A content analysis of scientific news in two South African daily newspapers

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Abstract

In a world that is increasingly shaped by science and technological developments, the need for scientists and for scientifically literate people is as real in South Africa as it is globally. Science education and science communication are two fields that address the science needs of these two groups of people in a society. While science education produces future scientists and engineers, it is science communication that provides the science information that the general citizens need to participate fully and thoughtfully on scientific issues in their society. A review of literature related to this study determined that most studies of newspaper science coverage were conducted extensively in developed countries while here in South Africa and other African countries the field is still relatively under researched. It is within this context that this study sought to determine how two South African newspapers namely the Star and the Citizen, covered science news between the 1st of January 2014 to the 30th June 2015. A content analysis of news articles was conducted using the framing perspective to examine how the two newspapers portrayed scientific news. The science articles were further analysed to determine their relevance to South African science classrooms in a bid to bridge the gap between science in newspapers and school science.

The content analysis of the 44 selected articles determined that the newspapers covered science news mainly in the physics, chemistry, general science, environmental and ecology fields. The newspapers mainly portrayed science news in the social progress and the economic development and competitiveness frames. Science articles were seen to be relevant to science education as resource materials to link school science and everyday life and to generally promote scientific literacy. It was therefore recommended that teachers should consider using science articles in the media to enhance science learning thereby providing their learners with a holistic approach to science education.

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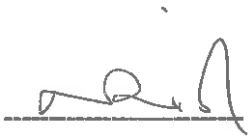
- My husband Bruce, children Anesu and Atipa who complete my life.
- Lastly to God, from whom all blessings flow.

Plagiarism Declaration

I declare that this report is my own unaided work. It is being submitted in partial fulfilment of the requirements for the degree of Masters (MSc) in Science Education at the University of Witswatersrand. It has not been submitted before for any other degree or examination in any other university.



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Chapter 1

Background to the study

1.1 Introduction

After formal school, the only contact that most people have with science is through magazines, the radio, television and newspapers. These methods of communication have been used to inform people about the work that the science community continues to do in different fields. This has over time led to the development of the field of science communication which acts as a channel and an interpreter of scientific news from the science community to the general public.

According to Boerger (2015) the basic function of a newspaper is: to inform, interpret the news, provide a service to readers, and to entertain. While the newspapers strive to perform all these four functions for their readers, in most cases, a newspaper will tend to focus on one function more than others. This study seeks to look at how selected South African newspapers inform and interpret scientific news for the 12.4-million South Africans that buy the urban dailies and 5.5-million South Africans who receive community newspapers. Priest (2010) commented that some science reports in newspapers are simply reprinted press releases from experts in the science field. Not much effort is made to process the information into simpler words that readers can get. The reports often speak in scientific jargon that most people cannot understand creating misconceptions and in some cases perpetuating myths and misunderstandings in the reader's minds. Could this be the case with our own newspapers in South Africa? This study aims to find out.

Nature has it that people tend to be interested in current issues that directly impact their lives. Currently the issue of electricity shortage is on everyone's lips in South Africa. Load shedding schedules seem to be here to stay, at least for the foreseeable future[1]. The drought that the country is also experiencing has also resulted in water shortages, compounding South Africa's woes. One would think that those interested in educating the public about science issues would take this opportunity to inform and educate the people about the use of alternative sources energy such as solar energy. This is an example of relevant and useful science news for the average South African at this point. Science teachers and environmentalist may use such news articles as teaching resources. It was therefore another purpose of this study, to determine the relevance of scientific news reported in the newspapers to the South African people in general and to the science learner in the classrooms of South Africa.

[1] At the time of the research, South Africa was experiencing electrical power challenges and water shortages.

1.2 Purpose Statement

This study sought to determine how scientific news was reported by two daily newspapers namely The Citizen and The Star, from the 1st of January 2014 to the 30th June 2015. The following questions guided the study:

- Which science fields received the most coverage in the Star and the Citizen newspapers from January 2014 to June 2015?
- How was the science portrayed in the two papers?
- What school science could be learnt (if any) in the newspapers during the selected time?

1.3 Rationale

As this study trod the precarious path between science education and science communication questions of the aim and the purpose of the study come to mind. Much care needed to be taken that the research did not become more of journalism research than an educational one as I endeavoured to determine the scientific news that newspapers feed a good percentage of South Africans every day. Davis and Russ (2015) stated that these two fields share a common goal of "helping non-experts and non-members of the professional science community develop knowledge of content and processes of scientific research" (p. 222). The researchers pointed out that it is in science education that adults are equipped to understand scientific issues that they later encounter as science communication in the media. They further argue that it is time that both fields can learn from each other and then together seek ways to increase the scientific literacy of the society. Hence this research endeavoured to determine if and how science education can benefit from scientific news in the media.

On June the 7th 2012, IOL news published an article entitled "Shocking statistics on SA education". In the article the writer, Mtshali (2012) reported that when 100 learners enrol for grade 1, only 40 of the learners will reach grade 12. Out of the 40 that reach grade 12, 28 will actually pass matric. 4 out of the 28 will enter university and one of the four will eventually graduate. This paints a gloomy picture for the South African education picture as a whole and even a gloomier picture for science education in particular. Less than half of the 40 learners who reach matric take science as a subject at this level. From then on the chances of pursuing science as a career become nonexistent. Yet science or some form of science touches almost all aspects of our lives. From health, technology, environmental issues and even in issues of religion, science follows us. Newspapers are one way of keeping the general public informed and even continue learning about new developments in these scientific issues.

Over the years researchers such as Yager (1992) have discussed scientific literacy, which affords people from all walks of life the scientific knowledge that is required to respond to scientific issues which so directly impact their lives. In turn, research into teaching and learning has since introduced

an approach to teaching science, known as Science-Technology-Society (STS) in response to this need for a scientifically literate society. Aikenhead (1994) defined STS as "teaching about natural phenomena in a manner that embeds science in the technological and social environments of the student" (p.48). STS teaching is about combining science content with society and technology contexts and I believe newspapers may provide the much needed resources for the success of this approach to science teaching.

Given the said large number of people that newspapers come in contact with daily or weekly, one would want to determine the kind of scientific news that gets to the public and how the news is reported in different papers. This speaks to the first and the second research questions. On the other hand one would also want to see if the newspapers provide the 'science for living' I mentioned earlier and if the papers can be used in science education to help learners learn some of the abstract science concepts that seem to allude many. In light of this, one can then say that the results of my study in response to the third research question could be valuable to science teaching and to the educational system as a whole.

Davis and Russ (2015) stated that "despite the fact that reading popular science news articles is a widespread practice, few studies have directly investigated learning in this context" (p.247). This study aimed to add to the literature on learning science in informal contexts in general and in newspapers in particular. While my study did not set out to determine if learning occurs after reading a scientific newspaper article, it sought to determine opportunities for learning a school relevant science in the scientific news articles reported by two South African daily newspapers mentioned in section 1.2 above. In a review of literature related to my study I gathered that the bulk of studies conducted on science in the media were mainly conducted in the western world. A number of science news studies were done on framing climate change in countries such as Nigeria, Kenya and Ghana. Of the few studies that were conducted on science coverage in the media in Africa, the studies by Van Rooyen (2002) and Turner (2008) were relevant to my study. These two studies focused on science news reported in newspapers based in Gauteng and in Cape Town respectively. Conducting this study also gave me the opportunity to see if some research findings of science newspapers studies conducted abroad hold true for us here in South Africa.

I set out to conduct the research without any particular newspapers in mind since my knowledge of South African newspapers was limited. To carry out the study, the purposive/purposeful sampling strategy was used to select two newspapers from the large number of South African newspapers in circulation. I eventually selected two newspapers namely The Citizen and the Star. The two papers were firstly selected because of their substantial readership and circulation in South Africa. Secondly the two papers were widely distributed in the Gauteng province and were aimed at literate English readers. I discuss the sampling methods employed in this study in more detail later on in section 3.3.

An internet search of science news articles in the Star and the Citizen newspapers yielded a total of 44 articles that could best answer the research questions. Two newspapers content analysis of 44 science newspaper articles from the Star and the Citizen newspapers from the period of January 2014 to June 2015 was conducted. Articles were analysed using pre-determined codes to determine what and how science news was reported. I refer to these predetermined codes in detail later in section 3.3, when I discuss the study methodology in detail in chapter 3. In Chapters 4, the quantitative and the qualitative findings of this study are presented and discussed in response to the first two research questions which sought to determine the science field that received the most coverage and to determine how the science news was portrayed by the Star and the Citizen newspapers during the study time frame. Chapter 5 responds to the third research question. In this chapter I discuss the possibility of using science articles from the newspapers to enhance the teaching and learning in the classroom. The study then winds down in chapter 6, with a summary of the study findings, conclusions, recommendations and lastly some reflections on the study as a whole. Meanwhile, I turn to a discussion of the literature that this study drew on in chapter 2.

Chapter 2

Conceptual Framework

2.1 Introduction

In the early years of one's lifetime, attending school is a right that each child should be afforded. In this school context the content to be learnt is often prescribed by the curriculum as determined by the government. In science education the same is true and in the pursuit of syllabus completion, some teachers tend to focus only on content that is relevant to examinations. In such situations a learner who asks other questions which may not necessarily be in the syllabus often are reminded to stay on the concepts as outlined by the curriculum. In many science classrooms curiosity and creativity is not encouraged as teachers race to complete the syllabus. Noting this, Albert Einstein came to the conclusion that 'it is a miracle that curiosity survives formal education' yet interest and curiosity is essential for learning science.

After school, some people go into the world of work while others go into various business ventures. Most never come in contact with science again except in science articles in the media often out of sheer curiosity. A trip to the shops or the doctor often brings in new 'scientific knowledge' in the form of the many magazines one turns to after a long wait in the queue. My friend reads many articles on anti-aging remedies that the media reports as proven scientific research; another friend changes her diet every month in response to new researches in the media that often promise working solutions to her long battle with weight. All these people are adults who have left formal science classes but who still turn to the media for the many 'scientific issues' that so directly impact their lives. This goes to show the impact that the media has as a source of knowledge for the many folk that listen to news reports and read newspapers and magazines. One might then wonder if all the scientific articles that one finds in the media are based on real science. It is therefore the purpose of this study to do a content analysis of two South African newspapers to answer this question.

The research reviewed in this chapter is therefore literature that focused on analyses of science content in newspapers, science, science education, science communication, learning science in school contexts, learning science in out-of-school contexts in general and learning science in newspapers in particular. I will start by discussing content analysis.

2.2 Analyses of Science Content in newspapers

Krippendorff (2013) defined content analysis as a "research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use" (p. 24). This study therefore draws from a number of content analysis studies that have been done since the 1940s when newspapers were analysed for political propaganda (Wimmer and Dominick 1987). Content analysis has been a principal research method for analysing newspaper articles since then and it is to these studies that I turned to understand how content analysis works.

A content analysis of agricultural issues reported in two major Nigerian daily newspapers was conducted by Awojobi and Adeokun (2012). This is an example of the interdisciplinary use of content analysis of newspapers for varied reasons. In this case the study used the Punch and the Guardian to determine the extent to which daily newspapers were involved in disseminating agricultural information. Eighty (80) newspapers between 2007 and 2010 were analysed for daily reportage, space allocation and types of stories. The study results showed that 70%, 78.8%, 66.3% and 60% of the newspapers analysed in the years 2007, 2008, 2009 and 2010 respectively, did not report any agricultural issues. The study concluded that the papers could not have played a significant role in the improvement of agricultural production and urged papers to publish more agricultural relevant news.
In the science field, Schäfer (2010) conducted a meta-analysis research on the written media science coverage of existing studies. The study sought to contrast and combine findings from a number of studies on science coverage in the media from the years 1960's to 2000s. From the many science articles to choose from, the research's final sample consisted of 215 publications, 201 journal articles and 14 books.
For inter-coder reliability, two coders pre-tested the coding scheme, discussed coding decisions, and finally coded the publications. Data were coded on to an electronic code sheet. Coding included details about the articles' publication (author, title, journal, publication date), about the text's subject (scientific discipline(s), media type, country of focus, period of analysis), and about its methodology (cross-sectional, longitudinal, case study, qualitative vs. quantitative, random or other sampling strategy).

The study sought to determine how scientific topics were evaluated in the mass media; what frames (if any) were found. The study was also aimed at finding out if the authors of the sample articles had searched for and/or found biased reporting. While this study looked at the sciences broadly, it still yielded results that are meaningful to my present study. Firstly, the study determined that while science has received a growing amount of coverage over the last decades, media coverage has mostly been in the natural sciences while neglecting the social sciences and humanities. The study determined that researchers were using a mixture of research designs and methods and that the recent availability of full texts databases has since allowed researchers to conduct more comprehensive studies easily than in the past. Schäfer (2010) also determined that media coverage

in the Western countries was most often analysed, with almost no African, South American, or Asian countries in the literature. Lastly, print media were the most prominent media type analysed, due to the accessibility of databases and the relative ease of analysis which, unlike television analysis, does not require sound or moving image coding. Schäfer (2010) therefore recommended that the analysis of media coverage shift away from the natural sciences, Western countries, and print media. My study will add to literature on science media coverage in Africa broadly and in South Africa in particular.
Related to my study is a research conducted by Hijmans, Pleijter and Wester (2003). This was a content analysis study of scientific news coverage in Dutch newspapers. The study set out to find out how much attention newspapers paid to the coverage of scientific research related topics while focusing on the research background, methods, ranges of uncertainty and the probable risks and/or benefits the research outcomes might imply. The study found out that the papers showed a relatively high attention to scientific research but the news lacked the research backgrounds and its methodological aspects. It was also determined that the scientific news did not discuss the relevance of research findings.

The second part of the study by Hijmans et. al (2003) was conducted by the interviewing of ten news editors and science journalists. The interviews showed that "for journalists, reporting on scientific research means avoidance of complex information in science news section" (p. 171). This shows that by the time one reads a newspaper paper article, one does not read the news as it came from the scientist, but one also reads the science as interpreted by the journalist. Readers of newspapers must therefore be wary of quoting newspaper articles as authorities on scientific issues. It is then of great importance that science journalists should have some level of scientific competency to better convey correct scientific news to the public. How correct the science news is reported in the newspapers could have prompted researchers such as McIlwaine (2003) to carry out a study to determine how much real science Australian and New Zealand newspapers published between the years 1996 to 2002.

To answer this question, McIlwaine (2003) conducted an analysis of nine newspapers from Australia and one from New Zealand. The study used strict criteria to filter out what the researchers called non-core science and pseudo-science which included news in the computer technology, consumer health, astrology and lifestyle news. The study then focussed on all the other science news. McIlwaine (2003) determined that there was a general increase in the amount of science news reported in the papers during that period. McIlwaine (2003) concluded that the quantity of 'real science' in the papers is often determined by the availability of newspaper space in response to local or global economic conditions. When there are more advertisements or more pertinent news at hand, science news reporting tended to diminish.

Content analysis may also be used to determine trends in newspapers as Gordon, Deines and Havice (2010) set out to do. Their study sought to determine how intensely the issue of global warming was

reported in 144 articles published between the years 2004 to 2006 in a Mexican newspaper called the Reforma. The study used the framing perspective and determined that the ecology/science frame and consequences frames were the most intensely reported frames. I also used the framing perspective in my study to determine how The Star and The Citizen newspapers framed science news. I will discuss framing in detail in section 2.6.

