36 | 2,571 | 2 | 1 | 1 | 9 | | 43 | 3,308 |
| 4 | 5 | 1 | 0 | 7 | 1 | 40 | 2,857 | | 2 | 2 | 3 | 6 | 52 | 4 |
| 5 | 4 | 2 | 0 | 6 | 2 | 42 | 3 | | 2 | | 1 | 10 | 58 | 4,462 |
| 6 | 1 | 1 | 2 | 4 | 6 | 55 | 3,929 | 1 | 2 | 2 | 3 | 5 | 48 | 3,692 |
| 7 | 6 | 1 | 4 | 3 | 0 | 32 | 2,286 | | 5 | 2 | 3 | 3 | 43 | 3,308 |
| 8 | 4 | 1 | 3 | 4 | 2 | 41 | 2,929 | 1 | 3 | 3 | 3 | 3 | 43 | 3,308 |
| 9 | 2 | 3 | 8 | 0 | 1 | 37 | 2,643 | 1 | 3 | 2 | 3 | 4 | 45 | 3,462 |
| | | | | | | | | | | | | | | |
| | | | | | | 366 | 2,905 | | | | | | 415 | 3,547 |

| | | Group 3 | | | | | | | Group 4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | Total 3 | Ave | 1 | 2 | 3 | 4 | 5 | Total 4 | Ave |
| | 1 | 7 | 7 | | 51 | 3,40 | 1 | | 7 | 8 | | 54 | 3,375 |
| 2 | 10 | 2 | 1 | | 32 | 2,13 | 3 | 4 | 5 | 4 | | 42 | 2,625 |
| 2 | 8 | 5 | | | 33 | 2,20 | 3 | 2 | 5 | 3 | 1 | 39 | 2,786 |
| | 1 | 6 | 5 | 1 | 45 | 3,46 | 1 | 4 | 4 | 3 | 3 | 48 | 3,2 |
| | 2 | 2 | 8 | 3 | 57 | 3,80 | 4 | | 1 | 3 | 6 | 49 | 3,5 |
| 1 | | 4 | 7 | 3 | 56 | 3,73 | 4 | 1 | 4 | 4 | 3 | 49 | 3,063 |
| 3 | 2 | 8 | 1 | 1 | 40 | 2,67 | 4 | 3 | 5 | 1 | 3 | 44 | 2,75 |
| 1 | 1 | 6 | 5 | 2 | 51 | 3,40 | 5 | 1 | 2 | 5 | 3 | 48 | 3 |
| 2 | 2 | 6 | 4 | 1 | 45 | 3,00 | 4 | 1 | 6 | 4 | 2 | 50 | 2,941 |
| | | | | | | | | | | | | | |
| | | | | | 410 | 3,09 | | | | | | 423 | 3,027 |

| Total | |
|---|---|
| Total | Ave |
| 200 | 3,46 |
| 145 | 2,50 |
| 151 | 2,72 |
| 185 | 3,38 |
| 206 | 3,69 |
| 208 | 3,60 |
| 159 | 2,75 |
| 183 | 3,16 |
| 177 | 3,01 |
| | |
| 1614 | 3,14 |

School 1: 4 Classes Boys post-test Data

| School 1 | 26 Boys | | 1 | | | | | | | 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Post-tests | 1 | 2 | 3 | 4 | 5 | Total 1 | Ave | 1 | 2 | 3 | 4 | 5 | Total 2 | Ave |
| 1 | 0 | 0 | 0 | 6 | 1 | 29 | 4,143 | | | 1 | 3 | | 15 | 3,75 |
| 2 | 0 | 1 | 1 | 4 | 1 | 26 | 3,714 | | 0 | 0 | 4 | | 16 | 4 |
| 3 | 0 | 0 | 2 | 2 | 3 | 29 | 4,143 | | 0 | 0 | 4 | | 16 | 4 |
| 4 | 0 | 0 | 2 | 2 | 3 | 29 | 4,143 | | 0 | 1 | 3 | | 15 | 3,75 |
| 5 | 0 | 0 | 2 | 2 | 3 | 29 | 4,143 | | 0 | 1 | 3 | | 15 | 3,75 |
| 6 | 0 | 0 | 0 | 5 | 2 | 30 | 4,286 | | 1 | 0 | 3 | | 14 | 3,5 |
| 7 | 0 | 0 | 2 | 3 | 2 | 28 | 4 | 0 | 1 | 3 | 0 | | 11 | 2,75 |
| 8 | 0 | 0 | 1 | 5 | 1 | 28 | 4 | | 1 | 0 | 3 | | 14 | 3,5 |
| 9 | 0 | 2 | 3 | 1 | 1 | 22 | 3,143 | 0 | 1 | 1 | 2 | | 13 | 3,25 |
| | | | | | | | | | | | | | | |
| | | | | | | 250 | 3,968 | | | | | | 129 | 3,583 |

| | | 3 | | | | | | | 4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | Total 3 | Ave | 1 | 2 | 3 | 4 | 5 | Total 4 | Ave |
| | 1 | 3 | 5 | 1 | 36 | 3,60 | | | 0 | 5 | | 20 | 4 |
| 0 | 1 | 1 | 6 | 2 | 39 | 3,90 | | 0 | 0 | 5 | | 20 | 4 |
| | 1 | 3 | 6 | 0 | 35 | 3,50 | | 1 | 1 | 3 | | 17 | 3,4 |
| 2 | | 2 | 2 | 4 | 36 | 3,60 | 1 | | | 0 | 4 | 21 | 4,2 |
| 2 | 1 | 0 | 3 | 4 | 36 | 3,60 | 1 | | | 2 | 2 | 19 | 3,8 |
| 1 | | 4 | 1 | 4 | 37 | 3,70 | 1 | | | 1 | 3 | 20 | 4 |
| 4 | 1 | 1 | 4 | 1 | 30 | 2,73 | 1 | | 1 | 2 | 1 | 17 | 3,4 |
| 1 | 3 | 0 | 4 | 2 | 33 | 3,30 | 1 | | | 2 | 3 | 24 | 4 |
| 2 | 1 | 1 | 3 | 2 | 29 | 3,22 | 0 | 0 | 2 | 1 | 2 | 20 | 4 |
| | | | | | | | | | | | | | |
| | | | | | 311 | 3,46 | | | | | | 178 | 3,867 |

| Total | |
|---|---|
| Total | Ave |
| 100 | 3,87 |
| 101 | 3,90 |
| 97 | 3,76 |
| 101 | 3,92 |
| 99 | 3,82 |
| 101 | 3,87 |
| 86 | 3,22 |
| 99 | 3,70 |
| 84 | 3,40 |
| | |
| 868 | 3,72 |

School 1: 4 Classes Girls post-test Data

| School 1 | 58 Girls | | 1 | | | | | | | 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Post-tests | 1 | 2 | 3 | 4 | 5 | Total 1 | Ave | 1 | 2 | 3 | 4 | 5 | Total 2 | Ave |
| 1 | 1 | 0 | 2 | 8 | 3 | 54 | 3,857 | | 2 | 0 | 6 | 5 | 53 | 4,077 |
| 2 | 1 | 0 | 3 | 7 | 3 | 53 | 3,786 | | 1 | 0 | 8 | 4 | 54 | 4,154 |
| 3 | 1 | 0 | 1 | 7 | 5 | 57 | 4,071 | | 0 | 0 | 6 | 7 | 59 | 4,538 |
| 4 | 1 | 1 | 5 | 3 | 4 | 50 | 3,571 | | 0 | 4 | 5 | 4 | 52 | 4 |
| 5 | 1 | 1 | 4 | 6 | 2 | 49 | 3,5 | | 0 | 2 | 6 | 5 | 55 | 4,231 |
| 6 | 0 | 2 | 1 | 8 | 3 | 54 | 3,857 | | 0 | 4 | 4 | 5 | 53 | 4,077 |
| 7 | 3 | 2 | 6 | 2 | 1 | 38 | 2,714 | 0 | 3 | 5 | 3 | 2 | 43 | 3,308 |
| 8 | 1 | 1 | 5 | 5 | 2 | 48 | 3,429 | | 2 | 2 | 6 | 4 | 54 | 3,857 |
| 9 | 1 | 3 | 6 | 1 | 3 | 44 | 3,143 | 0 | 3 | 2 | 2 | 6 | 50 | 3,846 |
| | | | | | | | | | | | | | | |
| | | | | | | 447 | 3,548 | | | | | | 473 | 4,01 |

| | | 3 | | | | | | | 4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | Total 3 | Ave | 1 | 2 | 3 | 4 | 5 | Total 4 | Ave |
| | 1 | 2 | 7 | 5 | 61 | 4,07 | 1 | 1 | 0 | 6 | 8 | 67 | 4,188 |
| 0 | 1 | 8 | 3 | 3 | 53 | 3,53 | 1 | 3 | 2 | 5 | 5 | 58 | 3,625 |
| | 1 | 3 | 3 | 8 | 63 | 4,20 | | 2 | 3 | 5 | 6 | 63 | 3,938 |
| 1 | | 1 | 6 | 6 | 58 | 4,14 | 1 | 1 | 2 | 4 | 8 | 65 | 4,063 |
| 1 | 0 | 0 | 7 | 7 | 64 | 4,27 | 2 | 1 | 4 | 3 | 5 | 53 | 3,533 |
| 1 | 1 | 1 | 7 | 5 | 59 | 3,93 | 0 | 2 | 2 | 6 | 5 | 59 | 3,933 |
| 1 | 2 | 7 | 2 | 3 | 49 | 3,27 | 1 | 6 | 3 | 2 | 4 | 50 | 3,125 |
| 1 | 1 | 1 | 8 | 4 | 58 | 3,87 | 0 | 1 | 4 | 6 | 5 | 63 | 3,938 |
| 1 | | 4 | 4 | 6 | 59 | 3,93 | 1 | 3 | 3 | 5 | 4 | 56 | 3,5 |
| | | | | | | | | | | | | | |
| | | | | | 524 | 3,91 | | | | | | 534 | 3,76 |

| Total | |
|---|---|
| Total | Ave |
| 235 | 4,05 |
| 218 | 3,77 |
| 242 | 4,19 |
| 225 | 3,94 |
| 221 | 3,88 |
| 225 | 3,95 |
| 180 | 3,10 |
| 223 | 3,77 |
| 209 | 3,61 |
| | |
| 1978 | 3,81 |

School 1: Data Summary

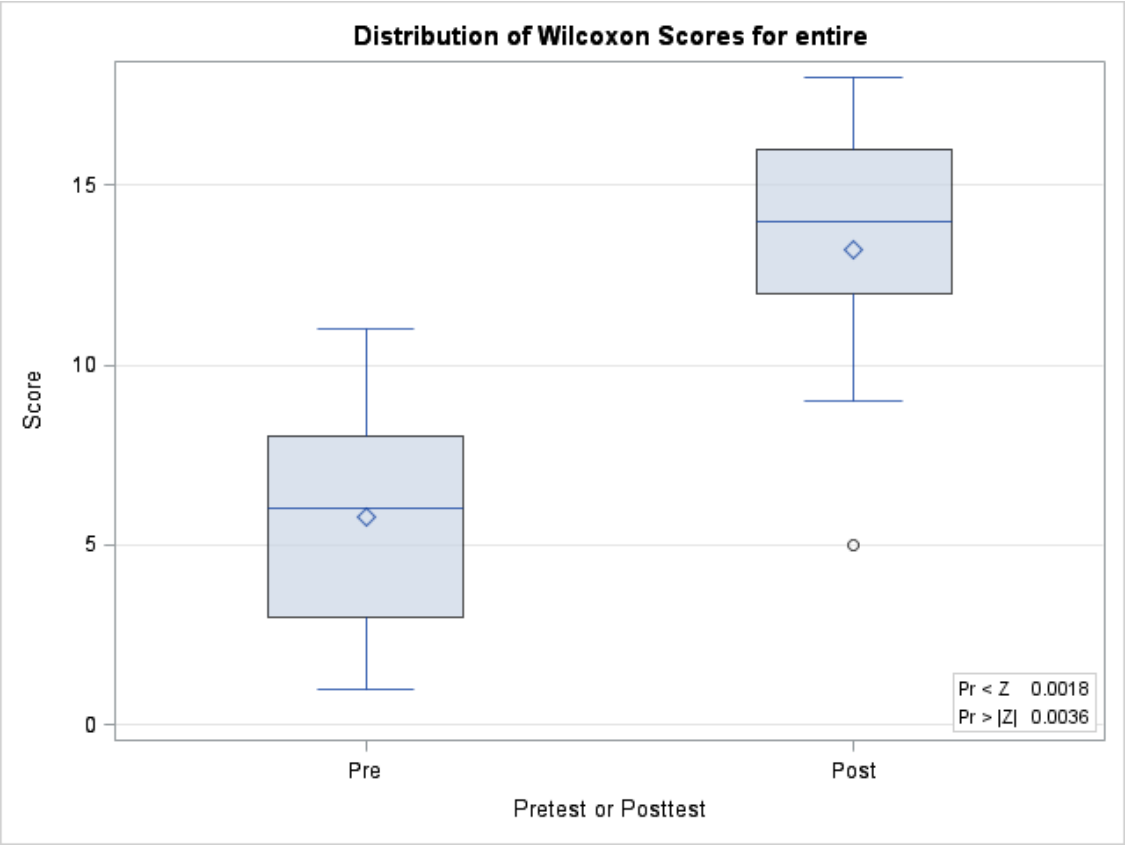
| Boys pre | | | Boys post | | | | Girls pre | | | Girls post | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ave | | | Ave | | | | Ave | | | Ave |
| | 3,491071 | | | 3,873214 | | | | 3,457486 | | | 4,047058 |
| | 2,858929 | | | 3,903571 | | | | 2,504144 | | | 3,774473 |
| | 2,450198 | | | 3,760714 | | | | 2,716209 | | | 4,186848 |
| | 3,091071 | | | 3,923214 | | | | 3,37967 | | | 3,944196 |
| | 3,639286 | | | 3,823214 | | | | 3,690385 | | | 3,882692 |
| | 3,516071 | | | 3,871429 | | | | 3,604178 | | | 3,950183 |
| | 2,807143 | | | 3,219318 | | | | 2,752518 | | | 3,103411 |
| | 3,207143 | | | 3,7 | | | | 3,159066 | | | 3,77247 |
| | 2,892857 | | | 3,40377 | | | | 3,011393 | | | 3,605586 |
| | | | | | | | | | | | |
| | 3,105974 | | | 3,719827 | | | | 3,141672 | | | 3,807435 |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | 52,64936 | | % interest | 67,99568 | | | % interest | 53,5418 | | % interest | 70,18588 |
| | | | | | | | | | | | |
| | | | % inc | 15,34632 | | | | | | % inc | 16,64408 |

| | Whole school | | 26 boys and 58 girls. | | | |
|---|---|---|---|---|---|---|
| Pre-tests | | Ave | | Post-tests | | Ave |
| | | 3,467882 | | | | 3,993249 |
| | | 2,613958 | | | | 3,814432 |
| | | 2,633872 | | | | 4,054949 |
| | | 3,290342 | | | | 3,937702 |
| | | 3,674568 | | | | 3,864282 |
| | | 3,576907 | | | | 3,925807 |
| | | 2,769426 | | | | 3,139287 |
| | | 3,173947 | | | | 3,750039 |
| | | 2,974703 | | | | 3,543119 |
| | | | | | | |
| | | 3,130623 | | | | 3,780319 |
| | | | | | | |
| | | | | | | |
| | % interest | 53,26557 | | | % interest | 69,50796 |
| | | | | | | |
| | | | | % inc | | 16,24239 |
| | | | | | | |
| | | | % inc of amount available | | | 34,75466 |

The average increase in interest level per learner for the whole school is 16.24%

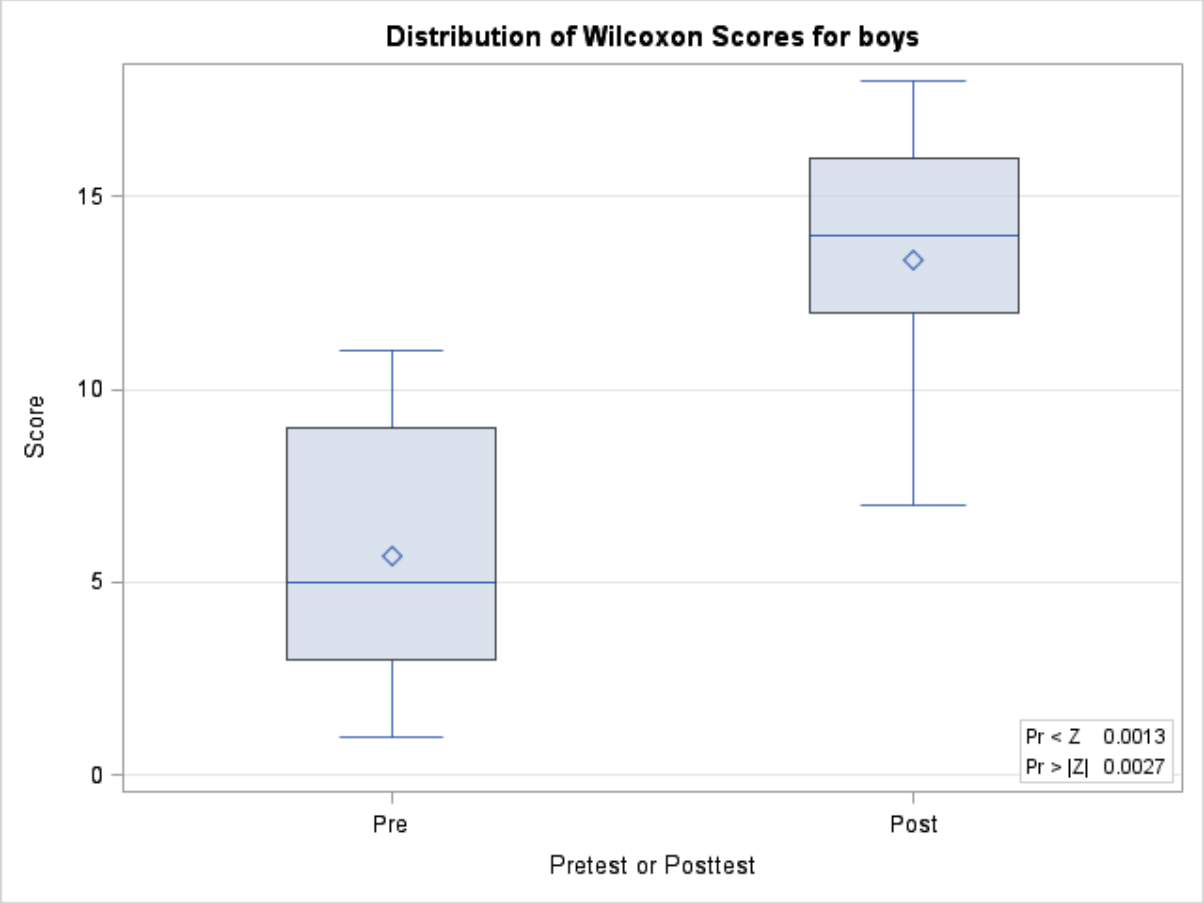
If we take the possible amount of increase available from the initial interest level of 53.27%, the increase in interest becomes 34.75%.

Graph of results for school 1: Distribution of Wilcoxon scores for the whole school.




Graph of results for school 1: Distribution of Wilcoxon scores for the girls.