A study of media coverage of science and technology in Africa was conducted in 2011 by a research team from the Makerere University's Department of Journalism and Communication. Led by Lugalambi (2011), the study set out to determine the nature, the volume, the quality and the scope of science and technology reporting in the African media. The researchers also endeavoured to "examine the conditions that foster and those that impede the coverage of science and technology" (p. 4) in the media. Content analyses of selected newspapers from Cameroon, Kenya, Ghana, Namibia, Uganda and South Africa were conducted at selected times to yield the data which was necessary to answer some of the research questions. Interviews were also conducted in some countries to gather the views of scientists, policy makers and journalists about the coverage of science and technology in the media.

The study determined that "science and technology were inadequately covered, or the coverage was uninformed and sometimes sensational" (Lugalambi et. al, 2011, p. 10). The researchers attributed the minimal coverage of science and technology news to the lack of specialized knowledge and competence on the part of African journalist. It was seen that while the journalists acknowledged their inadequacies, newsrooms in Africa were however not investing in improving their science news reporting coverage capacities. It was determined that science news articles tended to be sensational in order to sell the papers. This was a bone of contention between the journalists and scientists, with the latter accusing the former of misrepresenting the scientific community in order to appeal to the newspaper consumers. In their recommendations Lugambi et.al (2011) suggested that the media in Africa should have explicit policies and guidelines for the coverage of science and technology issues. Secondly, media organizations were urged to invest in people with science and technology backgrounds to cover science news in ways that can be understood by the public while still 'keeping the science in the science articles'.

Closer home, a study on science and technology coverage in the South African print media was conducted by Rooyen (2002). This was a quantitative content analysis of South African newspapers to identify its large-scale patterns and trends. Fifteen South African publications were monitored over a period of three months, from 18th March to 17th June 2002. South African regional and national print media titles, which reflect a geographical and cultural diversity in its target markets and are produced by South African based companies, were selected.

The project was a team effort that involved 22 students from the Department of Journalism at the University of Stellenbosch. The students had to monitor the publications on a weekly basis and

complete a questionnaire on the relevant science articles published. A project leader monitored the selected articles and compiled an electronic database. At the end of the study the team concluded that the small percentage of science and technology articles published during the research period pointed to a lack of science and technology coverage in the South African press. They also found that the local press is too dependent on foreign publications and news agencies in the provision of science stories and recommended that similar studies be conducted often at different intervals to assess scientific news coverage in newspapers in South Africa.

The study by Turner (2008) also sought to compare the coverage of science news by six Cape Town newspapers namely the Cape Argus, Cape Times and Die Burger, Saturday Argus, Sunday Argus and the Saturday Edition of the Die Burger. The study was conducted between the 1st of June and the 31st of July 2007. A content analysis of 3116 articles was conducted to determine how the papers differed in the way they portrayed science news. The researcher also sought to find out what caused the differences and hypothesized that science writers' scientific knowledge, level of education, interests, beliefs about reporting and their interactions with newspaper structures were the factors that influenced science news coverage.

Turner (2008) used a mixed approach to research methodology in that she coupled content analysis of the news articles with questionnaires and interviews to determine editors and journalists' views and attitudes towards science reporting. From the findings, the researcher concluded that the papers with the most science coverage were the Cape Times and the Saturday Argus and that life sciences, health and medicine were the fields that were covered the most during that period of time. The study confirmed some the findings by Rooyen (2002) I referred to above. It was found out that the presence of science journalists or editors on the newspaper staff did not necessarily increase the amount of science coverage. This suggests that in covering science news, other factors besides journalist attitudes and knowledge play a significant part in what the public finally receives as science news.

The studies discussed above are some of the many examples of the use of content analysis. This illustrates the popularity of newspapers as readily available sources of data that may be analysed to gather information on how different issues are presented in the print media. I decided to also conduct a content analysis of two South African newspapers to determine what science and how the science is portrayed in the papers. One might then ask, what is science?

2.3 Science

Krippendorff (2013) stated that the "nature of text demands that content analysts draw specific inferences from a body of texts to their chosen context" (p. 30). In this study the chosen context is science in the newspapers and so I will briefly discuss what science is in the context of this study.
Some science teachers like me often define science terms such as dynamics, kinematics electrostatics and even electricity, but have never thought to define science. Feynman (1998) discussed the plural nature of science and described science as a word that is used to describe three things and stated that "science is used to sometimes refer to a special method of finding things out, while in other times science refers to the body of knowledge arising from the things found out and lastly science also refers to the new things one can do or the actual doing of new things" (p. 5). In most cases what people generally call science is actually technology which is often the practical part of science. Noting this plural nature of science mentioned above, this study will take Feynman's (1998) second definition of science 'as the body of knowledge arising from the things found out', and focus on other fields of science reported in newspapers except science in the field of health and technology. I decided to omit these two fields because they are by nature designed to inform, and make people aware of what they can do with the newfound science. Secondly, I think science in the health and technology fields may be more relevant to science communication in the public understanding of science than to science education. Omitting these two fields from the research categories helped the study remain relevant to science education which in turn made it easier to respond to the third research question which sought to determine the school science that could be learnt in newspaper articles published in the Star and the Citizen newspapers between the 1st of January 2014 and the 30th of June 2015.

Ziman (1984) stated that science has historical, philosophical, sociological, psychological, and economical aspects. These four aspects are interlinked in education that focuses on the acquisition of knowledge, the development of technological inquiry, problem solving and decision-making skills by an individual in school contexts and in out-of-school contexts. This is an education that continues throughout life, starting as science education in formal school and continuing in out-of-school contexts as science communication. In the following section I will therefore discuss how learning science occurs in the school context first, followed by learning science in out-of school contexts in general and in newspapers in particular. Lastly, I will endeavour to show how these contexts can be used to complement one another in achieving the goal of at least, a scientifically literate society.

2.4 Learning Science

Alanis Morissette, a rock singer, sings a song entitled "you learn". In the song she explains how people learn in all of life's situations. This song resonates well with the belief that people learn in all contexts and that it is in light of these contexts that we view all things, including the learning of new knowledge that people often encounter in school. This is especially true in this twenty first century where the boundaries between formal and informal learning contexts are fast disappearing as technology advances. Teachers, in particular science teachers are then left with a task to take advantage of this fact and look to out-of-school learning centres for such opportunities for learning and use them to complement school knowledge. The media may provide students with opportunities to learn scientific concepts. Rennie (2007) reviewed literature on learning science in museums, on field trips, science centres and from the media and came to the conclusion that "teachers should link the out of school experiences and formal science education since the two are components of one inclusive education system" (p.155).

Almost on a daily basis my learners ask questions about scientific news they would have encountered in the media. In some cases the questions apply to the topic at hand and in other cases they do not. As a teacher, when the questions apply, the questions provide a lead to a discussion that often becomes a meaningful learning experience for my learners. This is what Davis and Russ (2015) meant when they challenged science teachers to "create contexts in which productive framings are activated and then encourage students to apply those same framings to science texts" (p. 246). I do this when I use my learners' prior knowledge to make sense of new knowledge. This is well in line with constructivist learning theory which holds the view that knowledge is constructed by the mental activities of learners. Learners are allowed to construct their own knowledge and fulfil their individual learning needs and interests. Constructivists maintain that learners create new mental schemes based on previous knowledge and /or stage of development and that learning is directly correlated with the motivation to learn. Furth (1970) concluded that "a person has a concept when he assimilates a given situation to available general schemes or from another perspective, when he accommodates general schemes to particular schemes" (p. 39).

The policy statement for the National Association for Research in Science Teaching (2003) in the USA summed it all up well when the committee agreed that "learning rarely, if ever, occurs and develops from a single experience. Rather learning in general and learning science in particular, is cumulative, emerging over time through a myriad of human experiences....." (cited in Rennie 2007, p. 126). Such experiences may also be found even in reading newspapers. There can therefore be no separation between what one learns in school and what one learns out of school.

2.5 Where school science meets newspaper science

In this 21st century, when the realities of our actions as humans on the environment are fast catching up with us, a scientifically literate society is essential if we hope to salvage whatever is left of the environment. Science teachers are therefore called to adopt a science that focuses on the acquisition of knowledge, the development of technological inquiry, problem solving and decision-making skills by the learners. An approach to teaching that seeks to develop values and ideas that learners can apply in their interactions with science, technology and society for both their local and global community (Hassard, 2005, p. 399). This suggests that learning science should be an activity for all learners if we hope to educate a people who can function in this age of science and technology. Science teachers worth their salt would then seek to know and understand how learning occurs in order to make informed decisions in their classrooms on what and how to teach their students the best way they can. "What a teacher does and how a teacher teaches, is more important in stimulating student learning than a curriculum framework" (Yager, 1992, p.2). It is good to have a sound curriculum framework on paper, it however remains just that unless teachers enact it.

With the constant and rapid technological advances that humans are making, there is need for more scientists, entrepreneurs and 'green' citizens. It therefore rests upon science teachers to employ all at their disposal such as the knowledge gained at science centres, on field trips and in the media, to make scientists of everyone to some extent, hence the need to find a common ground between science education and science communication. Back in 1991, Wellington entitled his essay 'Newspaper science, school science: friends or enemies?' Can the two ever have a common ground? This common ground is determined by the twofold purpose of science education as a field that is, "to prepare future scientists for their professional roles and to prepare citizens for life in a society where science impinges upon private and civic decisions" Feinstein (2015, p. 149).Given this purpose of science education, it would therefore serve the society well to have members who have the "ability to study newspaper science with understanding and with healthy scepticism which will enable them to study critically articles on scientific breakthroughs, crackpots and unconventional professors." (Wellington, 1991, p.370). This ability is the key to a democratic society where individuals can participate in scientific debates and are able to make informed decisions on such matters. This points out to the merits of exposing and teaching learners about science in the media at school level.

A study that illustrated how newspaper articles maybe used in the science classroom was conducted by Jarman and Mcclune (2002). This was a survey of the use of newspapers in science instruction by secondary teachers in Northern Ireland. The survey was conducted in 50 schools where the heads of science departments or their nominees were interviewed to determine the pattern and purpose of newspaper use, the classroom practice and curricular priorities of the teachers. The study findings were much in line with the various components of STS teaching discussed below.

The study determined that out of the 50 heads of department interviewed, only 4 indicated that they did not make use of print media in their science classrooms. The rest stated they used newspapers as teaching resources and for display purposes in the corridors and on notice boards. The researchers reported that 22% of the teachers interviewed said that they would actively search for relevant science news articles to incorporate into their teaching notes, while 66% stated that they used newspaper article in an incidental fashion. The second goal of the study was to determine the intentions of the teachers in using newspaper articles in their classrooms. 76.1% of the teachers stated that they used newspapers to illustrate the links between school science and science in everyday life. One teacher said "I want to stress that science is not something that just happens in Room B2 or happens in their textbooks. It's happening out there and it's happening out there all the time" (Jarman and Mcclune, 2002, p. 1002). Over the years, science students have asked me to explain the relevance of some scientific topics. Often these learners would not get a satisfactory answer as I try to chase the curriculum as required by the Department of Education. Some have even dropped the subject altogether, citing its irrelevance to their lives and chosen careers. As the teachers in the study pointed out, science teachers may use newspaper articles show that science is all around us which in turn promote interest in the subject. Teacher intentions in using newspapers in science classroom also included the use of newspapers to reinforce school science, to present up-to-date information, to respond to pupil enquiry, to promote critical evaluation of material and as resources for project work.

Interestingly, only 4% of the science head of departments interviewed in the study stated that they used newspapers to promote literacy in their classrooms yet literacy is a basic requirement to learning. Vygotsky's (1978) socio-cultural theory suggests that a person's cultural experiences play an important role in the development of higher mental functions in an individual through the internalization of speech. While the advocates of Piaget state that higher mental functions emerge from one's actions, for Vygotsky language is the key to human thinking. Language is the tool that enables an individual to understand the world, to communicate and develop their own knowledge. Learning is dependent on one's ability to understand a language and to order one's thoughts into a language that can be communicated to others. This is the basis of the education system in general. In science education in particular, the scientific community has its own culture and language that one should learn to become a part of. Learning science therefore involves learning to speak 'science'. Wenger (1998, p. 105) seemed to agree when he said that "learning to become a legitimate community participant involves learning how to talk". It is therefore important to learn some form of scientific language in order to understand science. Newspapers may well provide such interesting opportunities for reading and learning science which textbooks often lack and this may well assist learners in developing their literacy skills.

While Jarman and Mcclune (2002) reported that the heads of department cited various advantages to using newspapers in science classrooms, they also noted a number of disadvantages as well. The most frequently cited disadvantage was inaccurate or misleading science. They stated that the

science news articles were often superficial, simplistic and biased. A competent science teacher may even use these flaws in the science news articles to teach learners how to critically think through the information they receive in the media. The fact that most science news covered in the newspapers is seldom related to the curriculum is a disadvantage that some teachers also cited for their reluctance to use newspapers in the classroom. The education policy in Ireland where the research was conducted did not at the time consider science in the media as an issue to be accorded a formal place in the curriculum. Teachers use their own initiative to use newspapers. While this current study has a similar educational context, it is the purpose of this study to determine the extent to which the science news in the Star and the Citizen in South Africa can be used in the science classrooms by teachers who may be so inclined. General findings of the study by Jarman and Mcclune (2002) included the fact that most of the topics in which newspapers were used as resource materials were on environmental issues, followed by health and human biology. Appropriate news articles for physics and chemistry were reported to be scarce and too difficult for learners to understand.

Jarman and Mcclune's (2002) findings discussed above reiterate the fact that there are benefits to using newspapers in the classroom. To teach, one must not only be able to explain facts and concepts, one must be able to show the learners why the facts are worth knowing and how they relate to other concepts in theory and in real life situations. However, to be able to use newspapers effectively a teacher should have a good pedagogical content knowledge (PCK). PCK is a "blend of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented and adapted to diverse interests and abilities of learners" (Wilson 2004 as cited in Bishop and Denley, 2007, p.7). This means that PCK involves even issues such as the learners' conceptions, difficulties in the learning of subject matter, the knowledge of how to help learners learn by employing effective instructional approaches and representations (Heywood and Parker, 2010, p.140). It is knowledge developed by teachers to make the subject matter of particular topics accessible to learners.

Shulman (1986) called PCK "a dimension of subject matter knowledge for teaching....it includes the most powerful analogies, illustrations, examples, explanations and demonstrations, in a word, the ways of representing and formulating the subject that make it comprehensible to others" (p. 9). In a world that is constantly changing both culturally and scientifically, a teacher's PCK is never complete, Bishop and Denley (2007) stated that, "learning to teach science is a journey that takes many twists and turns, but always at the centre is the notion of pedagogical reasoning....where the adaptation and tailoring of ideas and materials involves processes of selection and critical appraisal" (p. 24). This suggests that a science teacher should continually select appropriate learning material, design and tailor activities according to the needs of his/her learners. I discuss the teaching of science in more detail later in section 5.4

The traditional method of teaching science viewed the teacher as the source of knowledge and was aimed at imparting knowledge that would make students pass and go on to the next grade. For most students it was rote learning without much understanding of concepts and their relevance to everyday life. In order to make science make sense to learners STS teaching was introduced. This is in line with the constructivist learning theory I discussed above. The STS approach to science is synonymous with "environmental education, social responsibility, public understanding of science and citizen science" (Hassard, 2005, p. 399). STS teaching focuses on the acquisition of knowledge, the development of technological inquiry, problem solving and decision-making skills by the learner. The approach also seeks to develop values and ideas that learners can apply in their interactions with science, technology and society for both their local and global community.

According to Aikenhead (1994) STS teaching starts from the society where learners realise a problem or a societal question. This often then creates a technological need which in turn drives one to the need for some scientific content knowledge. Lastly the content knowledge then informs technology on the answer to the societal question. This sequence of instruction as suggested by Aikenhead (1994) takes learners through the processes of science. It allows for inquiry as learners identify a societal problem. Learners learn to hypothesis about the problem, design and conduct an appropriate investigation in a bid to solve the problem. Learners also learn to think critically about their findings, come to relevant conclusions and make recommendations. As learners go through these processes students get a deeper understanding of the science and technology involved.