Graph of results for school 1: Distribution of Wilcoxon scores for the boys.



## **Addendum F**: **School 2 results**: One class of 20 learners, 13 boys and 7 girls**.**

Addendum F: School 2: One class Boys and Girls Pre-test Data

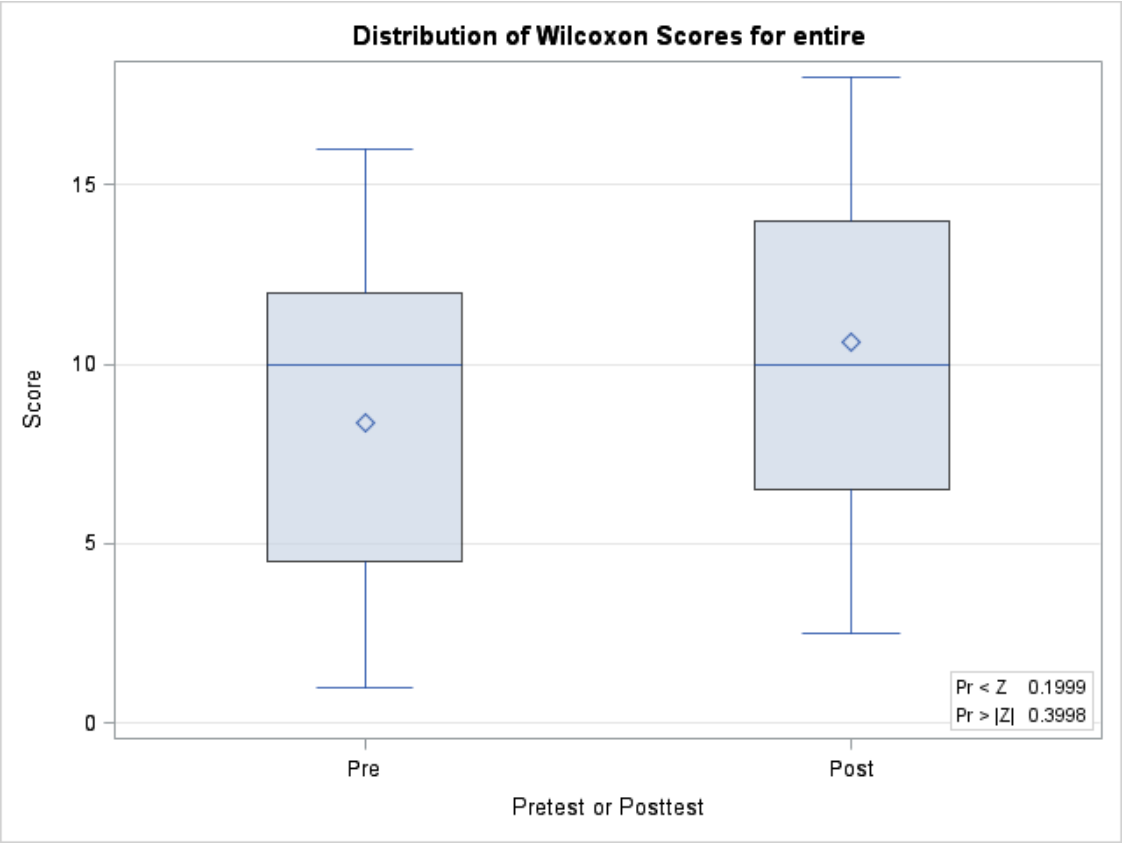
| School 2 | Boys | | Pre-test | | | | | | Girls | | Post-test | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre-tests | 1 | 2 | 3 | 4 | 5 | Total | Ave | | 1 | 2 | 3 | 4 | 5 | Total | Ave |
| 1 | 2 | 1 | 5 | 5 | 0 | 39 | 3 | | | 2 | 3 | 2 | | 21 | 3 |
| 2 | 2 | 2 | 7 | 2 | 0 | 35 | 2,692 | | 1 | 4 | 1 | 1 | | 16 | 2,286 |
| 3 | 1 | 3 | 2 | 5 | 0 | 33 | 3 | | | 1 | 2 | 4 | | 24 | 3,429 |
| 4 | 1 | 2 | 3 | 5 | 2 | 44 | 3,385 | | | 1 | 3 | 1 | 2 | 25 | 3,571 |
| 5 | 0 | 3 | 2 | 3 | 5 | 49 | 3,769 | | 1 | 1 | | 2 | 3 | 26 | 3,714 |
| 6 | 1 | 2 | 4 | 2 | 4 | 45 | 3,462 | | | 0 | 2 | 2 | 3 | 29 | 4,143 |
| 7 | 3 | 2 | 5 | 3 | 0 | 34 | 2,615 | | 1 | 0 | 1 | 0 | 5 | 29 | 4,143 |
| 8 | 1 | 3 | 2 | 5 | 2 | 43 | 3,308 | | | 1 | 1 | 0 | 4 | 25 | 4,167 |
| 9 | 1 | 1 | 6 | 4 | 1 | 42 | 3,231 | | 1 | 0 | 1 | 2 | 3 | 27 | 3,857 |
| | | | | | | | | | | | | | | | |
| | | | | | | 364 | 3,162 | | | | | | | 222 | 3,59 |

Boys and Girls Post-test Data

| | Boys | | Post-test | | | | | | Girls | | Post-test | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Post | 1 | 2 | 3 | 4 | 5 | Total | Ave | | 1 | 2 | 3 | 4 | 5 | Total | Ave |
| | 1 | 0 | 0 | 9 | 3 | 52 | 4,00 | | 1 | | 0 | 6 | | 25 | 3,571 |
| | 1 | 1 | 5 | 1 | 5 | 47 | 3,62 | | | 1 | 1 | 4 | 1 | 26 | 3,714 |
| | 1 | 0 | 2 | 7 | 3 | 50 | 3,85 | | 0 | 0 | 2 | 3 | 2 | 28 | 4 |
| | 2 | 2 | 3 | 3 | 3 | 42 | 3,23 | | 1 | 2 | | 0 | 4 | 25 | 3,571 |
| | 2 | 2 | 2 | 4 | 3 | 43 | 3,31 | | 0 | 3 | | 0 | 4 | 26 | 3,714 |
| | 2 | 1 | 3 | 5 | 1 | 38 | 3,17 | | 0 | | 1 | 1 | 5 | 32 | 4,571 |
| | 4 | 3 | 1 | 4 | 1 | 34 | 2,62 | | 1 | 1 | 1 | 0 | 4 | 26 | 3,714 |
| | 2 | 1 | 3 | 4 | 3 | 44 | 3,38 | | 2 | | | 3 | 2 | 24 | 3,429 |
| | 2 | 3 | 3 | 3 | 2 | 39 | 3,00 | | 0 | 1 | 2 | 0 | 4 | 28 | 4 |
| | | | | | | | | | | | | | | | |
| | | | | | | 389 | 3,35 | | | | | | | 240 | 3,81 |
| | | | | | | | | | | | | | | | |
| | | | | | | % inc | 4,736 | | | | | | | % inc | 5,489 |

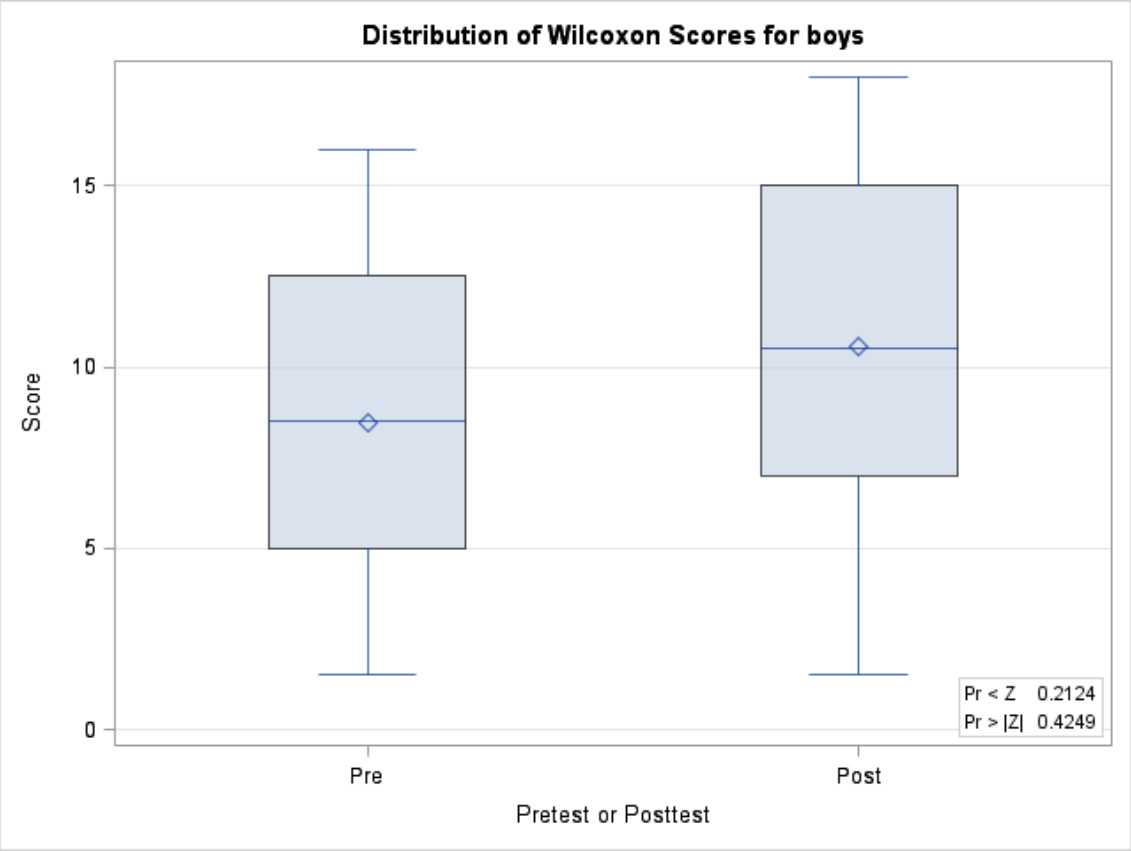
| Whole school | | boys 13 girls 7 | | |
|---|---|---|---|---|
| Pre-test | Ave | | Post-test | Ave |
| | 3,00 | | | 3,85 |
| | 2,55 | | | 3,65 |
| | 3,15 | | | 3,90 |
| | 3,45 | | | 3,35 |
| | 3,75 | | | 3,45 |
| | 3,70 | | | 3,66 |
| | 3,15 | | | 3,00 |
| | 3,61 | | | 3,40 |
| | 3,45 | | | 3,35 |
| | | | | |
| | 3,31 | | | 3,51 |
| | | | | |
| % int | 57,80 | | % int | 62,80 |
| | | | | |
| | Overall % inc | | 5,00 | |
| % inc of amount available | | | 11,8486 | |

Graph of results for school 2: Distribution of Wilcoxon scores for the whole school.




Graph of results for school 2: Distribution of Wilcoxon scores for the girls.

Graph of results for school 2: Distribution of Wilcoxon scores for the boys.



## **Addendum G**: **School 3 results**: 33 Learners, 23 boys and 10 girls.

Addendum G: School 3: One class group Boys and Girls Pre-test Data

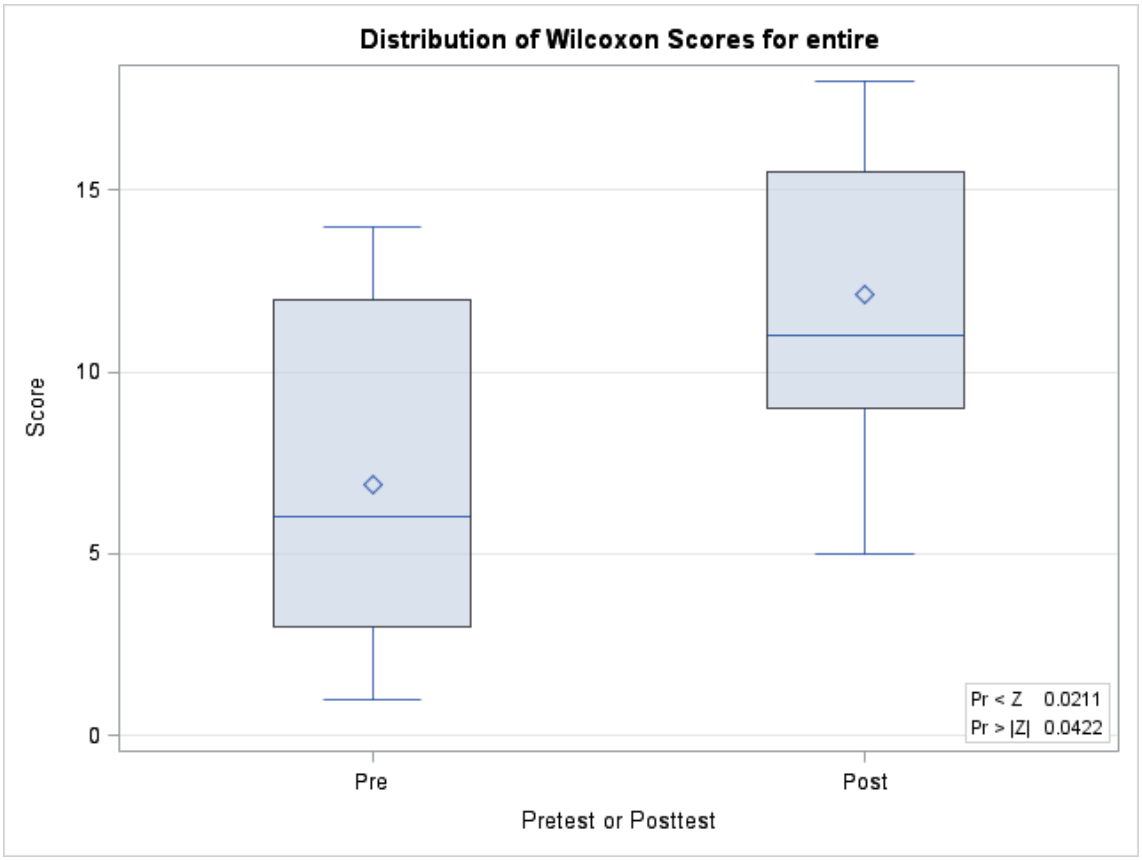
| School 3 | | 23 Boys | | | | | | | 10 Girls | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre-tests | 1 | 2 | 3 | 4 | 5 | Total | Ave | | 1 | 2 | 3 | 4 | 5 | Total | Ave |
| 1 | 2 | 3 | 7 | 9 | 5 | 90 | 3,462 | | 2 | 0 | 3 | 5 | 1 | 36 | 3,273 |
| 2 | 6 | 10 | 5 | 2 | 0 | 49 | 2,13 | | 5 | 1 | 3 | 1 | | 20 | 2 |
| 3 | 7 | 7 | 6 | 3 | 1 | 56 | 2,333 | | 5 | 4 | 1 | 0 | 1 | 21 | 1,909 |
| 4 | 7 | 3 | 8 | 5 | 2 | 67 | 2,68 | | 3 | 1 | 4 | 2 | 2 | 35 | 2,917 |
| 5 | 3 | 3 | 5 | 5 | 9 | 89 | 3,56 | | 2 | 2 | 2 | 3 | 2 | 34 | 3,091 |
| 6 | 2 | 2 | 5 | 14 | 2 | 87 | 3,48 | | 2 | 1 | 4 | 2 | 2 | 34 | 3,091 |
| 7 | 7 | 4 | 8 | 6 | 0 | 63 | 2,52 | | 4 | 3 | 1 | 2 | 1 | 26 | 2,364 |
| 8 | 5 | 6 | 7 | 3 | 4 | 70 | 2,8 | | 3 | 1 | 2 | 3 | 2 | 33 | 3 |
| 9 | 5 | 9 | 4 | 6 | 1 | 64 | 2,56 | | 2 | 2 | 5 | 1 | 1 | 30 | 2,727 |
| | | | | | | | | | | | | | | | |
| | | | | | | 635 | 2,836 | | | | | | | 269 | 2,708 |
| | | | | | | | | | | | | | | | |
| | | | | | | % int | 45,9 | | | | | | | % int | 42,7 |

Boys and Girls Post-test Data

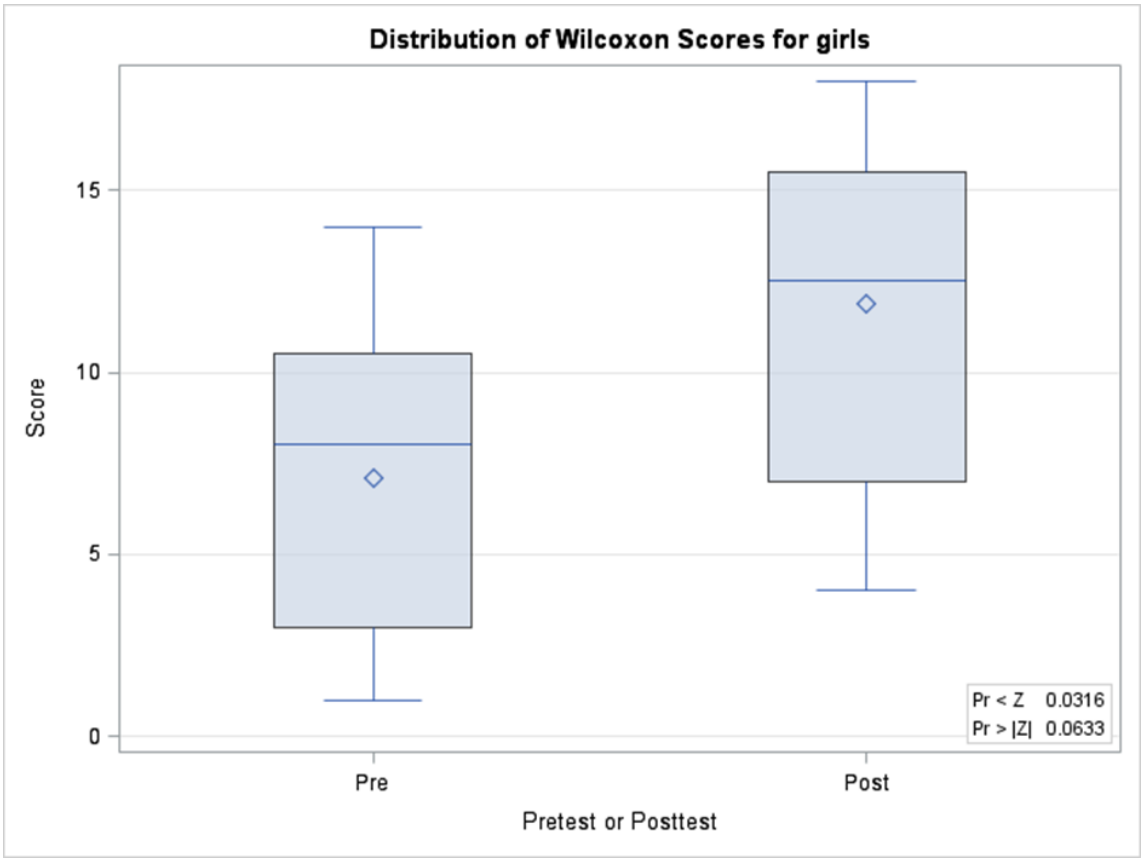
| | Boys | | Post | | | | | | Girls | | Post | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Post | 1 | 2 | 3 | 4 | 5 | Total | Ave | | 1 | 2 | 3 | 4 | 5 | Total | Ave |
| | 0 | 1 | 5 | 9 | 8 | 93 | 4,04 | | 2 | | 0 | 4 | 4 | 38 | 3,8 |
| | 1 | 1 | 11 | 7 | 3 | 79 | 3,43 | | 2 | 3 | 0 | 4 | 1 | 29 | 2,9 |
| | 0 | 2 | 10 | 8 | 4 | 86 | 3,58 | | 2 | 1 | 0 | 7 | 0 | 32 | 3,2 |
| | 2 | 2 | 4 | 9 | 5 | 79 | 3,59 | | 3 | 2 | 1 | 4 | 0 | 26 | 2,6 |
| | 2 | 3 | 5 | 8 | 5 | 80 | 3,48 | | 1 | 2 | 1 | 5 | 1 | 33 | 3,3 |
| | 3 | 1 | 6 | 8 | 5 | 80 | 3,48 | | 2 | | 2 | 5 | 1 | 33 | 3,3 |
| | 4 | 4 | 10 | 2 | 2 | 60 | 2,73 | | 3 | 3 | 1 | 2 | 1 | 25 | 2,5 |
| | 3 | 3 | 7 | 7 | 3 | 73 | 3,17 | | 2 | | 2 | 3 | 2 | 30 | 3,333 |
| | 1 | 5 | 8 | 3 | 6 | 77 | 3,35 | | 1 | 2 | 2 | 4 | 1 | 32 | 3,2 |
| | | | | | | | | | | | | | | | |
| | | | | | | 707 | 3,43 | | | | | | | 278 | 3,126 |
| | | | | | | | | | | | | | | | |
| | | | | | | % int | 60,72 | | | | | | | % int | 53,15 |
| | | | | | | | | | | | | | | | |
| | | | | | % increase boys | | 14,81 | | | | | | % increase girls | | 10,45 |