In STS science teaching, learners look at their environment and are encouraged to seek ways of taking care of their environment. Since sustainable development is the term on environmentalists' lips these days, it is through STS teaching that knowledge on sustainable development can be disseminated through the society. Yager (1992) talked of a scientific literacy that STS science teaching affords learners and says that it is this literacy that learners gain as they respond to issues which impact their lives. Their interest and motivation to learn science is thus captured and held.

In STS teaching there are two extremes that science teachers should avoid and settle for the middle ground. One would not want to be so society based in one's teaching as to forget the science. On the other hand one would not want to be so science focused as to forget the relevance and application of the science to the society. In addressing real-life problems the science must be used to either explain or solve societal issues. In class discussions, debates, role play, drama or even projects, the goal is to learn the relevant science (Hassard, 2005; Jegede, 1994; Pedretti, 1999) since it is the role of science education to teach a science that merges one's everyday knowledge and scientific concepts taught at school. Hassard (2005) says "look outwards from science to society to see how science is, or could be applied" (p. 403).This is the science that is needed for these times we live in, a science for life.

Having seen that STS is a way of teaching science that is problem based and takes into account learners social and personal contexts (Hassard, 2005; Jegede, 1994; Pedretti, 1999), a science teacher may want to know how to implement this teaching approach. This is where science in newspapers may be used in STS teaching. Teachers select relevant newspaper articles to use as resources for appropriate topics. According to Hassard (2005) STS content is interdisciplinary in nature. It requires the study of topics such as health, food, agriculture, industry, mineral resources, ethics and social responsibility. While these topics do not necessarily fall in any of the traditional science disciplines, they can be studied across the various disciplines as they are deemed relevant by the teacher. This spoke to the third research question of this present study which sought to determine if the science news articles published in two South African newspapers could be used to enhance the learning and teaching of science in the classrooms.

As seen in the foregoing, the learning of science in both formal school and in the media is largely at the mercy of people who interpret science as it comes from scientists. In the media the science reported is often an interpretation of journalists, reporters, television and radio producers and so on. In education the process of interpreting, filtering and packaging science is carried out by science educators, science teachers, examination boards and members of various science bodies. Science education is aimed at changing thought processes and conceptualizations. (Lewenstein, 2015).On the other hand science communication is largely concerned with science in the hope of changing attitudes and behaviours (Lewenstein, 2015). As much as the goals for science education and science communication are different, both serve the common purpose of increasing the scientific literacy of the society by the interpretation of science. In the following section, I discuss the framing theory to show how framing in science education and in science communication can be productively combined to reach this mutual goal of a scientifically literate society.

2.6 Framing

Davis and Russ (2015) stated that in order to bridge the fields of science communication and science education, focus must be placed on framing as it is used to analyse texts in the two fields. Since this study sought to bridge these two fields, I decided to use framing as my theoretical framework as I conducted a content analysis of science news articles in two South African daily newspapers to determine how science was portrayed and if the science could be used to enhance science teaching and learning.

The most commonly cited definition of framing is to "select some aspects of a perceived reality and make them more salient in a communicating text" (Entman, 1993, p. 52) in a way that promotes a certain meaning. Framing describes how different people view or interpret a piece of text depending on their multi-faceted context. Framing in science communication has been used to shape public perspectives while in science education, framing has been used to "describe teaching and learning by

exploring how individuals or groups make sense of their learning context" David and Russ (2015, p. 227). Concurring with the above definition of framing, Krippendorff (2013) posited that the meanings of a text or discourse are firstly, always brought to it by someone. As stated above the learning of science in both formal school and in the media is therefore largely influenced by the interpreters of science news as it comes from the scientists.

Secondly, texts do not have single meanings but multiple meanings which may be interpreted differently depending on contexts, discourse and the purpose of the text. In the science education context, the meanings of texts or discourse are aimed at changing thought processes and conceptualizations (Lewenstein, 2015) while in science communication they are largely concerned with changing attitudes and behaviours (Lewenstein, 2015). As much as the goals for science education and science communication are different, both serve the common purpose of increasing the scientific literacy of the society by the interpretation of science.

Entman (1993) stated that frames highlight some bits of information about an item that is the subject of a communication by making the bits of information more noticeable, meaningful, or memorable to audiences. Framing has therefore been linked to the agenda setting theory, where those who have the power to influence others decide on what is to be known and believed by others in order to promote or discourage certain attitudes, beliefs and behaviours. In the media what is newsworthy is determined by editors and journalists who often do not see science in the media as educating the public but as making money. This has sometimes been reflected in the way science is reported to the detriment of accurate science. Turner (2008) reported that this is where scientists and journalists have had problems with one another in the past, where the former thought the latter were not presenting the correct science to the public. She pointed out that there has however been more cooperation and collaboration in the reporting of scientific news between journalist and scientist in recent years.

Understanding how and why framing is done makes it possible for one to recognise the frames that would have been used in a piece of writing or discourse. Entman (1993, p. 52) suggested that frames in the news can be examined and identified by 'the presence or absence of certain keywords, stock phrases, stereotyped images, sources of information and sentences that provide thematically reinforcing clusters of facts or judgements". In analysis of texts, key words such as male/female may be used to emphasize gender related issues. In other texts the sentence construction may be aimed at portraying a particular reality. A sentence that reads, 'a fifteen year old mother dropped her child while lighting a cigarette' may be used to emphasize the irresponsible behaviour of teenage mothers. Certain images may also be used to frame issues in pictorial texts hence it has often been stated that a picture says a thousand words. An image of a famous person drinking a certain drink may cause many people to want to drink that type of drink.

In looking for frames in texts it is important to know that frames can either be issue-specific or generic. Issue-specific frames only apply to specific topics, events and issues, while generic frames are not context bound but can be applied to a variety of issues. In this present study, generic frames that are often used in science related public discourse were used to respond to the second research question of this present study which sought to determine how two South African newspapers portrayed science issues.

Davis and Russ (2015) conducted a case study of the changes in science knowledge that occur in a piece of scientific research as it passes from a scientist to a reporter and finally to the general public. The study used data collected from videos and interviews from twenty adults who represented non-scientists, four scientist from a large Midwestern university and fifteen staff members of the university's news service. The data were coded and analysed to determine the frames that shape participants' understanding of scientific knowledge.

In their findings the researchers attributed the changes in scientific knowledge to dynamic framing by each individual at each level and determined that some frames were shared across participants regardless of whether they were scientists, reporters or the general public. This shows that people learn or interpret science in similar ways despite their differences in social and educational levels. Davis and Russ (2015) viewed framing in science education as a dynamic process that evolves from the input of the physical world, the culture, and the social interactions. The researchers posited that "particular framings or sets of knowledge afford—or allow—particular types of reasoning on the part of teachers or students" (Davis and Russ, 2015, p. 228). Framing and learning co-emerge in interaction.

While Davis and Russ (2015) provided a common ground between science communication and science education by focusing on framing, it is Zamith et al. (2012) that provide my research with more insights on framing as a perspective I intend to employ in conducting my study. The study examined how four national newspapers from Argentina, Brazil, Colombia and the United States portrayed climate change in articles published between the 31st of December 2008, and the 1st of January 2010. While the study by Zamith et al. (2012) focused on climate change, my study focussed on scientific news coverage in South Africa in a bid to answer the first research question mentioned in the previous chapter which sought to determine the scientific news the Star and the Citizen report on a daily basis.

Zamith et al. (2012) sought to conduct a comparative study of "how differing contexts may affect climate news coverage and ultimately policymaking and public opinion" (p. 7). Four papers were selected for this study because of their influential statuses in their respective countries and after much scrutiny for climate relevance, a total of 457 articles were selected and those formed the sample for study. A similar sampling method was followed in the current study. A more comprehensive description of the methods followed in this study is explained in the section on research methods in the following chapter.

Zamith et. al. reported that a coding instrument was developed using Nisbet's framework (2009) and applied to the sample articles to determine how climate news was reported. Nisbet's framework (2009, p. 18) comprised of eight frames that could be applied to climate change as shown in table 1 below.

Table 1: Nisbet's Framework

Frame	Defines science issues as
Social progress	A means of improving quality of life or solving problems; alternative interpretation as a way to be in harmony with nature instead of mastering it.
Economic development and competitiveness	An economic investment; market benefit or risk; or a point of local, national, or global competitiveness.
Morality and ethics	A matter of right or wrong; or of respect or disrespect for limits, thresholds, or boundaries.
Scientific and technical uncertainty:	A matter of expert understanding or consensus; a debate over what is known versus unknown; or peer-reviewed, confirmed knowledge versus hype or alarmism.
Runaway science	A need for precaution or action in face of possible catastrophe and out-of-control consequences; or alternatively as fatalism, where there is no way to avoid the consequences or chosen path.
Public accountability and governance:	Research or policy either in the public interest or serving special interests, emphasizing issues of control, transparency, participation, responsiveness, or ownership; or debate over proper use of science and expertise in decision making ("politicization").
Middle way/alternative path	A third way between conflicting or polarized views or options.
Conflict and strategy	A game among elites, such as who is winning or losing the debate; or a battle of personalities or groups (usually a journalist-driven interpretation).

Nisbet's framework (2009, p. 18)

In using Nisbet's framework, the researchers hoped to find out if there were significant differences in the way U.S and South American newspapers firstly framed the issue of climate change, secondly determine the differences in the tone, then the scope and lastly in the classes of sources that were consulted by the media in the different papers.

It was my intention to also conduct a similar study, but mine was to be a study of two papers that cater for two similar audiences to determine their science coverage and the relevance of the scientific news they cover to the present science curriculum in South African schools. To achieve this, I used Nisbet's framework as the conceptual framework that would guide the study analysis. I applied this framework to code my data for the presence or the absence of frames. Some of the frames in the framework such as morality and ethics, public accountability and governance and conflict and strategy lent themselves well to the discussion of socio-scientific issues in the science classroom. Their presence enabled me to answer the third question of my study which aimed to find out if scientific news articles in newspapers could be used in formal school contexts.

The study by Zamith et al. (2012) determined that the different newspapers differed in the volume of attention given to climate change and also in the frames that the papers emphasized. The researchers reported that the newspapers in Brazil and the United States presented the issue of climate change in economic terms and placed emphasis on the policy progress being made to combat the issue. On the other hand, Argentina and Colombia newspapers tended to be alarmists and portrayed climate change as an urgent matter which carried dire consequences for the global village. It was seen that the issue of climate change had become heavily politicized as the main sources of climate change news were government officials.

The issue of climate change in the media was also researched in some Nigerian and South African newspapers by Tabgo (2010). In Nigeria, the national newspapers selected were the Guardian and Vanguard while South Africa the Star and the Guardian were also selected for their high circulation ranges. The study looked at the newspapers' coverage of climate change during two separate first quarters 2009 and 2010, i.e January to March 2009 and January to March 2010. This study also looked at the coverage of climate change in four Ghanaian newspapers namely Daily Graphic, Daily Guide, Ghanaian Times and Business & Financial Times during the period October 2008 to March 2009. The study sought to firstly determine how well the media covered climate change in Africa. Secondly, the study sought to find out the challenges that journalists faced in reporting news on climate change and their personal attitudes towards the coverage of the issue in the media.

The study determined that the extent of climate change coverage was very low in both the South African and Nigerian media. It was seen that the two South African newspapers studied recorded a higher number of articles than their Nigerian counterparts. All the newspapers framed the issue of climate change as "a concern only for the elites and those in government" (Tabgo, 2010, p. 29). The papers portrayed climate change as a topic that concerns the government and other people in high places who may have a say on policies.

The researchers reported that the papers also emphasized the scientific frame in their news coverage of climate change. This shows that the coverage of the issue was not written with the general public in mind who often struggle to understand the science jargon written in the newspapers. It was also seen that the African newspapers relied heavily on international newspapers for their articles on climate change. There were very few articles on climate change within the African context reported during this period in all the papers. Tabgo (2010) attributed this to the fact that there seemed to be very few African scientists and researchers involved in the issue of climate change.

In line with previous research on science coverage in newspapers, Tabgo (2010) reported that 60% of the interviewed journalists cited lack of training as one of the reasons for the poor coverage of the issue of climate change in the African media. The issue of limited resources for journalists and the

need to sell the papers also contributed to the low coverage of climate change. It was reported that, when competing with sensational news on corruption, politics and entertainment, climate change news often suffered. Similar findings were also reported by Cramer (2008) who examined media coverage of climate change from January 2005 to December 2005 in three daily newspapers from the Western region of South Africa (the Cape Times, the Cape Argus and Die Burger).

The issues raised here by previous newspaper studies may be true for the newspapers under scrutiny in this study hence this chapter discussed science in newspapers, how science is portrayed and if the science articles can be used to promote the learning of science in the classroom. I focussed on content analysis as a concept on which my study research methods rest, followed by how learning science occurs in science education and in science communication as a result of framing. The review of literature has shown that not much research on science in newspapers has been done in South Africa and in the Citizen and the Star newspapers in particular. My research will add broadly to the empirical evidence on learning science in the media in South Africa and in particular, evidence on learning science from newspapers.

Chapter 3

Research Design and Methodology

3.1 Introduction

In the previous chapter, the literature from which this study drew from was discussed. A summary of literature on how science was portrayed in newspapers was given. This was followed by a discussion on how this framing of science news in newspapers can be useful in science education. In Chapter 1, I stated the purpose of this study, which was to answer the following questions:

- Which science fields received the most coverage in the Star and the Citizen newspapers from January 2014 to June 2015?
- How was the science portrayed in the two papers?
- What school science could be learnt (if any) in the newspapers during the selected time?

In this chapter, I discuss the research design, the research instruments, the sampling method, the sample, the data collection methods and the data analysis methods employed in carrying out this study. I will go on further to point out credibility and ethical issues related to this study and explain how they were handled.

3.2 Methodology

According to Leedy (1997) "methodology is merely an operational framework within which the data are placed so that their meaning maybe seen more clearly" (p. 104). For a long time research has been classified as either quantitative or qualitative as defined by the nature of information the research sought to determine. Quantitative research focussed on quantifying data and numbers characterized such studies. Qualitative research on the other hand focussed on seeking relationships and patterns in data. Both types of research had their weaknesses and strengths. Researchers have over the years then sought to minimize the research methods' weaknesses by introducing a mixed methods approach to doing research.

To determine the methodology to for this study, I looked to the nature of the data I would need to answer my research questions and decided to use the mixed methods approach to conduct my study. Mixed methods research is "the class of research where a researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (Johnson and Onwuegbuzie, 2004, p. 17).The argument in mixed methods research is that "the whole is greater than the sum of its parts" (p. 51) since the method incorporates the strengths of the first two methods. This improves the quality of the research as it allows a researcher to view data with both quantitative and qualitative lenses.

The main advantage to using a mixed approach to research is that the numbers in quantitative analysis "can be used to add precision to words, pictures and narratives" in the qualitative analysis, on the other hand the "words, pictures and narratives can be used to add meaning to numbers" (Johnson and Onwuegbuzie, 2004, p. 21). It is this "convergence and corroboration" of findings that can provide strong evidence on which a researcher can make a conclusion at the end of a study. While I chose the mixed research method for its strengths, it also has some weaknesses. According to McMillan and Schumacher (2010) the method can often be too difficult for a single researcher to carry out both the quantitative and qualitative research methods in a single study to the extent that one method may be used only superficially. Johnson and Onwuegbuzie (2004) concurred with this and explained that since the study requires more extensive data, it also needs more time and resources which a research team may be in a better position to provide than a single researcher. The main disadvantage of my choice of research method was that I was the only researcher in this current study and that my research time frame was also short. This was however a small price to pay for the advantages that the mixed approach to research afforded my study.