| | Whole School | | Boys 23 | Girls 10 | |
|---|---|---|---|---|---|
| | | Ave | | | Ave |
| Pre-test | | 3,40 | | Post-test | 3,97 |
| | | 2,09 | | | 3,27 |
| | | 2,20 | | | 3,47 |
| | | 2,75 | | | 3,29 |
| | | 3,42 | | | 3,42 |
| | | 3,36 | | | 3,42 |
| | | 2,47 | | | 2,66 |
| | | 2,86 | | | 3,22 |
| | | 2,61 | | | 3,30 |
| | | | | | |
| | | 2,80 | | | 3,34 |
| | | | | | |
| | % int | 44,93 | | | 58,423 |
| | | | | | |
| | | | | | |
| | | Overall % inc | | 13,49 | |
| | | | | | |
| | % inc of amount available | | | 24,5 | |

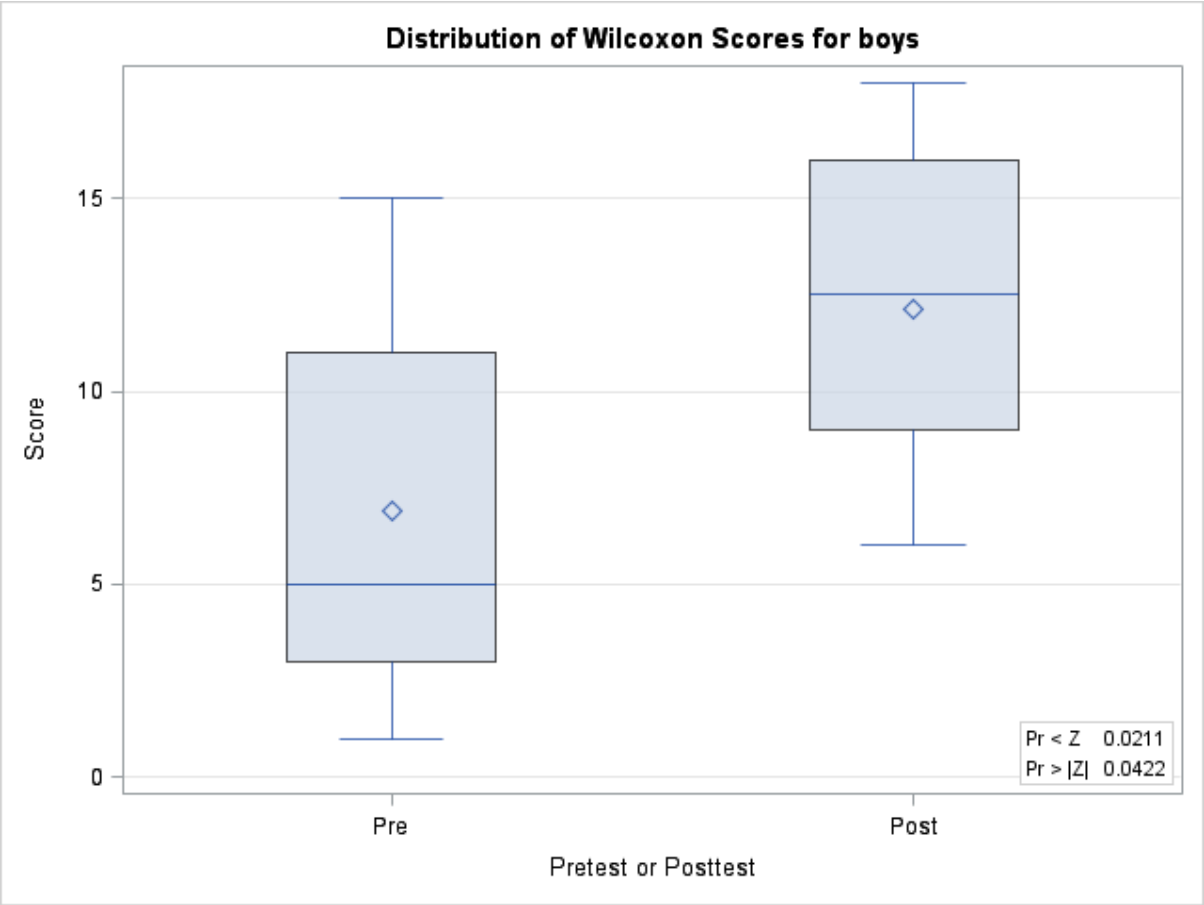
Graph of results for school 3: Distribution of Wilcoxon scores for the whole sample.




Graph of results for school 3: Distribution of Wilcoxon scores for the girls.



Graph of results for school 3: Distribution of Wilcoxon scores for the boys.



**Addendum H**: **School 4 results**: 3 Classes, 85 learners: 60 boys and 25 girls

Boys Pre-test Data

| School 4 | 60 Boys | | 1 | | | | | | | 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre-tests | 1 | 2 | 3 | 4 | 5 | Total 1 | Ave | 1 | 2 | 3 | 4 | 5 | Total 2 | Ave |
| 1 | 0 | 5 | 6 | 6 | 2 | 62 | 3,263 | | 2 | 1 | 8 | 4 | 59 | 3,933 |
| 2 | 1 | 10 | 5 | 3 | 0 | 48 | 2,526 | 1 | 4 | 6 | 4 | | 43 | 2,867 |
| 3 | 2 | 6 | 5 | 5 | 1 | 54 | 2,842 | 1 | 4 | 7 | 1 | 1 | 39 | 2,786 |
| 4 | 0 | 3 | 3 | 7 | 6 | 73 | 3,842 | 1 | 0 | 2 | 8 | 4 | 59 | 3,933 |
| 5 | 1 | 0 | 0 | 6 | 12 | 85 | 4,474 | | 0 | 1 | 5 | 9 | 68 | 4,533 |
| 6 | 1 | 3 | 1 | 9 | 5 | 71 | 3,737 | 1 | 0 | 2 | 5 | 7 | 62 | 4,133 |
| 7 | 2 | 4 | 3 | 7 | 3 | 62 | 3,263 | 1 | 1 | 5 | 5 | 3 | 53 | 3,533 |
| 8 | 1 | 2 | 4 | 2 | 10 | 75 | 3,947 | | 1 | 2 | 9 | 3 | 59 | 3,933 |
| 9 | 0 | 2 | 5 | 9 | 4 | 75 | 3,75 | 1 | 2 | 3 | 3 | 5 | 51 | 3,643 |
| | | | | | | | | | | | | | | |
| | | | | | | 605 | 3,516 | | | | | | 493 | 3,699 |
| | | | | | | % Int | 62,9 | | | | | | % Int | 67,49 |

| | | 3 | | | | | | Total boys | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | Total 3 | Ave | | Total | Ave |
| | 1 | 5 | 11 | 9 | 106 | 4,08 | | 227 | 3,76 |
| 2 | 3 | 10 | 10 | 1 | 83 | 3,19 | | 174 | 2,86 |
| 2 | 5 | 7 | 10 | 2 | 83 | 3,19 | | 176 | 2,94 |
| 0 | 1 | 5 | 8 | 12 | 109 | 4,19 | | 241 | 3,99 |
| 0 | 0 | 1 | 8 | 17 | 120 | 4,62 | | 273 | 4,54 |
| 0 | 3 | 3 | 9 | 11 | 106 | 4,08 | | 239 | 3,98 |
| 0 | 3 | 10 | 7 | 6 | 94 | 3,62 | | 209 | 3,47 |
| 0 | 2 | 6 | 11 | 7 | 101 | 3,88 | | 235 | 3,92 |
| 2 | 3 | 8 | 5 | 8 | 92 | 3,54 | | 218 | 3,64 |
| | | | | | | | | | |
| | | | | | 894 | 3,82 | | 1992 | 3,68 |
| | | | | | % Int | 70,51 | | % Int | 66,97 |

School 4: 3 Classes Girls Pre-test Data

| School 4 | Girls | | Group 1 | | | | | | | Group 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre-tests | 1 | 2 | 3 | 4 | 5 | Total 1 | | 1 | 2 | 3 | 4 | 5 | Total 2 | Ave |
| 1 | 1 | 1 | 3 | 3 | 0 | 24 | 3 | 1 | 1 | 1 | 7 | 0 | 34 | 3,4 |
| 2 | 2 | 5 | 0 | 1 | | 16 | 2 | 1 | 4 | 2 | 3 | 0 | 27 | 2,7 |
| 3 | 2 | 5 | 0 | 1 | 0 | 16 | 2 | 3 | 4 | 2 | 0 | 1 | 22 | 2,2 |
| 4 | 0 | 0 | 1 | 2 | 4 | 31 | 4,429 | 0 | 0 | 2 | 4 | 4 | 42 | 4,2 |
| 5 | 0 | 1 | 0 | 4 | 3 | 33 | 4,125 | | 0 | 0 | 2 | 7 | 43 | 4,78 |
| 6 | 0 | 0 | 1 | 2 | 5 | 36 | 4,5 | 0 | 2 | 2 | 1 | 5 | 39 | 3,9 |
| 7 | 0 | 1 | 1 | 2 | 4 | 33 | 4,125 | 1 | 2 | 3 | 1 | 3 | 33 | 3,3 |
| 8 | 0 | 0 | 1 | 3 | 4 | 35 | 4,375 | 0 | 2 | 2 | 3 | 3 | 37 | 3,7 |
| 9 | 0 | 0 | 1 | 1 | 6 | 37 | 4,625 | 1 | 1 | 4 | 3 | 1 | 32 | 3,2 |
| | | | | | | | | | | | | | | |
| | | | | | | 261 | 3,687 | | | | | | 309 | 3,49 |
| | | | | | | | | | | | | | | |
| | | | | | | % Int | 67,1627 | | | | | | % Int | 62,1605 |

| | | Group 3 | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | Total 3 | Ave | | Points | Ave |
| | 0 | 0 | 6 | 1 | 29 | 4,14 | | 87 | 3,51 |
| 0 | 3 | 1 | 2 | 1 | 22 | 3,14 | | 65 | 2,61 |
| 2 | 1 | 2 | 2 | | 18 | 2,57 | | 56 | 2,26 |
| | 1 | 2 | 1 | 3 | 27 | 3,86 | | 100 | 4,16 |
| 1 | 0 | 0 | 2 | 4 | 29 | 4,14 | | 105 | 4,35 |
| 0 | 0 | 0 | 3 | 4 | 32 | 4,57 | | 107 | 4,32 |
| 0 | 0 | 1 | 4 | 2 | 29 | 4,14 | | 95 | 3,86 |
| 0 | 0 | 0 | 3 | 4 | 32 | 4,57 | | 104 | 4,22 |
| 0 | 0 | 1 | 3 | 3 | 30 | 4,29 | | 99 | 4,04 |
| | | | | | | | | | |
| | | | | | 248 | 3,94 | | 818 | 3,70 |
| | | | | | | | | | |
| | | | | | % Int | 73,4127 | | % Int | 67,5786 |

School 4: 3 Classes Boys Post-Test Data

| School 4 | Boys | | 1 | | | | | | | 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Post-tests | 1 | 2 | 3 | 4 | 5 | Total 1 | Ave | 1 | 2 | 3 | 4 | 5 | Total 2 | Ave |
| 1 | 0 | 0 | 2 | 10 | 6 | 76 | 4,222 | 1 | | 1 | 7 | 6 | 62 | 4,133 |
| 2 | 0 | 1 | 3 | 9 | 5 | 72 | 4 | 1 | 1 | 2 | 10 | 1 | 54 | 3,6 |
| 3 | 0 | 1 | 7 | 8 | 2 | 65 | 3,611 | | 2 | 4 | 7 | 2 | 54 | 3,6 |
| 4 | 0 | 2 | 0 | 7 | 9 | 77 | 4,278 | 1 | 0 | 1 | 5 | 8 | 64 | 4,267 |
| 5 | 0 | 1 | 1 | 5 | 11 | 80 | 4,444 | | 0 | 4 | 2 | 9 | 65 | 4,333 |
| 6 | 2 | 0 | 1 | 8 | 7 | 72 | 4 | | 0 | 1 | 8 | 6 | 65 | 4,333 |
| 7 | 2 | 1 | 2 | 9 | 4 | 66 | 3,667 | 0 | 3 | 2 | 7 | 3 | 55 | 3,667 |
| 8 | 1 | 1 | 2 | 3 | 11 | 76 | 4,222 | | 1 | 1 | 9 | 4 | 61 | 4,067 |
| 9 | 0 | 1 | 1 | 7 | 9 | 78 | 4,333 | 0 | 0 | 4 | 7 | 3 | 55 | 3,929 |
| | | | | | | | | | | | | | | |
| | | | | | | 662 | 4,086 | | | | | | 535 | 3,992 |
| | | | | | | | | | | | | | | |
| | | | | | | % Int | 77,16 | | | | | | % Int | 74,8 |

| | | Group 3 | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | Total 3 | Ave | | Points | Ave |
| | 0 | 2 | 12 | 12 | 114 | 4,38 | | 252 | 4,25 |
| 0 | 2 | 4 | 11 | 9 | 105 | 4,04 | | 231 | 3,88 |
| | 0 | 7 | 10 | 9 | 106 | 4,08 | | 225 | 3,76 |
| 0 | | 3 | 12 | 11 | 112 | 4,31 | | 253 | 4,28 |
| 0 | 1 | 1 | 8 | 16 | 117 | 4,50 | | 262 | 4,43 |
| 0 | 3 | 2 | 5 | 16 | 112 | 4,31 | | 249 | 4,21 |
| 0 | 3 | 5 | 7 | 11 | 104 | 4,00 | | 225 | 3,78 |
| 0 | 3 | 2 | 9 | 12 | 108 | 4,15 | | 245 | 4,15 |
| 2 | 0 | 7 | 8 | 9 | 100 | 3,85 | | 233 | 4,04 |
| | | | | | | | | | |
| | | | | | 978 | 4,18 | | 2175 | 4,09 |
| | | | | | | | | | |
| | | | | | % Int | 79,49 | | % Int | 77,15 |

School 4: 3 Classes Girls Post-test Data

| School 4 | Girls | | Group 1 | | | | | | | Group 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Post-tests | 1 | 2 | 3 | 4 | 5 | Total 1 | Ave | 1 | 2 | 3 | 4 | 5 | Total 2 | Ave |
| 1 | 0 | 1 | 0 | 5 | 1 | 27 | 3,857 | | 0 | 0 | 7 | 3 | 43 | 4,3 |
| 2 | 0 | 1 | 2 | 3 | 2 | 30 | 3,75 | 1 | 1 | 3 | 2 | 3 | 35 | 3,5 |
| 3 | 1 | 0 | 2 | 5 | 0 | 27 | 3,375 | 1 | 4 | 1 | 2 | 2 | 30 | 3 |
| 4 | 0 | 0 | 1 | 5 | 2 | 33 | 4,125 | 0 | 1 | 0 | 5 | 4 | 42 | 4,2 |
| 5 | 0 | 0 | 1 | 5 | 2 | 33 | 4,125 | | 0 | 1 | 4 | 5 | 44 | 4,4 |
| 6 | 0 | 0 | 1 | 3 | 4 | 35 | 4,375 | 1 | 1 | 0 | 4 | 4 | 39 | 3,9 |
| 7 | 0 | 1 | 2 | 2 | 3 | 31 | 3,875 | 0 | 0 | 4 | 2 | 4 | 40 | 4 |
| 8 | 0 | 0 | 2 | 4 | 2 | 32 | 4 | | 0 | 1 | 5 | 4 | 43 | 4,3 |
| 9 | 0 | 0 | 2 | 2 | 4 | 34 | 4,25 | 1 | 1 | 1 | 3 | 4 | 38 | 3,8 |
| | | | | | | | | | | | | | | |
| | | | | | | 282 | 3,97 | | | | | | 354 | 3,933 |
| | | | | | | | | | | | | | | |
| | | | | | | % Int | 74,26 | | | | | | % Int | 73,33 |