McMillan and Schumacher (2010, p. 397) stated that the findings of mixed methods research may "mislead readers if the approach to the study does not fully integrate both types of designs". In as much as I firstly quantified science news in two South African newspapers, I was also interpretive in my analysis of how the newspapers portrayed the science news. This was to ensure that I sufficiently merged the two research designs. Interpretivism works on the premise that there are multiple socially constructed realities (McMillan and Schumacher 2010). Picasso (1966) stated that "if there were only one truth, you couldn't paint a hundred canvases on one theme". What I sought to present in this study was therefore simply one view out of the many views that may have been embedded in the data.

In this current study the framing perspective was used to examine how two South African newspapers portrayed scientific news. Framing was discussed in detail in section 2.6. To achieve this, I used the content analysis research technique to answer my research questions which aimed to determine the scientific news in South African newspapers and to find out the extent to which the scientific news could be used in science classrooms to promote the learning of science concepts and to increase the science literacy of the society at large.

I decided to do a content analysis of newspaper articles because of the many advantages to content analysis which makes it a research technique synonymous with newspapers analysis studies as illustrated by the literature reviewed in chapter 2 section 2.2 These advantages include the fact that content analysis can reduce vast quantities of data to smaller categories that can be analysed both quantitatively and qualitatively. Secondly data are always available to all and their analysis can be replicated. The analysis of texts can provide valuable historical and cultural insight over time. Content analysis is also unobtrusive in that "researchers do not intrude into the social life by observing or

interviewing but rather examine existing non-interactive texts" Hesse-Biber and Leavy (2011, p. 228). This is the flexible nature of content analysis which even allows for research to be conducted on and about some social groups that may be difficult to reach. This existence of data outside of the researcher's influence, gives it a level of authenticity that other research methods lack.

Content analysis however has been known to have its own weaknesses. While it sounds easy, content analysis is a time consuming activity that requires much reading on the researcher's part. Secondly coder interpretation may mar data which often has implications on the reliability of the study. While this disadvantage may be a limitation to my study, I decided to combine the quantitative aspects of the study with its qualitative aspects in order to enhance the credibility of finding. Of this combination, McMillan and Schumacher (2010) state that one method compensates for the weaknesses of the other allowing for improved study reliability. Lastly content analysis does not easily explain why a particular phenomenon is observed, however this was not my intention in this current study. Here, the idea was to simply determine what science and how science news was framed in two South African daily newspapers.

3.3 Sampling

In explaining sampling, Leedy (1997) said, "this is the way we learn: by sampling judiciously, by looking intently with the inward eye. Then, from these few that you behold, tell us what you see to be true" (p. 189). Out of a large population a small number can be drawn to represent the whole population. There are quite a number of sampling methods that one may employ in conducting research. Often the method depends on what a study seeks to find. Sampling methods include convenience, quota, cluster, random, stratified, purposeful and systematic sampling (McMillan and Schumacher, 2010).

According to the Audit Bureau of Circulation of South Africa, 2013, there are 22 daily and 25 weekly newspapers in circulation in South Africa. Most are in English and Afrikaans. Some newspapers are distributed provincially while a few are distributed throughout the country. To select the newspapers for this study, I looked at all the newspapers in South Africa as published by the Audit Bureau of Circulation of South Africa, 2013. The search yielded information about their circulation and readership numbers. The Daily Sun newspapers had the highest circulation of 296 489 and a readership of 5 554 000. The newspaper is aimed at reporting news that covers local gossip and events that occur in ordinary people's lives. The Sowetan also had a high circulation of 98 258 and a readership of 1 646 000. The Sowetan, like the Daily Sun is aimed at English literate black readers and also tends to cover local news about daily occurrences in the ordinary South African's life. Although these two papers were the mostly read newspapers in South Africa at the time of the research, their news coverage of science news was none existent and could therefore not be used for this study. Others newspapers included the Pretoria News, which had a circulation of 18 775 and a readership of 141 000. The New Age was determined to have a readership of 107 000 but its

circulation data could not be determined since the newspaper was not registered with the Audit Bureau of Circulation of South Africa. Newspapers such as the Herald and other province based papers were not considered for selection in this study because of their geographical area of distribution.

In selecting a sample for my study, I used the purposive/purposeful sampling strategy which McMillan and Schumacher (2010) defined as a sampling procedure where only subjects with certain characteristics that best inform the research are selected. The researchers pointed out that it is the sampling strategy that is often used in qualitative research and since my study was aimed at analysing science news in the newspapers, I needed a representation of the newspapers and articles that were likely to have the information I required for my study. Since the quantitative aspects of my study sought to determine the science field that received the most coverage during the chosen timeframe, I decided to use the selected sample to answer this question too.

Two newspapers were therefore selected from the sizeable number of newspapers that one finds in circulation daily and weekly in South Africa, namely The Citizen and the Star. The two papers were selected because they were among the newspapers with a substantial readership and circulation in South Africa. The Citizen had a circulation of 63 851 and a readership of 451 000, while the Star had a circulation of 106 484 and a readership of 615 000 (Audit Bureau of Circulation of South Africa, 2013). The two papers were both mainly distributed in the Gauteng province and were aimed at literate English readers. The two newspapers were also selected because I found that they made easy reading, were easily accessible and most importantly, they covered science news.

An internet search of science news articles in the Star and the Citizen newspapers for the period 1st of January 2014 to the 30th June 2015 was conducted. I chose these time frames because of the currency/recency of the dates in relation to the present study. The search initially yielded a total of 3062 articles. I then decided to be more subject-specific in my search for science articles to include Anthropology & Archaeology, Astronomy, Biomedicine, Botany, Zoology, Cell and Molecular biology, Chemistry, Earth Science, Environment and Ecology, Mathematics, Paleobiology, Physics and General Science. The resulting articles were further screened until a total of 44 articles were selected to make up the study sample. Science articles that featured other science news besides science in the field of health science and technology were thus selected and analysed for presence of frames according to Nisbet's framework (2009) described in figure 2.1.

Entman (1993, p. 52) stated that frames in the news can be examined and identified by 'the presence or absence of certain keywords, stock phrases, stereotyped images, sources of information and sentences that provide thematically reinforcing clusters of facts or judgments.' In line with this, I therefore searched for science articles that contained general scientific words such science, chemistry and environment from the newspapers' websites and archives. I further screened the resulting articles to a smaller number of articles that met the study's definition of science as it was described in section

2.3. This ultimately made up my sample of 44 articles, 27 from the Star newspaper and 16 from the Citizen newspaper.

3.4 Data Preparation

According to Wimmer and Dominick (1987) once a sample has been selected and the unit of analysis has been selected the next step is to construct categories for analysis. Hatch (2002) referred to this method of analysing data as typological analysis which she described as a method in which "data analysis starts by dividing the overall data into categories or groups based on predetermined typologies" (p. 152). Elsewhere, Richards and Richards' (1995, cited in Opie, 2004) concurred and stated that it is an approach to coding, where "general categories are determined in advance and the purpose of the study is to test a hypothesis and to show whether the categories apply and are elucidated in data" (p. 169). This study employed this research method. I approached newspaper articles with pre-determined categories in terms of science fields and frames. The fact that I knew what I was looking for in the data made the research run more easily and more efficient. While pre-determined categories are an advantage of the typological analysis, the approach also tends to blind the researcher to other dimensions that may be in the data.

The newspaper in which an article was reported was firstly noted as well as its title and date of publication. I also made a word count of the article to record its length so as to determine whether the article was reported as news or as a feature. The first task of this study was to determine what other science besides science in the health and technology field do the Citizen and the Star newspapers report. To answer this research question articles, data were classified according to a modified version of typology used in a similar study conducted by Rooyen (2002). The articles were firstly categorized into 13 selected fields (see Appendix A) to establish the science fields that received greater coverage in the specified time for the study. I chose to use these fields in this study because of their relevancy to school science content.

To respond to the second part of my study which sought to determine how science news was reported in the papers, I identified the frames present in the articles and coded the science news against Nisbet's (2009) framework discussed in section 2.6. (also see appendix B). This is a framework of typical frames found in public discourse which served as the coding manual for this study. This coding manual described all the possible categories for analysis and it was used in conjunction with a coding schedule on which the data relating to a typology were entered (see appendix C). As previously stated in section 2.6, I decided to use the framing categories such as morality and ethics, public accountability and governance and conflict and strategy because of their use in discussions of socio-scientific issues in the science classroom. Their presence enabled me to answer the third question of my study which aimed to find out if scientific news articles in newspapers could be used in formal school contexts.

It was not easy to categorise news articles since some articles had overlapping categories and frames. It was not this present study's intention to provide an exhaustive account of the articles'

contents, but to identify the dominant frames in the article. Table 2 below has examples of selected quotes from texts to illustrate how and why I assigned particular frames to newspapers articles.

Table 2: Typology of frames used in newspaper articles

Frame	Description	Examples
Social progress	Ways of improving the quality of life for individuals or society.	• Researchers took a forearm from a dead rat and attached it to a living creature where it quickly became a functioning limb. The US breakthrough brings hope that amputees could eventually grow their own replacement "biolimbs".
Economic development and competitiveness	Of monetary value, economic implications	• At the beginning of the 2000s that orthodoxy collapsed. We realised all of a sudden that we had competition," he added. The project - run in conjunction with researchers at the National Polytechnic Institute of Toulouse (INP) and the French Vine and Wine Institute (IFV) - now appears to be bearing fruit
Morality and Ethics	One's values and principles	• Scholes welcomes the "moral authority" of Pope Francis, who this week urged the world's leaders to act to stop "extraordinary" climate change from destroying the planet, reminding wealthy countries that they bear responsibility for causing climate change.
Scientific and technical uncertainty:	Gap in scientific knowledge, Groundbreaking science	• Carmakers, Takata and the government all want to find out just how much humidity and time it takes to cause the problem, both of which are unknown.
Pandora's box/Frankenstein's monster/Runaway science	Science that hurts the society	• Climate change could wipe out all the health gains made in the last 50 years and urgent steps need to be taken to prevent further increases in global temperature. This is according to the findings of the Health and Climate Change Commission set up by the British medical journal,
Public accountability and governance	Policy issues protecting the public,	• The government gazetted the final regulations this week. They are to guide the exploration and production of oil, gas and hydraulic fracturing. Importantly, this means the government can process applications to explore for shale gas • The festival's co-founder, said that for scientists it was a chance to escape the lab and meet the people affected by their research, or paying for it via their taxes
Middle way/alternative path	A balanced/unbiased view to issues A third way between conflicting or polarized views or options.	• "Did the parting of the sea really happen? We will never know," says Holland. "But Carl Drews has used impeccable science to show both where and how it may have happened." • Faith and science can be compatible if you are willing to consider other interpretations of the text, other ideas of how this could have happened," he say
Conflict and strategy	Opinions on debatable issues (often journalists driven)	• If the government was serious about avoiding catastrophic climate change, this country would be urgently transitioning away from coal

Below is an example of a coding sheet that illustrates how newspaper articles were coded.

Article ID : The Star **Date: 18 May 2015**

Article Title: Two pints and a shot of science, please **Total Number of words: 733**

Type of Science Reported: General

Treatment
1. General News √
2. Feature
3. Commentary/ Criticism
4. Other

Frames: public accountability and governance

Evidence

- Dr Praveen Paul, 35, the festival's co-founder, said that for scientists it was a chance to escape the lab and meet the people affected by their research, or paying for it via their taxes"
- "Talking science in a pub, she said, helped close the knowledge gap between the researchers and the public".

Application in Science Education

	Grade	Learning area/Topic	Correctness of Content
1		Any grade to show how relevant and interesting science can be.	
2			

General Reaction (1 = negative.....5 = positive)
How interesting was the article?
1 2 3 4 5
How clear understandable was the writing?
1 2 3 4 5
Is this a story I would choose to use in my science classroom
1 2 3 4 5

This coding sheet was filled in for all the 44 articles that comprised the study sample. It was from these coding sheets that data analysis could begin (Appendix D is a blank coding sheet).

3.5 Data Analysis

Having coded the data, I started with data analysis. This involved looking for patterns, relationships and themes within typologies. In looking for patterns, I was looking for regularities in the form of similarities, differences, frequency, sequence, correspondence and causation as defined by Hatch (2002). While seeking relationships I identified links that existed between data elements. Lastly in this section I endeavoured to determine the integrating concepts within the data, commonly referred to as themes. These are statements of meaning that run through all or most of the data (Hatch, 2002).

I believe that CAQDAS (computer-assisted qualitative data analysis software) could have been of much use in my study in that it might have helped me make sense of the data quicker since it is said to "remove most of the clerical tasks associated with manual coding and retrieval of data" (Bryman, 2008, p.565). CAQDAS has many advantages over manual paper-and-pencil coding. The software efficiently stores, organizes, manages, and reconfigures data for analysis. It has the ability to quickly search, collect and display keywords, phrases and similarly-coded data for examination saving the researcher a lot of time. CAQDAS can also perform actions as retrieve, filter, group, link, and compare, enabling the researcher to perform such human actions as infer, make connections, identify patterns and relationships, interpret, and build theory with the data (Saldana, 2008). Despite being aware of all these advantages to using CAQDAS, I decided not to use any such software for this study due to my short research timeframe. Being a novice researcher, I felt that I would spend much precious time on first learning the program rather than on the actual research processes. Below is a summary of the steps which were followed in this study for data analysis as suggested by Hatch (2002, p. 153).

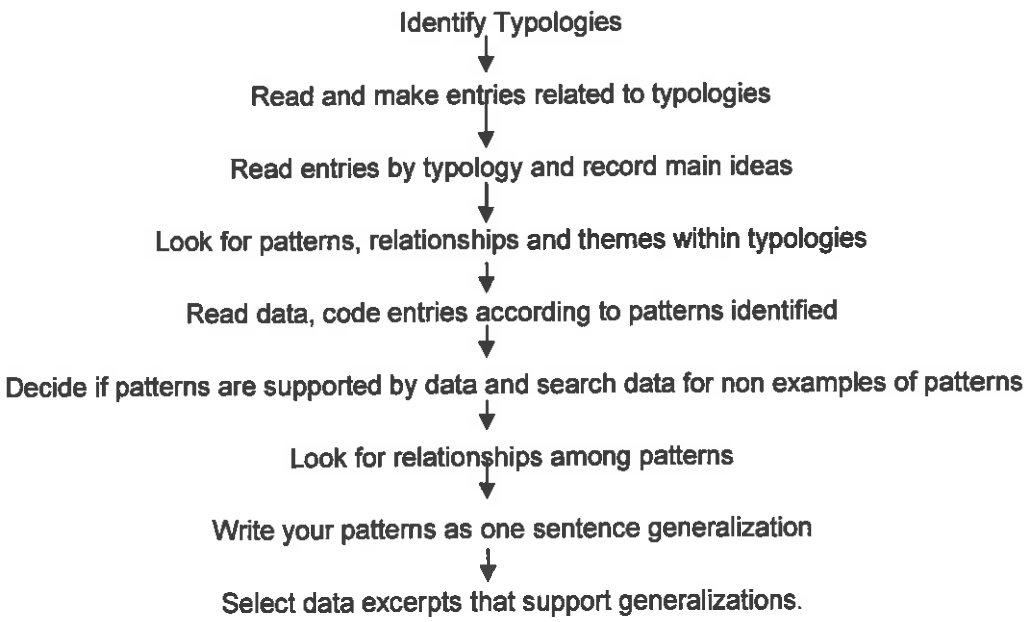

Figure 3.1: Summary of data analysis process

This summed up my study. The next step was to determine if the observed patterns were supported by data and to identify contradictions to my findings. This helped in making conclusions and generalizations of my research findings described in detail in chapter 4 and 5.

3.6 Data Presentation

The quantitative data analysis in chapter 4 of this study, addressed my first research question: 'Which science fields received the most coverage?' The quantitative data comprised of frequency counts of science fields and frames present in the articles. Counting frames enabled me to answer the second question of the study which sought to determine how newspapers framed science news during the research period of time. Statistical charts in the form of frequency tables and graphs were used for the data presentation of the quantitative aspects of this research, while descriptions and explanations covered the qualitative aspects.

Armed with the Curriculum and Assessment Policy Statement (CAPS) (2012) documents for both the Further Education and Training (FET) phase and the General Education and Training (GET) phase , I also sought to determine if the science news articles could be used in the classroom to achieve one of the National Curriculum Statement for physical sciences' aim which seeks to "produce learners that are able to use science and technology effectively and critically, showing responsibility towards the environment and the health others" (p. 3). The presence of Nisbet's (2009) frames on social progress, morality and ethics and public accountability and governance in an article was used as an indication that the articles could be used as resources for teaching a society relevant issue on appropriate science topics, as outlined by the CAPS document. In applying these frames to the articles I was looking to see if the science news reported had a means of improving the quality of life or of solving problems that might arise in society due to scientific issues. The relevant school science topic/s was stated on the coding sheet.

Since reading news articles is often voluntary, it follows that the science articles in newspapers have to be interesting and fairly easy to understand. In the last part of this study I therefore included this aspect to determine if the science news reported in the newspapers was written in a way that would appeal to the reader, for this would increase the likelihood of the articles' use in the science classroom. This was solely based on my opinion as the main coder of the articles.

3.7 Reliability

I would have also used CAQDAS for the legitimacy and credibility that it gives qualitative research as stated by Feilding and Lee (1998, cited in Opie, 2004). Elsewhere, Richards and Richards' (1995, cited in Opie, 2004) concurred and stated that CAQDAS is an important means of validating qualitative research. This is due to the fact that a computer can keep trail of analytic procedures that

can be replicated at any time better than people. Having decided to use the traditional way of content analysis, I had to look at other ways of validating my study.

McMillan and Schumacher (2010) defined reliability as "the extent to which measures are free from error" (p. 179). In content analysis, much can go wrong in the coding of data in terms of defining categories. If category definitions are not clear and exhaustive, the research questions may not be fully answered. To achieve an acceptable level of reliability, Wimmer and Dominick (1987) emphasize the definition of category boundaries with maximum detail. In choosing to modify content analysis instruments from Rooyen (2002) and Nisbet (2009), I increased the reliability of my study in that my units of analysis (frames) were adapted from tried and tested instruments in media research.

To ensure reliability for my study, I also employed two types of reliability. The first type of reliability was intra-coder reliability, where a researcher reanalyzes the same text and different times (Krippendorf, 2004), also called the test and re-test method, this just ensures that the researcher fine tunes his/her own coding technique. I coded my data against Nisbet's framework for the first time. I let the data rest for a week and came back to do the same coding process over again. This was repeated a second and a third time to improve my coding technique. I finally determined that I had gotten this part right when I achieved an agreement of 86% the three texts analysis I set out to do.

Gibbert (2008) emphasised two words with regards to reliability, transparency and replication. A study is reliable if the study methods can be followed and replicated by another researcher. Good reliability is therefore a result of careful unitizing, codebook construction coder training. Other researchers such as Krippendorf (2013) and Hesse-Biber and Leavy (2011) concurred and suggested that coders should be trained in the case where different coders are used since human errors increase. In this study, my colleague who was carrying out a similar study served as a second coder for part of my study to ensure that my analysis instruments had clearly defined categories. This was to achieve some measure of inter-coder reliability where different coders agree on the meanings of most categories (Wimmer and Dominick, 1987). My supervisor's guidance was also valuable in this process. In conducting the pilot study, my colleague and I worked on 5 articles separately and coded them against Nisbet' framework. We reached a percent agreement of 81% for text codes. We resolved the differences in a discussion that followed.

3.8 Validity

McMillan and Schumacher (2010) defined validity as "a judgement of the appropriateness of a measure for specific inferences or decisions that result from the scores generated" (p. 173). Elsewhere it is simply the degree to which an instrument measures what it sets out to measure. In light of these definitions of validity, this study did not have validity issues to discuss since it did not use any research instruments such as questionnaires, tests or interviews for collecting data. The

study however used coding instruments which were developed after careful selection and pre-reading of sample texts to focus the study.

3.9 Ethical Issues

Ethical issues are intended to protect the rights and welfare of the study participants. This study therefore did not have any ethical issues to consider due to the following reasons:

- The research used data from newspapers which are open to the public.
- It did not involve humans or animal participants.

This chapter discussed the mixed methods approach employed in this study, were both quantitative and qualitative content analysis of newspaper articles was conducted to determine how science news was portrayed in the Star and the Citizen newspapers between the 1st of January 2014 to the 30th of June 2015. The reasons for using these methodological processes were also explained to make this study as replicable and as reliable as possible. The following chapter describes the findings of the study in response to the first and the second research questions posed in section 1.2 and repeated here in this chapter in section 3.1.

Chapter 4

Findings

4.1.1 Introduction

In this chapter, I present the quantitative and qualitative findings of this research, analyse the data and interpret them to answer the first two research questions posed in section 1.2. Section 4.1.2 speaks to the first research which was aimed at determining the science field that received the most coverage in the Star and the Citizen newspapers from January 2014 to June 2015. Section 4.2 responds to the second research question which sought to determine how science news was portrayed in the said newspapers for the same period of time. The third research question findings will be discussed in chapter 5.

4.1.2 General Science Coverage Trends

Before conducting a thorough study of science coverage in the Star and the Citizen newspapers between January 2014 and June 2015, I decided to determine the general trends around science news reporting in the newspapers. The resulting numbers of articles per science field were the number of articles that an internet search on the respective newspaper archives yielded as a result of typing in the respective science field. The findings of the two newspapers are here reported collectively since this was not a comparative study. Table 4 below shows the number of articles that the search yielded.

Table 4. Fields of Science

Type of Science	Totals
Anthropology & Archaeology	1
Astronomy	28
Biomedicine	0
Botany	6
Zoology	18
Cell & Molecular Biology	8
Chemistry	133
Earth science	10
Environment & Ecology	15
Mathematics	213
Paleobiology	18
Physics	162
Science	2450

From table 4, it is shown that typing in the term 'science' yielded the most number of articles. On viewing the article, it was seen that the bulk of the article spoke of science and but did not cover the actual science content. It was seen that most of the articles that mentioned science included position titles such as 'the minister of science and technology' while other articles were about science and mathematics teaching and learning in South Africa. Physics and chemistry had relatively high numbers of articles and here again most of the articles were about titles such as professor or doctor of physics and events or exhibitions on physics. Many chemistry articles had nothing to do with chemistry as we know it in the laboratory but with the 'chemistry' between individuals in real life or in the media. Here, the word chemistry is used as a metaphor and not as a scientific term. Figure 4.1 below paints a picture of the science field frequencies shown in table 4 above. I decided not to include the results for the term 'science' in this section since the resulting articles of this search included articles varying in content range to include even the social sciences.

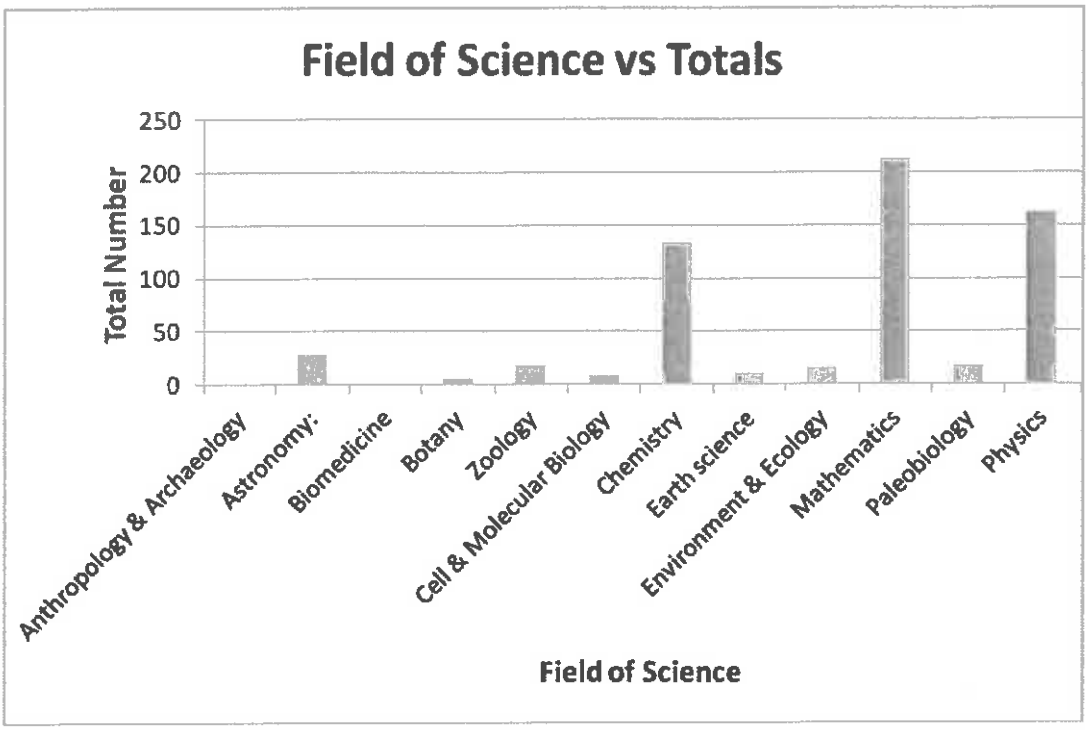

Figure 4.1: Fields of Science

In general this initial search for articles showed that while the two newspapers in the study write about science, one needed to search diligently for articles that could be useful to reach the goals of this study which were to determine the science field that received the most coverage in the Star and the Citizen newspapers from January 2014 to June 2015, secondly, to determine how the science news was portrayed and lastly, to determine the school science that could be learnt in the newspapers during this selected time frame. In the following section I discuss the findings of the actual study, based on the research sample which consisted of 44 science articles from the two newspapers. As

explained in the sampling section in chapter 3, the sample articles were selected from the vast number of articles shown above according to their relevance to science as defined in this study.

4.1.3 Actual Study Findings

As explained in section 3.3, the purposive sampling method was used to select a total of 44 science articles that could best answer the research questions. These articles were then classified according to a modified version of Rooyen's typology (2002) (see Appendix A) to determine the dominant science field reported in the two newspapers. While the study by Rooyen (2002) had 15 categories, for the purposes of this study I decided to use only 13 categories as I pointed out in section 3.4. It should be noted that the findings reported here in this chapter are specific to the sample and valid for the time period between 1st of January 2014 and 30th of June 2015.

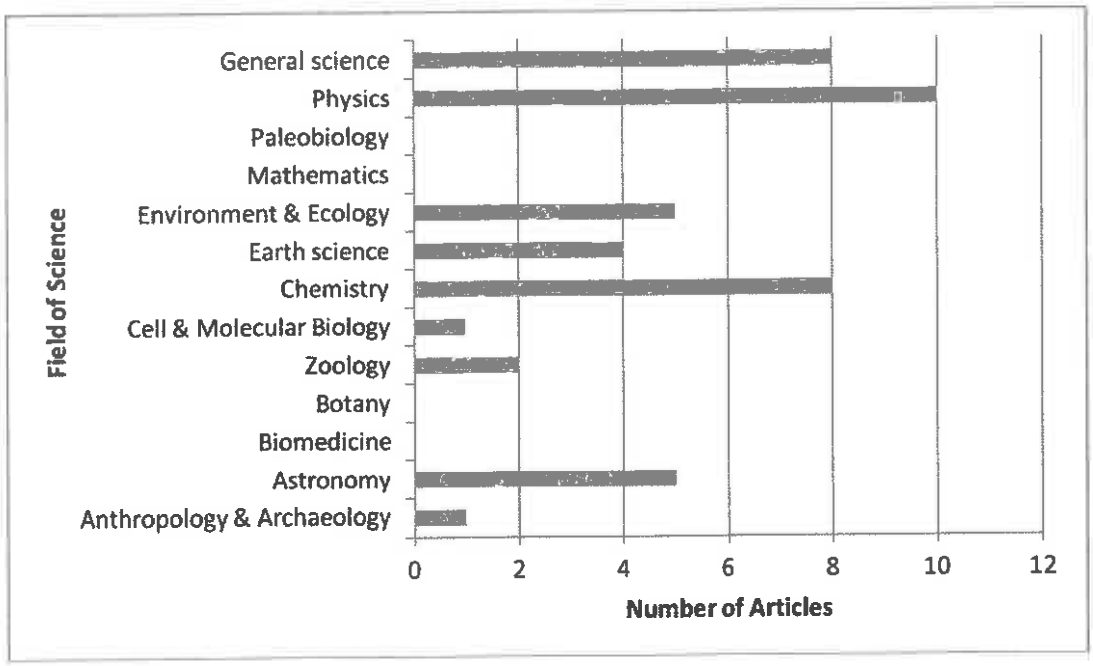

Figure 4.2: Field of science coverage

The study determined that out of the 44 articles analysed, the science field of physics received the highest amount of coverage, with 10 out of 44 articles (23%). Chemistry and general science articles both made up for 18% of the research sample. These were followed by astronomy and environment & ecology science fields which both made for 16% of the research sample. Earth science articles were 4 out of the 44 articles that is about 9% of the sample, followed by cell & molecular biology and anthropology &archeology which both had a coverage of 2% each. According to the definitions of the science fields described in appendix 1, none of the articles selected could be categorised in the

mathematics, botany, biomedicine, and paleobiology science fields. The biomedicine field was defined as the science of clinical medicine, biochemistry and basic biology. It was quite difficult to find articles that were relevant to this field without including the health field issues which I decided to eliminate in this study as I explained in section 3.4. As shown in section 4.2 above, the search for mathematics in general yielded 213 articles, on applying the definition of mathematics according to the categories by Rooyen (2002) which defined mathematics as the science of numbers none of the articles were seen relevant to the present study. It was seen that the bulk of the articles mentioned mathematics or discussed issues of mathematics and not the science of numbers. Lastly it was also determined that during the selected time frame, the papers did not cover articles in the paleobiology field.

4.2 Portrayal of Science

In this section, I report the findings of the study in an attempt to answer the second research question which sought to determine how science news was portrayed in the Star and the Citizen newspapers during the period January 2014 to June 2015. I discuss how the news articles were treated first in section 4.2.1, followed by how the science news was framed in section 4.2.2.

4.2.1 Treatment

While the treatment of articles does not directly answer any of this study's research questions, it broadly gives an overview of how science news was portrayed by the newspapers which was the second aim of the study. The treatment of articles refers to the way an article is written. Articles may be written as general news, as a feature or as commentaries. According to Lynch and Peer (2002) general news articles tend to emphasize facts of recent events while features tend to be longer, reflective and entertaining. Commentaries were however not part of the research sample and hence this category was excluded here. Table 4.3 below shows the study findings with respect to science articles treatment.

Table 5: Treatment of articles

Treatment	Frequency
News	41
Feature	3

Table 5 above shows that 93% (41 out of 44) of the science articles were reported as general news while only 3 out of 44 (7%) were reported as features. The findings make sense in that news sell newspapers and take up less newspaper space than features. News articles also focus on current

issues while features often cover issues that run over a period of time which may not be as 'juicy' as current news. A study by Lugalambi (2011) on media coverage of science and technology in Africa also determined similar trends and concluded that "science and technology stories stand a better chance of being reported if they qualify as news" (p. 19). It thefore makes more business sense for a newspaper to have a higher number of news articles than features.