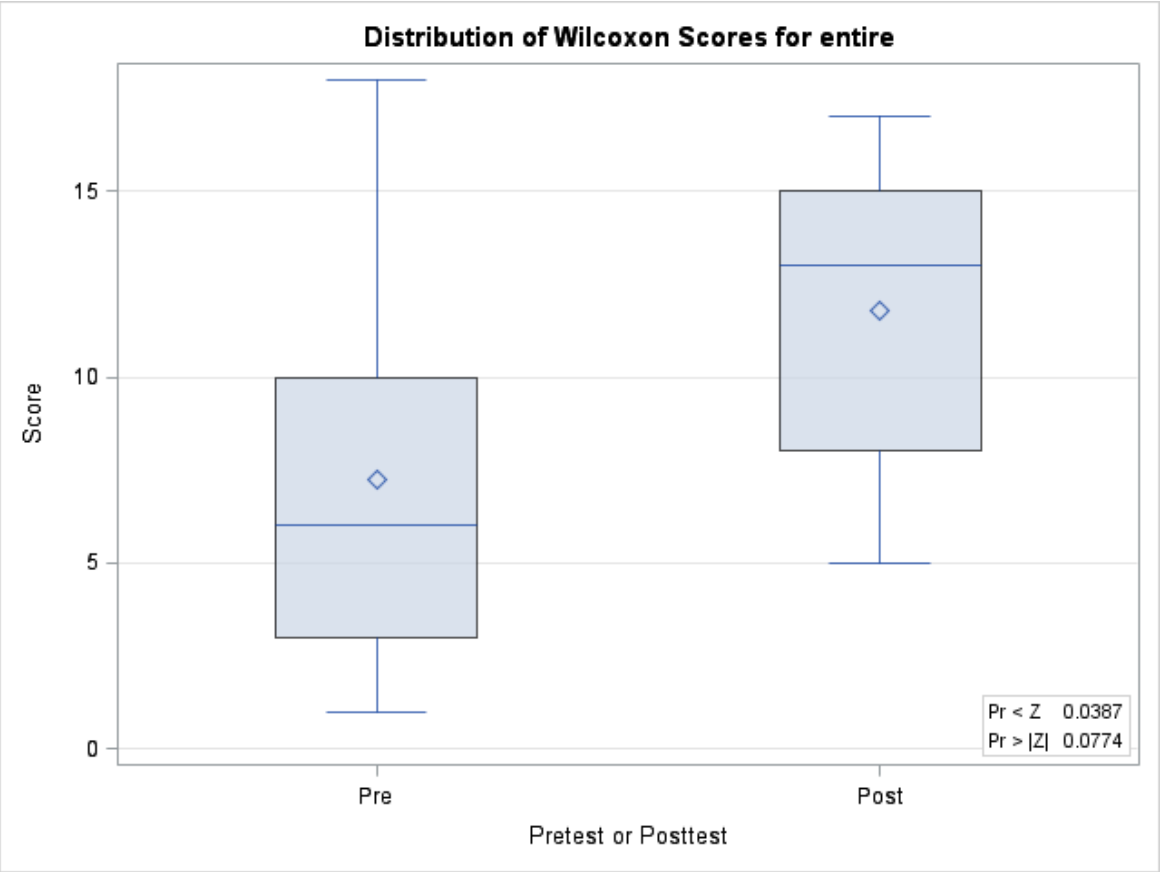
| | | Group 3 | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | Total 3 | Ave | | Points | Ave |
| | 0 | 0 | 5 | 1 | 25 | 4,17 | | 95 | 4,11 |
| 0 | 0 | 0 | 2 | 4 | 28 | 4,67 | | 93 | 3,97 |
| | 0 | 0 | 2 | 4 | 28 | 4,67 | | 85 | 3,68 |
| 0 | | 0 | 0 | 6 | 30 | 5,00 | | 105 | 4,44 |
| 0 | 0 | 0 | 2 | 4 | 28 | 4,67 | | 105 | 4,40 |
| 0 | 0 | 0 | 1 | 5 | 29 | 4,83 | | 103 | 4,37 |
| 0 | 0 | 1 | 2 | 3 | 26 | 4,33 | | 97 | 4,07 |
| 0 | 0 | 0 | 2 | 4 | 28 | 4,67 | | 103 | 4,32 |
| 0 | | 1 | 1 | 4 | 27 | 4,50 | | 99 | 4,18 |
| | | | | | | | | | |
| | | | | | 249 | 4,61 | | 885 | 4,17 |
| | | | | | | | | | |
| | | | | | % Int | 90,28 | | % Int | 79,29 |

School 4: Overall Increase of Interest

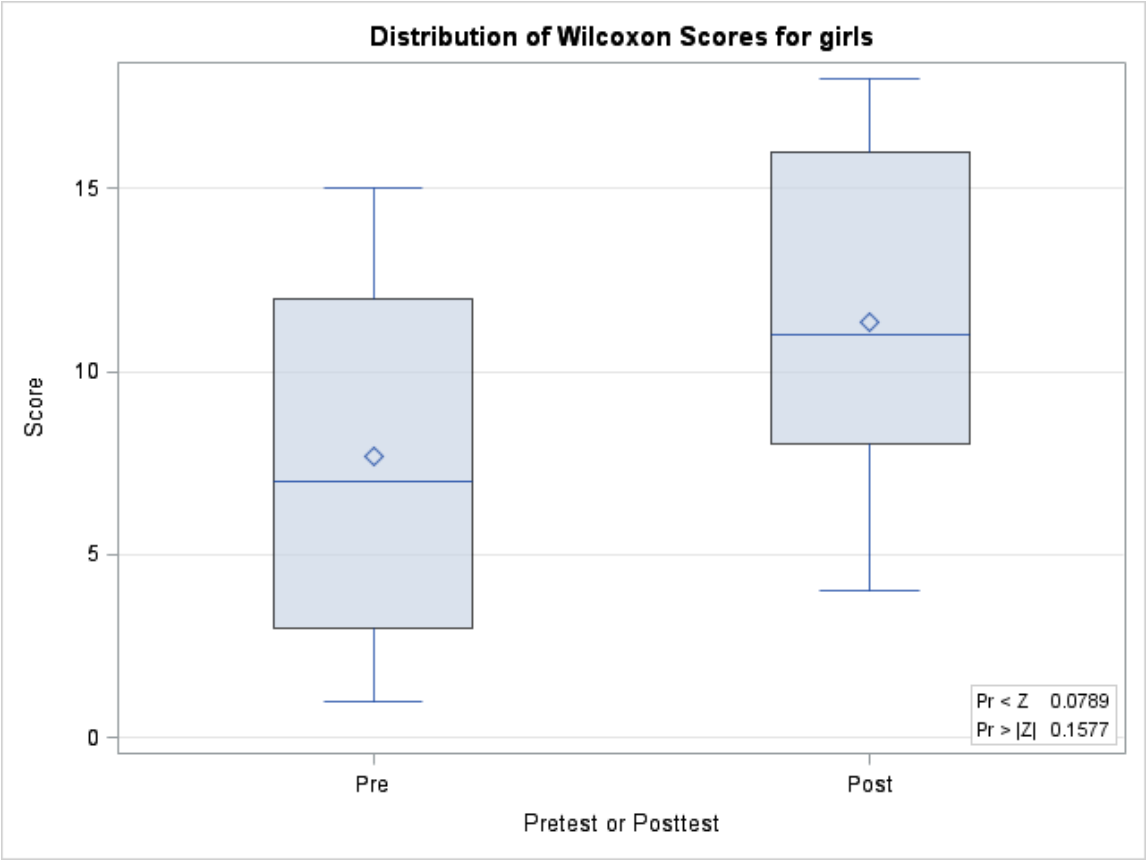
| Boys pre | | | Boys post | | | Girls pre | | | Girls post | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ave | | | Ave | | | Ave | | | Ave |
| | 3,758 | | | 4,2467 | | | 3,51 | | | 4,1079 |
| | 2,862 | | | 3,8795 | | | 2,61 | | | 3,9722 |
| | 2,94 | | | 3,7627 | | | 2,26 | | | 3,6806 |
| | 3,989 | | | 4,2840 | | | 4,16 | | | 4,4417 |
| | 4,541 | | | 4,4259 | | | 4,35 | | | 4,3972 |
| | 3,982 | | | 4,2137 | | | 4,32 | | | 4,3694 |
| | 3,471 | | | 3,7778 | | | 3,86 | | | 4,0694 |
| | 3,922 | | | 4,1476 | | | 4,22 | | | 4,3222 |
| | 3,644 | | | 4,0360 | | | 4,04 | | | 4,1833 |
| | | | | | | | | | | |
| | 3,679 | | | 4,0860 | | | 3,70 | | | 4,1716 |
| | | | | | | | | | | |
| % Int | 66,97 | | % Int | 77,1498 | | % Int | 67,58 | | % Int | 79,2890 |
| | | | | | | | | | | |
| | | | % inc | 10,1825 | | | | | % inc | 11,7104 |

| Whole school | | Boys 60 \girls 25 | | | |
|---|---|---|---|---|---|
| Pre test | Ave | | | Post-test | Ave |
| | 3,6862 | | | | 4,2059 |
| | 2,7890 | | | | 3,9068 |
| | 2,7392 | | | | 3,7385 |
| | 4,0400 | | | | 4,3304 |
| | 4,4843 | | | | 4,4175 |
| | 4,0828 | | | | 4,2595 |
| | 3,5840 | | | | 3,8636 |
| | 4,0082 | | | | 4,1989 |
| | 3,7594 | | | | 4,0793 |
| | | | | | |
| | 3,6859 | | | | 4,1112 |
| | | | | | |
| % Int | 67,1470 | | | % Int | 77,7789 |
| | | | | | |
| | | | | % inc | 10,6319 |
| | | | | | |
| | | | | | |
| % increase of amount remaining | | | | | 32,3621 |

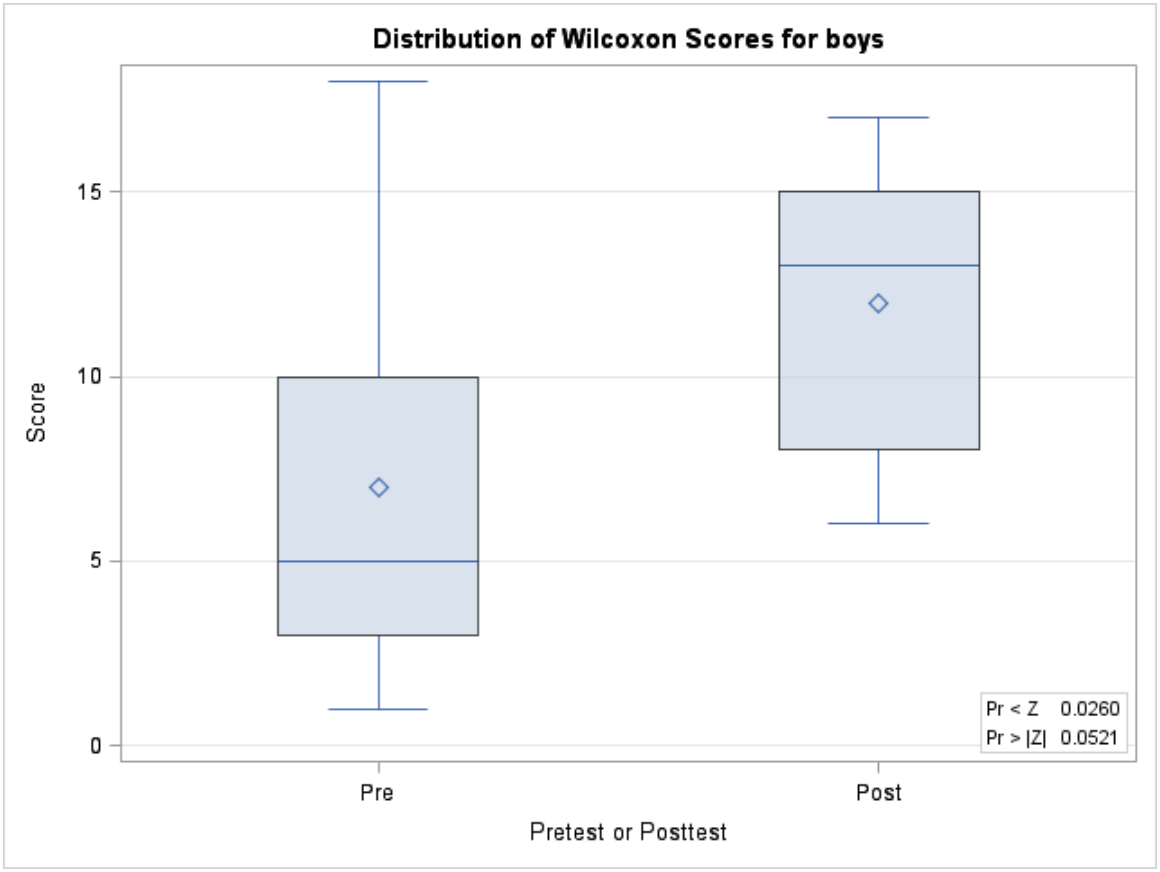
Graph of results for school 4: Distribution of Wilcoxon scores for the whole school.




Graph of results for school 4: Distribution of Wilcoxon scores for the girls.



Graph of results for school 4: Distribution of Wilcoxon scores for the boys.



## **Addendum I**: **Participating Schools' Summary Data**:

| Total sample of 222 learners from all 4 schools | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Pre-test Averages | | 1 | 2 | 3 | 4 | | Total Ave | % ave |
| Q | 1 | 3,4679 | 3,0000 | 3,4043 | 3,6862 | | 3,50 | 62,50 |
| u | 2 | 2,6140 | 2,5500 | 2,0909 | 2,7890 | | 2,60 | 39,94 |
| e | 3 | 2,6339 | 3,1500 | 2,2048 | 2,7392 | | 2,66 | 41,42 |
| s | 4 | 3,2903 | 3,4500 | 2,7517 | 4,0400 | | 3,51 | 62,79 |
| t | 5 | 3,6746 | 3,7500 | 3,4179 | 4,4843 | | 3,95 | 73,83 |
| i | 6 | 3,5769 | 3,7000 | 3,3621 | 4,0828 | | 3,75 | 68,74 |
| o | 7 | 2,7694 | 3,1500 | 2,4726 | 3,5840 | | 3,07 | 51,79 |
| n | 8 | 3,1739 | 3,6083 | 2,8606 | 4,0082 | | 3,49 | 62,15 |
| s | 9 | 2,9747 | 3,4500 | 2,6107 | 3,7594 | | 3,26 | 56,60 |
| | | | | | | | | |
| | | 3,1306 | 3,3120 | 2,7973 | 3,6859 | | 3,31 | 57,75 |
| | % | 53,2656 | 57,8009 | 44,9322 | 67,1470 | | 57,75 | |
| Post-test Averages | | 1 | 2 | 3 | 4 | | Total Ave | % Ave |
| Q | 1 | 3,9932 | 3,8500 | 3,9697 | 4,2059 | | 4,06 | 76,46 |
| u | 2 | 3,8144 | 3,6500 | 3,2727 | 3,9068 | | 3,75 | 68,86 |
| e | 3 | 4,0549 | 3,9000 | 3,4672 | 3,7385 | | 3,83 | 70,81 |
| s | 4 | 3,9377 | 3,3500 | 3,2906 | 4,3304 | | 3,94 | 73,47 |
| t | 5 | 3,8643 | 3,4500 | 3,4242 | 4,4175 | | 3,97 | 74,33 |
| i | 6 | 3,9258 | 3,6583 | 3,4242 | 4,2595 | | 3,95 | 73,87 |
| o | 7 | 3,1393 | 3,0000 | 2,6584 | 3,8636 | | 3,33 | 58,31 |
| n | 8 | 3,7500 | 3,4000 | 3,2222 | 4,1989 | | 3,81 | 70,30 |
| s | 9 | 3,5431 | 3,3500 | 3,3030 | 4,0793 | | 3,70 | 67,38 |
| | | | | | | | | |
| | | 3,7803 | 3,5120 | 3,3369 | 4,1112 | | 3,82 | 70,42 |
| | % | 69,5080 | 62,8009 | 58,4232 | 77,7789 | | 70,42 | |
| | | | | | | | | |
| | % diff | 16,2424 | 5,0000 | 13,4911 | 10,6319 | | | 12,67 |

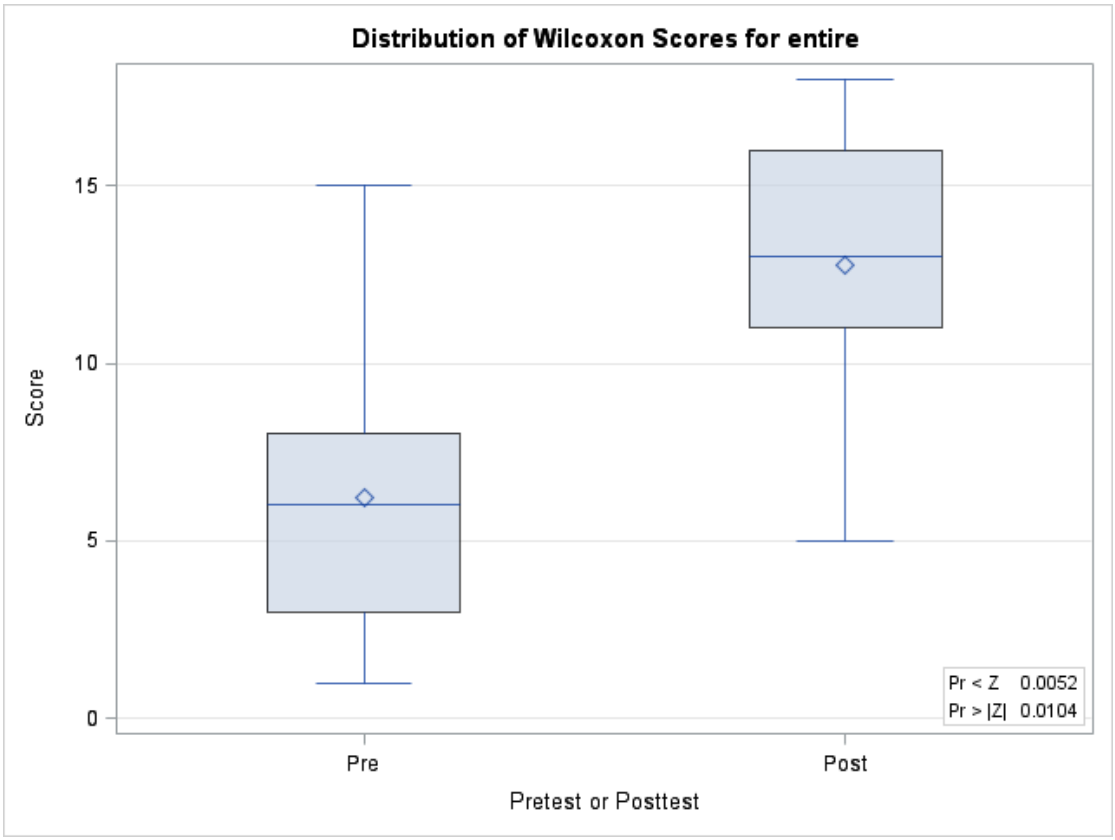
| | Overall increase using the schools averages | | | | | | |
|---|---|---|---|---|---|---|---|
| School | 1 | 2 | 3 | 4 | | total % diff | |
| | 16,2424 | 5,0000 | 13,4911 | 10,6319 | | 12,6724 | |
| | 84 | 20 | 33 | 85 | | | |

| | Overall increase using the average increase of each question | | | |
|---|---|---|---|---|
| | | Difference | % diff | % of available amount |
| | | | | |
| Q | 1 | 0,5584 | 13,96 | 37,2233 |
| u | 2 | 1,1570 | 28,92 | 48,1569 |
| e | 3 | 1,1756 | 29,39 | 50,1711 |
| s | 4 | 0,4272 | 10,68 | 28,7057 |
| t | 5 | 0,0201 | 0,50 | 1,9241 |
| i | 6 | 0,2052 | 5,13 | 16,4093 |
| o | 7 | 0,2611 | 6,53 | 13,5391 |
| n | 8 | 0,3260 | 8,15 | 21,5321 |
| s | 9 | 0,4315 | 10,79 | 24,8531 |
| | | | | |
| | Ave | 0,5069 | 12,67 | 29,9942 |
| | | | | |
| | | | | |
| | | | | |
| | % inc of amount available using school avarages | | | 30,2482 |

Here we see a slight difference in the resultant values between those obtained using the individual questions and using the school averages, of just over 0,25%. The cause of this is rounding off of values.

The true answer can clearly be seen to be about 30% increase in the amount of increase available; just under one third of the available increase possible.

Graph of results for all schools: Distribution of Wilcoxon scores for the whole sample.




Graph of results for all schools: Distribution of Wilcoxon scores for the girls.

Graph of results for all schools: Distribution of Wilcoxon scores for the boys.