4.2.2 Framing

To further determine how science news was portrayed in the two newspapers in question, the 44 articles that comprised the sample were analysed for presence of frames according to Nisbet (2009) framework of typical frames found in public discourse. The frames included the social progress frame, economic development and competitiveness, morality and ethics, middle pathway, conflict and strategy, public accountability and governance and scientific development and technical uncertainty. I had initially planned to assign a single frame per article but on noting that some articles had more than one frame, I then decided to identify and quantify all the frames in the newspaper articles. Ultimately, a total of 73 frames were identified in the 44 articles, making an average of 1,66 frames per article. I go on to discuss the eight identified frames and give examples of how the frames were portrayed in the various newspaper articles.

Table 6: Summary of article frames

Frame	No of articles	% of frames	List of articles
Social progress	18	25	8,10,12,15,16,18,19,26,27,28,30, 31,32,35,36,39,42,43
Economic development and competitiveness	19	26	10,11,13,15,16,20,26,27,28,30,31, 32,34,35,36,37,38,39,41
Morality and ethics	2	2.7	12 and 26
Scientific and technical uncertainty	15	20.5	3,8,15,16,19,20,21,22,24,25, 29,33,34,40,44
Runaway science	3	4.1	12,34 and 43
Public accountability and governance	10	13.7	1,3,5,6,12,17,23,27,28 and 40
Middle way/alternative path	2	2.7	6 and 14
Conflict and strategy	4	5.5	5, 9,12,34,36

4.2.2.1 Social progress

Of the 73 frames that were identified across the 44 newspaper articles, 18 (25%) were categorised in the social progress frame. The social progress frame describes texts that show improvement of the quality of life (*QL*) or texts that provide solutions to societal problems (*Societal Solutions, SS*). Such articles included articles such as article 8. Article 8 described how scientists had managed to grow bio-limbs in the laboratory using rats. In conducting this research they hoped to see amputees able to grow their own replacement "biolimbs" eventually. In this article, there is an improvement in the quality of life of amputees who lose their limbs to accidents or illnesses. Articles 10, 16, 19, 26 and 28 discussed energy production issues. In South Africa as in other countries, the quest to produce energy in an environmentally friendly way still continues. It is in the light of this to quest to provide a solution to the society's energy problems that these articles portrayed the social progress frame. Below are other examples of texts that showed social progress framing in these said articles.

Article 10

> She also did a simulated study of vegetable and mineral oil. Vegetable oil breaks down at a higher voltage, which is good. It is better than mineral oil in this sense. She said this could be good for the environment *(SS)*. (Star, 2014/11/20)

Article 16

> As the country enters a new era of technological advancement, industrialisation and competitiveness, so the vistas of job creation and poverty reduction rise *(QL)*.
>
> The government has already begun work on realising the goal of an additional 9 600MW of nuclear energy by 2023. This is based on the realisation that the country needs a diversified energy mix to meet current and future needs as stated in the Integrated Resource Plan 2010-2030. *(SS)*
>
> Koeberg nuclear power station in Cape Town helps to ensure electricity security for millions of people on the west coast. *(SS)* (The Star,

Article 19

> South Africa should give more serious thought to digging deep underground to tap the buried heat of the Earth to generate more electricity. This is the suggestion from geology and climate change researchers who suggest significant volumes of renewable power can be generated from using the latent heat of rock to produce steam and electricity *(SS)*. (The Star, 2014/04/15)

Article 20

> The results could prove useful for weather forecasters, since solar winds synchronise with the rotation of the sun, sweeping into the Earth's atmosphere at regular intervals. As these

streams are also tracked by Nasa, it offers the potential for predicting the severity of dangerous storms weeks in advance *(QL)*. "Such information could prove useful when producing long-range weather forecasts," he added. (The Star, 2014/05/16)

Article 26

Many people are familiar with South Africa's dire need for energy, one only has to consult a load shedding schedule to re-familiarise oneself with this. Shell, Falcon Oil & Gas from Canada, along with their American partner Chevron, as well as Challenger Energy from Australia are the companies interested in cracking open underground shale deposits to release natural gas which may, or may not, be there, hence the need for exploration. We regard it to be very important to look at the effects and the impacts during any of our activities that could happen to the environment. *(SS)* (The Citizen, 2015/05/17)

Article 28

We expect to present the outcome of this procurement process to Cabinet by year end. When completed, the new nuclear plant will generate around 9600 megawatts of electricity. *(SS)* (The Citizen, 2015/05/19)

The articles discussed above clearly indicated the interest that the issue of energy received during January 2014 to June 2015 as South Africa as a country was facing electricity shortages and attention turned to other sources of energy. While the papers mainly discussed the issue of fracking and nuclear power generation, none of them mentioned solar energy as an alternative energy source which is a sensible option for a country that enjoys the sun for most part of the year.

Article 27

So what can we do to roll back urban heat? "The first thing that you can do is plant trees, to provide shade," *(SS)* said Ingrid Coninx at Wageningen University and Research Centre in the Netherlands. Another quick and relatively cheap weapon is moving water: streams running through cities are not only a source of pleasure — they also absorb a remarkable amount of heat from the air, said Coninx. Other ideas are "green" and "cool" roofs — planting shrubs and trees on the tops of buildings, or painting or covering roofs to reflect sunlight *(SS)*. (The Citizen, 2015/06/10)

As shown above, article 27 was a report on how to reduce heat waves in urban areas. As the effects of climate change and global warming are causing extreme weather patterns, this is a welcome solution to reducing atmospheric temperatures. Once again the social progress frame is shown. A total of three articles were devoted to the development of telescopes in South Africa. These were articles 30, 31 and 32. Article 30 was the South African MeerKAT radio telescope project which had received R150 million from the Max Planck Institute for Radio Astronomy in Bonn, Germany. While

this article might have an economic and development frame (discussed in section 4.2.2.2), together with the other articles on telescopes, it also has the social progress frame because the development of the telescopes helped create employment and positively impacted the economy as a whole.

The remaining four articles also portrayed the social progress frame in that they focussed on how science research contributes to "social development in many parts of the world" (Science and Technology Minister Pandor, Article 35, 2014/10/20). These included articles 39 and 42 below.

Article 39

> The strategy, seven years in the making, would focus on growing the South African economy and meeting the needs of its people. It would look at how technology could be used to improve the lives of people in rural areas *(QL)*. (The Citizen, 2014/01/14)

Article 42

> ...concludes that a strong international consensus is essential to move the world to a global low-carbon economy, harnessing a crucial opportunity to protect human health, particularly of the poorest and most vulnerable populations, who stand to be hardest hit by the effects of climate change *(QL)*. (The Citizen, 2014/08/9)

The articles discussed above under the social progress frame collectively portray science's role in improving the quality of people's lives both at an individual and at a societal level. Having shown in this section how science news was portrayed in the social progress frame across science newspaper articles in the Citizen and the Star at the selected time, I now discuss the economic development and competitiveness frame.

4.2.2.2 Economic development and competitiveness

The economic development and competitiveness frame describes texts that refer to "economic investment *(EI)*; market benefit or risk; or a point of local, national, or global competitiveness" *(GC)* (Nisbet, 2009, p.18). The study determined that across the 44 newspaper articles, 19 out of the 73 frames identified were economic development and competitiveness frames. These articles or texts referred to either monetary costs *(MC)*, economic investments or market benefits. Below are examples of such articles.

Article 11

At the beginning of the 2000s that orthodoxy collapsed. We realised all of a sudden that we had competition," he added. The project - run in conjunction with researchers at the National Polytechnic Institute of Toulouse (INP) and the French Vine and Wine Institute (IFV) - now appears to be bearing fruit *(GC)* (The Star, 2014/08/11)

Article 16

What De Wit means is we need to invest in shale-gas research and development. These isotopes earn the country nearly R1 billion a year in foreign revenue. *(EI)*

Article 41

In the case of astronomy, South Africa's geographic advantage is complemented by historical investment in capacity and infrastructure. South Africa has long recognised this inherent merit and for this reason prioritised and invested in astronomy to benefit from the collateral benefits it offers. Commitments in astronomy have, and still do, represent the biggest investments being made by the Department of Science and Technology in any single scientific discipline. As a result, a number of significant astronomy initiatives have burgeoned in the region. *(EI)* (The Citizen, 2015/05/10)

Article 43

The Commission represents a major new collaboration between European and Chinese climate scientists and geographers, social and environmental scientists, biodiversity experts, engineers and energy policy experts, economists, political scientists and public policy experts, and health professionals .*(EI)* (2015/06/23)

Article 26

Fracking – the final frontier

Shell, Falcon Oil & Gas from Canada, along with their American partner Chevron, as well as Challenger Energy (also called Bundu) from Australia are the companies interested in cracking open underground shale deposits to release natural gas which may, or may not, be there, hence the need for exploration. Everyone is familiar with South Africa's dire need for energy, one only has to consult a load shedding schedule to re-familiarise oneself with this. *(EI)* (2015/17/05)

Article 28

South Africa will conclude its nuclear energy deal before the year is out, Tina Joemat-Petterson announced on Tuesday. *(EI)* (2015/05/19)

Article 30, 31, 32*(EI)*

These three articles are an example of news articles with more than one frame. Although articles 30, 31 and 32 were discussed in the previous section under the social progress frame the articles are also were also framed to show the economic and development frame. Investments have been made into the development of telescopes and this furthers studies in astronomy and helps put South Africa on the map in this field.

Article 34

> The proposal would cut funding to NASA's Earth Sciences division, which researches the planet's natural systems and processes — including climate change, severe weather and glaciers. Republican Lamar Smith, who chairs the House of Representatives' Science, Space and Technology Committee presented the proposal earlier in the week. *(MC)* (2015/05/01)

Article 35

> Africa needs science investment Pandor said this meant it was logical to propose investment in science and innovation that could offer Africa new opportunities for development *(EI)* (2014/10/20).

Article 36

> South Africa and the UK signed an agreement on Tuesday aimed at fostering the development of science and technology in both countries. *(EI)* (2014/09/09).

Articles 34, 35 and 36 above, reported on the economic investments and agreements that were made between different organizations for economic development.

Article 37 showed global competitiveness where wine producers were saying:

> "We didn't want to make the wine our grandfather would have made. We wanted to make the wine our grandfather would have made if he could," Vinovalie director Jacques Tranier told AFP. *(GC)* (2014/10/8).

Article 38

> Germany's Bayer to float chemicals division was going public with shares *(MC)* (2014/09/18).

Article 39

> A strategy to help grow the agricultural and manufacturing industry was announced in Pretoria on Tuesday. "We hope this strategy is a strong player in the South African economy," said

> Glaudina Loots, director of health innovation at the department of science and technology. *(EI)* (The Citizen, 2014/01/14)

As illustrated by the content of the articles, emphasis was placed on economic improvement in terms of energy resources, astronomy, agriculture and the manufacturing industry. The articles discussed in this section collectively show how science articles were written to portray the economic development and competitiveness frame. This is an important part of science news reporting since newspapers are also businesses that need to make money.

4.2.2.3 Morality and Ethics

The morality and ethics frame *(ME)* was one of the frames with the lowest frequency of all the 8 frames. Only 2 frames out of the determined 73 frames were science and morality and ethics frames. This frame refers to texts that show "a matter of right or wrong; or of respect or disrespect for limits, thresholds, or boundaries" (Nisbet, 2009, p. 18). These texts often portray one's personal principles and values. Examples include article 12, where a call is being made to more industrialised countries to help curb the effects of global warming on the Earth's climate.

Article 12

> Scholes welcomes the "moral authority" of Pope Francis, who this week urged the world's leaders to act to stop "extraordinary" climate change from destroying the planet, reminding wealthy countries that they bear responsibility for causing climate change. *(ME)* (2015/06/22)

Article 26 also discussed the environment and in the same vein as article 12, the article urged governments to continue to assess the effects that fracking in the Karoo would have on the environment before embarking on their activities.

Article 26

> "We regard it to be very important to look at the effects and the impacts during any of our activities that could happen to the environment. It is for this reason we carry out EIA's and it is a vital assessment the government is doing, overarching the EIA which will look only at the impact for instance of one well or one activity will have on the environment," Eggink says. *(ME)* (The Star, 2015/05/17)

The low number of articles under this frame is not surprising since morality is a delicate matter between individuals. The question would then be 'whose morality'. A similar trend was also noted by David and Russ (2015) in a content and framing analysis of science communication articles. It should however be noted that in issues that affect the public as those reported in newspapers, most governments and other concerned organizations, have put laws in place to ensure that people, companies and others, act morally and ethically.

4.2.2.4 Scientific and Technical Uncertainty

According to Nisbet (2009) the scientific uncertainty *(SU)* frame describes texts that depict "a matter of expert understanding or consensus *(C)*; a debate over what is known versus unknown; or peer-reviewed *(D)*, confirmed knowledge versus hype or alarmism" *(A)* (p.18). Articles that show this frame often show a gap in science knowledge, while others report on newly found science knowledge. Out of the 73 determined frames, 15 were portraying the scientific uncertainty frame. Among these were the following selected few.

Article 3

> The motor industry, fed up with slow progress in finding out why some airbags explode with too much force, has turned to a Virginia rocket science company for help in investigating the problem. *(SU)* (2015/02/27)

Article 8

> But he warned that much work was needed and it will be at least a decade before the first human bio-limbs can be tested. *(SU)* (2015/06/04).

Article 15

> A study found that chronic exposure to ultraviolet radiation triggers the release of endorphins - the so-called feel-good hormones - that function through the same biological pathway as highly addictive opiate drugs such as heroin and morphine. The study involved laboratory mice, but the researchers said they believe the findings are applicable to people because the biological response of skin to UV radiation in mice is so similar to humans. *(C)*

Article 16

> Nuclear energy and hydraulic fracking: Are they twin evils or do they open new vistas of opportunity. Concerns over the nuclear programme and hydraulic fracking have turned public discourse about these developments into a neo-religious, zero-sum debate characterising them as good or evil. *(D)*
>
> Such discourse may appear illuminating but we should guard against the ease with which we allow ourselves to be swept along by a tide of polarisation and idealism that ignores the complexity of the public policy choices countries have to make to advance innovation, inclusive growth, sustainability and prosperity. *(A)*

Article 20

> "Such information could prove useful when producing long-range weather forecasts," he added. Scientists hope to eventually use such data, along with weather forecasts, to pinpoint when lightning could strike *(C)* (The Star, 2014/05/16).

Article 21

> "The only thing we really know is that there is 'new physics' because the model that we have is not complete," said Luca Malgeri, a scientist working at the European research centre. *(D)* (The Star, 2015/06/03).

This frame points to the ongoing research on scientific concepts and how knowledge continues to be improved overtime. The above articles have certainly shown the uncertainty nature of science in that the scientists often clearly stated that they were not always 100% sure of what they were reporting. This is one aspect of the Nature of Science (NOS), that shows that science knowledge is dynamic, constantly changing as new knowledge unfolds. I discuss NOS in detail in section 5.6.3.3 of chapter 5.

4.2.2.5 Runaway Science

This frame is often placed in the heading or the first paragraph of an article. The runaway science frame or Pandora's box/Frankenstein's monster frame is characterised by texts that show "a need for precaution or action in face of possible catastrophe and out-of-control consequences; or alternatively as fatalism, where there is no way to avoid the consequences or chosen path" (Nisbet, 2009, 18). Elsewhere this frame portrays science that has the ability to hurt the society in some way. Examples of such articles included Article 12 that had the heading "Catastrophic climate woes ahead" (The Star, 2015/06/22), while article 34 carried the heading "Climate change, severe weather and glaciers" and article 43 was entitled 'Climate change to wipe out health gains' (The Star, 20/06/23).

All these articles spoke of unavoidable consequences and threats society. This is typical of runaway science frames, hence they were categorised as such in this section. Once again, this frame was also not common in the analysed texts with only 3 out of the total 73 frames. Similar findings were also determined by David and Russ (2015) who reported that only 2 out of the 225 frames identified in their texts, portrayed the runaway science frame.

4.2.2.6 Public governance and accountability

The public governance and accountability frame *(GA)* was defined as a frame that describes "research or policy either in the public interest or serving special interests, emphasizing issues of control, transparency, participation, responsiveness, or ownership; or debate over proper use of science and expertise in decision making (Nisbet, 2009,p. 18). David and Russ (2015) also described this frame as a frame that has to do with serving the public good as motivated by policy concerns. The study determined that across the 44 newspaper articles, 10 out of the 73 frames identified were public governance and accountability frames. Examples of articles that carried this frame include articles 5 and 9 among others.

Article 5

> Fracking rules 'flawed and lack science'. Johannesburg - The government's final regulations to guide fracking are "flawed, inadequate" and have numerous shortcomings, the Treasure Karoo Action Group says. They are to guide the exploration and production of oil, gas and hydraulic fracturing. Importantly, this means the government can process applications to explore for shale gas. *(GA)* (2015/06/13)

Article 9

> SA's maths, science teaching 'in crisis'. South Africa has the worst maths and science teaching in the world, according to a World Economic Forum (WEF) global competitiveness report - and maths and science tuition are in "crisis". *(GA)* (2014/09/10)

Article 5 reported on policies that had been put in place by the South African government to govern the fracking processes in Karoo for the good of the environment and the society at large. The article also stated that the government could then now process applications from companies that were interested in venturing into the production of oil and gas. This ensured some measure of transparency and control in the processes. In article 9 the government was fulfilling its obligation to the public by reporting on how poorly the learners are being taught mathematics and science in South Africa. The article went on to further explain what the government was doing to improve the situation.

4.2.2.7 Middle Pathway

Texts that show "a third way between conflicting or polarized views or options" (Nisbet, 2009, p. 18) are said to carry the middle pathway frame *(MP)*. Out of the 73 determined frames, only 2 were middle pathway frames. Article 6 was given the heading 'Science explains parting of Red Sea'. In the article the author explained the event from a scientific perspective while Christians on the other hand

believe that God parted the Red Sea. These are two opposite views which Carl Drews stated can be polarised "if one is willing to consider other interpretations of the text, other ideas of how this could have happened" (The Star, 2014/12/21).

Article 6

> "Did the parting of the sea really happen? We will never know," says Holland. "But Carl Drews has used impeccable science to show both where and how it may have happened."
>
> The second part of Drews' analysis therefore shows how an atmospheric event -- specifically situated in the landscape above, not today's Red Sea - could actually cause the parting of a body of water, so much so that a bridge or pathway of dry land is revealed that could be crossed by a group of people.
>
> What atmospheric phenomenon could make this occur? The paper describes a coastal effect called a "wind set down," in which strong winds - a little over 60 miles per hour - create a "push" on coastal water which, in one location, creates a storm surge. *(MP)* (The Star, 2014/12/21)

Article 14 discussed the theory of evolution and how the study of fossils helps scientists discover more about human origin. The theory of evolution which many religious and cultural groups categorically reject, traces humans to prehistoric apes. This is an alternative view to the origin of man as posited by Creationists who believe that God created all things in the one week

Article 14

> Billings explains that the more fossils and skeletons are available to examine and analyse, the deeper the scientist's understanding of evolution and the environmental forces that continually force changes in our human physiology and behaviour. *(MP)*

Having access to alternative views to issues is an important aspect of democracy in a society. The presence of these articles in the newspapers showed the role that science news reporting has in fostering a democratic society.

4.2.2.8 Conflict and Strategy

The conflict and strategy frame plays out as "a game among elites, such as who is winning or losing the debate; or a battle of personalities or groups (usually a journalist-driven interpretation)" (Nisbet, 2009, p.18). In chapter 2, section 2.6 on framing, I explained that texts meanings and interpretations are brought to them by the writer and the reader. In article 12, the opinion of the journalist came out strongly when s/he stated that "if the government was serious about avoiding catastrophic climate change, this country would be urgently transitioning away from coal (and false solutions like nuclear)

and embracing a combination of renewable energy and energy efficiency" (2015/06/22). In chapter 1 section 1.1, I echoed similar sentiments when I mentioned that South Africa was undergoing energy challenges. Articles under this frame therefore always bring to the fore front an individual's opinion. The study determined that out of the 73 determined frames, 4 were portraying the conflict and strategy frame.

It was my intention in this section to answer the question 'why articles were categorised in particular frames'. I have given evidence to this effect in this section. In the following section, I present a summary of the quantitave results of article framing to show how the Star and the Citizen newpapers portrayed science news between the 1st of January 2014 to the 30th of June 2015.

4.2.3.1 Summary of the quantitave results of article framing

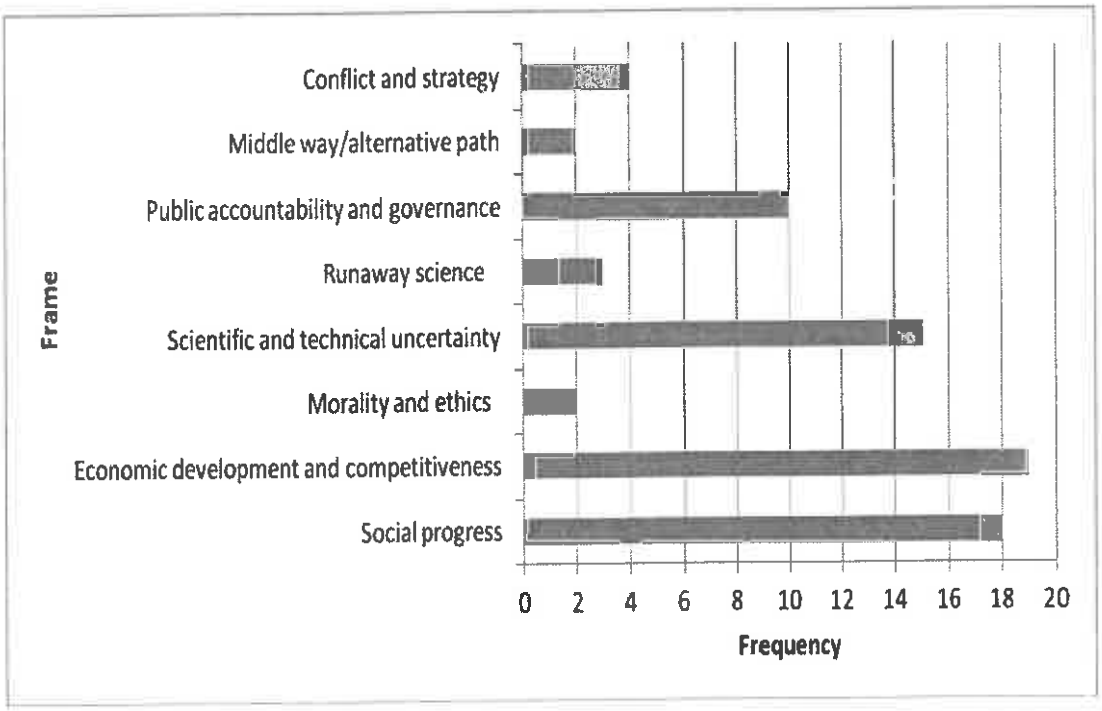

Figure 4.3: Frequency of Frames across articles

The study determined that the Star and the Citizen newspapers placed an almost equal emphasis on the social progress and the economic development and competitiveness frames in their portrayal of science news between the 1st of January 2014 and the 30th of June 2015. The frames made up 24.7% and 26% respectively of the 73 frames identified in the science news articles. The results of framing reported here are consistent with the findings of Zamith et al. (2012) in the four national newspapers they analysed from Argentina, Brazil, Colombia and the United States of America. The researchers

determined that the issue of climate change was primarily framed in two main frames namely, the economic development and competitiveness frame and the public accountability and governance frame.

Given the role that newspapers play in the public understanding of science it makes sense that the two newspapers would seek to inform and educate the public on issues that improve the quality of their life as defined by the social progress frame. In emphasing the social progress frame, the newspapers go a long way in disseminating the kind of science that is useful to the society, thereby increasing the scientific literacy of the society at large. In chapter 2, I explained that newspapers are also a business that also have to make money, it follows then that science news reporting in the newspapers would also be inclined towards the economic development and competitiveness frame as illustrated by figure 4.3 above.

15 out of the 73 frames were the scientific and technical uncertainty frame. For stories to qualify as news, they have to be interesting and contain new information. Science news articles in newspapers often report on scientific knowledge that is in most cases still under research hence the reports carry this element of uncertainty. The findings here are however in contrast to the findings of Zamith et al. (2012) who reported that the scientific uncertainity frame was less prevalent in the four South American newspapers they studied. Davis and Russ (2015) concurred with their findings. A run of my research sample text in a word cloud shown in figure 4.6 below showed that the term 'research' was the second most common word in my sample text. Whenever there is research there is often some form of uncertainty, I believe this is why this current study determined the uncertainty frame as the third most common frame, making up 20.1% of the total 73 frames identified.

While Public accountability and governance frame accounted for 13.6% of the frames in this prsesent study, Davis and Russ (2015) determined that the frame made up to 21.7% of their frames. The difference in results could be due to differences in the nature of texts analysed. This study looked at science articles in newspapers while the study by Davis and Russ(2015) analysed texts generated from interviews of scientists, reporters and the general public. The four least common frames were the conflict and strategy frame with 5.5%, the runaway science 4.1%, morality and ethics and middle way/alternative path both accounted for 2.7% of the identified 73 frames.

4.2.3.2 Word cloud

To confirm my findings on how the Star and the Citizen newspapers, portrayed science news during the research time frame, I decided to generate a word cloud from the study sample. A word cloud is "a special visualization of text in which the more frequently used words are effectively highlighted by occupying more prominence in the representation" McNaught and Lam, 2016, p. 630). The use of a word cloud here was appealing because of the fact the generation of word clouds is easy, readily

available and time saving. In a few seconds of uploading texts, a visual representation of key words and their frequencies is displayed. Word clouds are normally used at beginning of a research to determine frequency of words in texts to determine their usefulness or relevance to research questions. In this section I used a word cloud to identify the most frequently used words in the research texts in order to determine how the two newspapers in question framed science news. Figure 4.4 below shows a word cloud generated from the 44 news articles selected for this study.

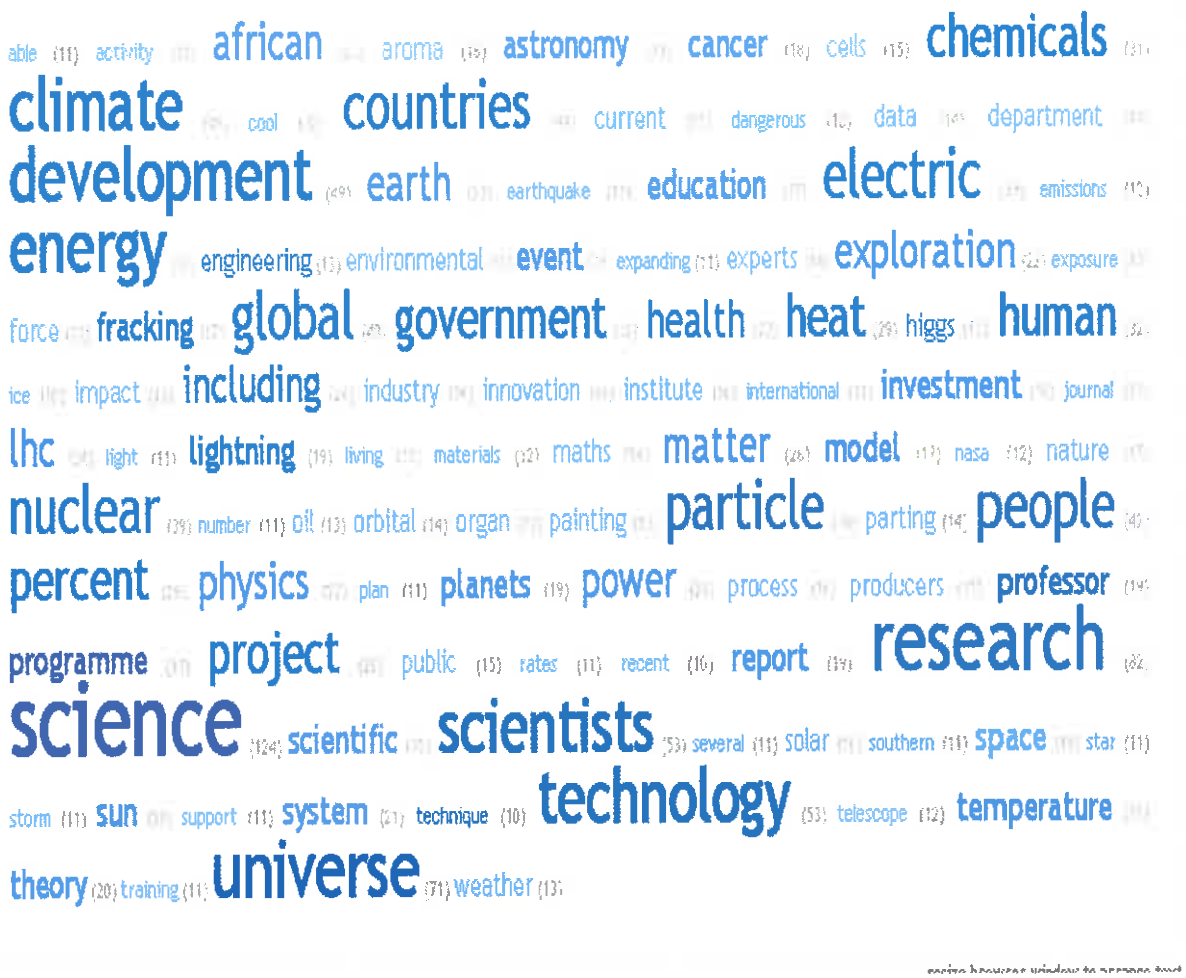

Figure 4.4: Word cloud of 100 most frequently used words in study texts

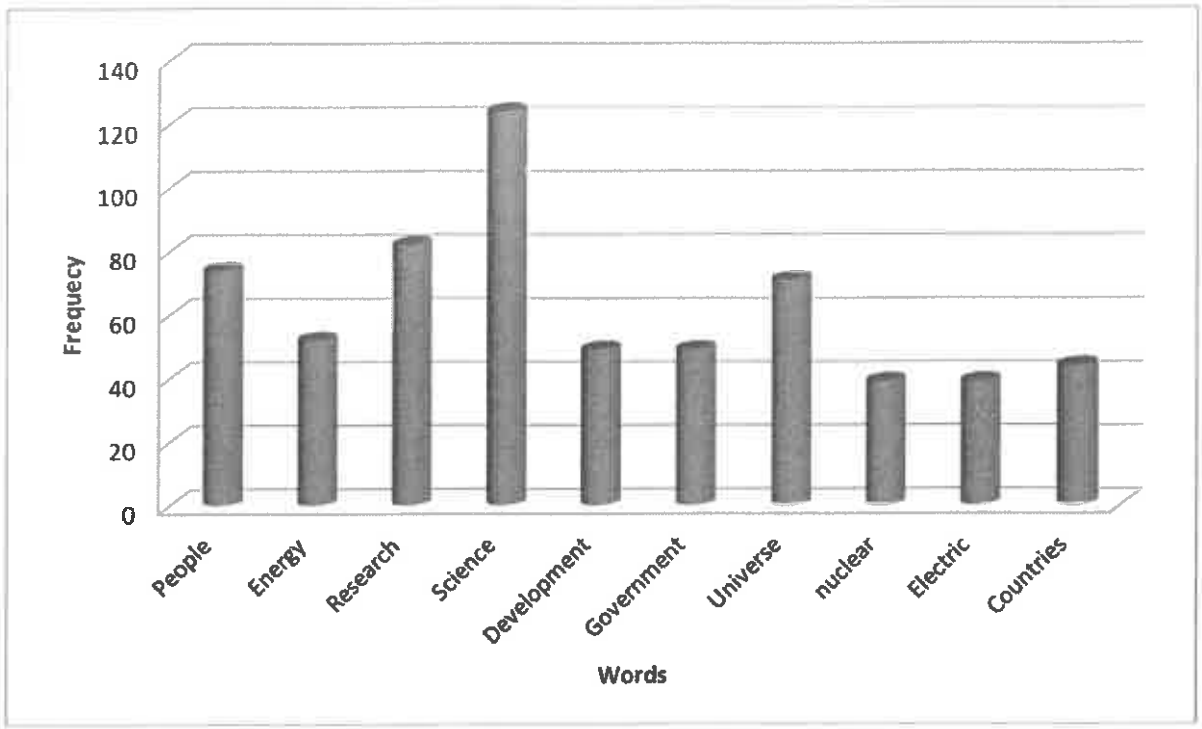

Figure 4.5: Frequency of the ten most words common words in study texts

The most frequent word in the texts was science, which confirmed the relevance of the selected articles to the research purposes. The list of the ten most frequently used words in research texts, resonate well with the identified research frames. The term 'development' may give the impression that the newspapers in the study portrayed science as an economic development issue. As seen in figure 4.5, this frame was the most common frame in the study. The term 'people/human' may be taken to mean that the science news reported during the research period had a social progress frame that seeks to improve the quality of life for the society. This was the second highest frame observed in the study. As stated earlier the term 'research' may depict the scientific uncertainty frame, the third most frequent frame of the study. Words such as government, countries and the universe in the texts may be interpreted as governments enforcing rules, regulations and policies to govern science issues.

Other words that were not so frequent as to be counted in the top ten words included words such as environment, investments, impact, innovation and cancer among others. The presence of these words in the research texts collectively confirmed the findings of the frame analysis summarized in section 4.2.3.1 above, that the Star and the Citizen mainly portrayed science news in the social progress frame and the economic development and competitiveness frame between the 1st of January 2014 to the 30th of June 2016.

Having described the findings of this study with respect to the first two research questions in this chapter, the following chapter responds to the third research question which sought to determine the extent to which science articles could be used to enhance science learning.

Chapter 5

Science Education and Science Communication

5.1 Introduction

In this chapter I attempt to bridge the gap between science communication and science education as I explore the possibility and the extent to which science news articles in newspapers can be used to enhance science learning in science classrooms. This is in response to the third research question. In section 5.1, I discuss how interesting I found the science news articles which comprised my sample. I then go on to show how articles may be used to teach various topics in natural sciences, physical sciences and life sciences from grade 9 to 12 in the current South African curriculum in section 5.2.

5.2 How interesting were the science news articles?

The reading of newspaper articles is often a voluntary action which largely depends on how interesting an article is to the reader. It is light of this fact of human nature that I decided to determine how interesting the science news articles selected were in a bid to determine their use in science classrooms as resource material. The interest levels ranged from a scale of 1 to 5. Below are the level descriptions:

Level 1... not interesting

Level 2...partly interesting

Level 3...interesting

Level 4...quite interesting

Level 5...very interesting.

It should be noted that the results reported here are based on what articles I found interesting as the main coder of this study. This compromises the validity and reliability of this part of my findings. I mention this as a study limitation later on section 6.3

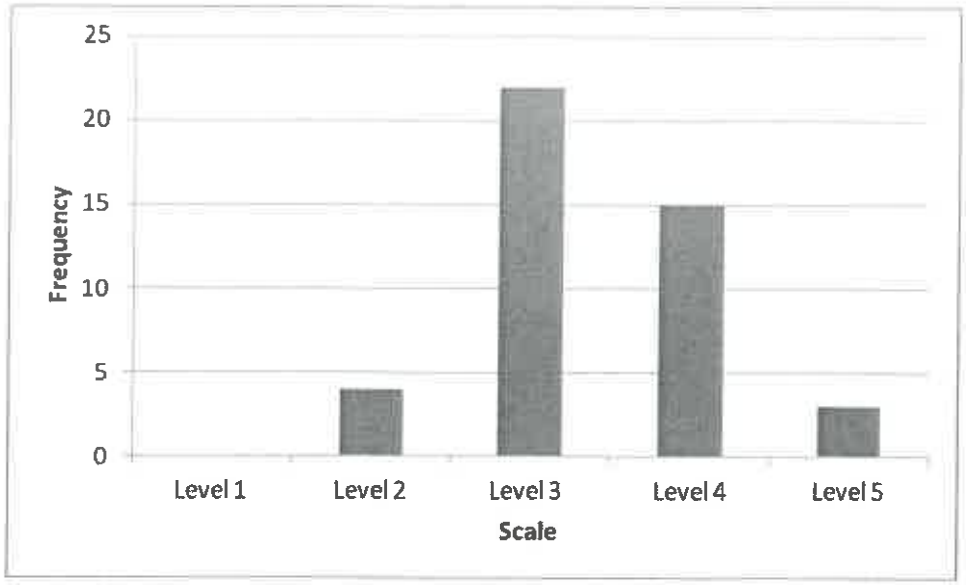

Figure 5.1: How interesting articles were determined.

Figure 5.1 above shows that most of the articles were deemed to be interesting since the graph is skewed to the right. Of the 44 articles in the study, 40 had a level 3 or above. The more interesting the science articles are, the higher their chances of being read, even in the science classrooms. These findings link to the third purpose of this study which was to determine if the science articles reported in the Star and the Citizen newspapers could be used in science classroom. I discuss this in the following section.

5.3 Science News and the Curriculum

This study was conducted in the South African context. It is in this context that the use of science news articles from the Star and the Citizen newspapers in science classrooms was considered. Table 5.1 below shows the number of articles that had some link to the curriculum as outlined in the Curriculum and Assessment Policy Statement (CAPS) document (2011). To determine the relevance articles, the article contents were analysed according to the science content requirements of the work schedules for grade 9 Natural Sciences, grade 10-12 physical sciences and grade 10-12 life sciences. Here again as in section 5.2 above I accept that the manner in which this was done lacks strong rigour.

Table 7: Article relevance to curriculum

Curriculum	Frequency
Applicable	32
Not Applicable	12

Table 7 above shows that 72.7 % of the 44 articles could be used in at least one of the science learning areas Although the remaining 27.3 % of the were categorised as science news, their use in science education can to simply make learners aware of what would be happening out there in the science world. Examples of such articles included articles 9 and 22. Article 9 was a report of an initiative by the KwaZulu-Natal science centre to tour different schools demonstrate some science experiments to learners in the hope of creating an interest for science. Article 22 described how scientist had recently found out the chemical ingredients to the paints that Picasso and other artists used in their work. The scientists hoped to use their newly found knowledge to preserve paintings in their original state for as long as possible.

Table 8 below shows a breakdown of the 32 articles that were relevant to curriculum into their respective learning areas.

Table 8: Learning Area to which applicable

Learning Area	Frequency
General Science	4
Physics	8
Chemistry	5
Astronomy	2
Life Sciences	5
Environment and Ecology	7

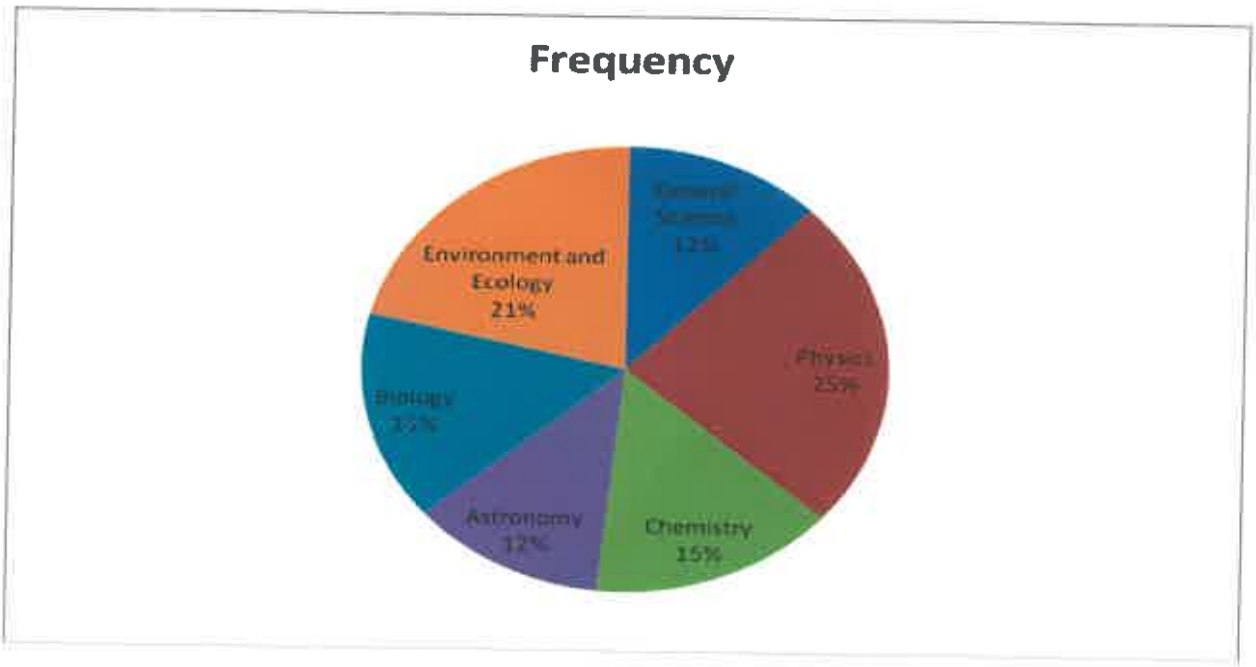

Figure 5.2: Learning Area to which applicable

Figure 5.2 shows that physics had the highest number of articles that were relevant to the curriculum with a percentage of 26%. This was followed by environment and ecology with 23%, chemistry and life sciences both had 16%, general science had 13%. Last was astronomy with 6% of the articles 32 articles. As much as environment and ecology are part of life sciences, in this study I decided to separate the two for reporting purposes. In the following section I discuss the use of these articles in the classroom to enhance science learning.

5.4 Teaching science using newspaper articles

A conversation with learners often reveals that teachers come in two groups, good and bad teachers. But, what do the so called good teachers know and do that other teachers are not aware of? What follows in this section is a discussion on how subject matter knowledge (SMK), pedagogical knowledge (PK) and pedagogical content knowledge (PCK) relate in the classroom, as they are said to be the knowledge bases that "underpin accomplished teaching" (Bishop and Denley, 2007, p.3).I will go on to explain knowledge transformation and how science teachers may transform science knowledge with the aid of science newspaper articles.

Of SMK Shulman (1986, p. 9) said it "goes beyond the knowledge of facts or concepts of a domain. It requires understanding the structures of the subject matter which include substantive and syntactic structures". On these structures, Heywood and Parker (2010, p. 140) referred to them as knowledge components of SMK. They went on further to say that "teaching is a profession informed by a range of knowledge bases which include the knowledge of facts and concepts of the discipline". This is the substantive component of SMK. The syntactic component is the knowledge of skills and processes of the discipline. The third component has to do with the beliefs about the teaching of the discipline which include the values, the significance of the science and even the attitudes toward the science.

PK "consists of general principles of instruction that are manifest in the teaching and learning of specific subjects" (Gilbert, 2010, p. 280). It refers to the general knowledge of learners and how they learn. PK also involves aspects of teaching that have to do with classroom management, discipline, curriculum interpretation and even teaching methods. It is common or generally applied to all subjects. All teachers of any subject and discipline need to have general pedagogical knowledge to be able to begin to teach. The fact that PK applies to all subjects and that previous discussions could not explain what served as sufficient SMK needed by teachers and what aspects of PK were relevant to specific subjects, is what I believe led people such as Schulman to come up with the idea of pedagogical content knowledge (PCK), which I touched on briefly in section 2.5.

Shulman (1986) calls it "a dimension of subject matter knowledge for teaching....it includes the most powerful analogies, illustrations, examples, explanations and demonstrations, in a word, the ways of representing and formulating the subject that make it comprehensible to others" (p. 9). This shows the

intricate relationship between SMK and PCK. In order for one to use these examples, analogies and illustrations in teaching, one needs the knowledge of the facts and concepts of the subject, and the knowledge of how and when to use them as well, and that is what is called PCK. This suggests that developing a sound PCK is an ongoing process that occurs as a teacher constantly seeks ways to better reach his/her learners. This study points to the use of science newspaper articles in science classrooms as an approach to teaching science in way that may make it real and relevant to learners.

Understanding what PCK entails, a teacher can then plan his/her lesson bearing in mind 'the what and the how' of a lesson. Shulman (1987) called it transformation, a process he said leads to the development of PCK. Transforming knowledge is what teachers do when they make decisions on what and how to teach. The teacher designs activities that best suit the students. S/he tailors them to address particular conceptual challenges, misconceptions or any other learning difficulties peculiar to his students. Science newspaper articles may sometimes be used to bring about important learning points or even some misconceptions that a teacher may use to teach concepts in their classrooms.

The representation of subject content requires a lot of imagination and improvising on the teachers' part. In recent years, knowledge transformation has however been made easier by technology. Video clips can be used to explain some concepts in physical sciences that cannot be modelled or demonstrated. Science news articles both electronic and hard copies may also provide the much needed resources for making science as real as possible for learners. The use of stories and analogies in science teaching often come as one teaches and often the stories and examples come from the students themselves which is sometimes based on information from the media as they struggle to make sense of the new knowledge. This goes to show that knowledge transformation occurs during the interactions in class, a teacher who knows his/her subject well will take advantage of these conversation to bring about learning. In the following sub-sections, I illustrate how teachers can use science news from newspapers to teach various topics in secondary school physics, chemistry, life sciences and natural sciences.

5.4.1 Astronomy

In the current South African curriculum, astronomy is covered in a learning area called the Natural Sciences from grade 4 to 9. Astronomy is broadly defined as the study of science of space, the sun, the moon and the stars. The following two articles discussed this science.

Article 33 stated that our solar system has two more planets waiting to be discovered which they believe lie beyond pluto. While the official list of planets in our solar system runs to eight for now, new discoveries may alter this list as new evidence for these two planets is discovered. This is relevant to the grade 7-9 natural sciences curriculum. A teacher may also discuss how Pluto was relegated to the status of dwarf planet in 2006 by the Astronomical Union. Astronomers over the years had found

other objects similar or larger than Pluto in what they called the Kuiper belt and this led to their reconsideration of the definition of planet. Pluto could not meet the requirements of planet and was therefore deemed a dwarf planet.

Article 41 reported on the success that South Africa enjoys as one of the leading centres of research in astronomy. The investments that have been made in the field which include Southern African Large Telescope (SALT) and the MeerKAT, have seen many young people choose careers in science, engineering and technology. Learners receive career guidance at grade 9 as they prepare to choose subjects to study in grade 10. This article is therefore relevant at this level because it may help broaden learners' career opportunities in the number of bursary programmes that astronomy as a field offers them.

5.4.2. Environment and Ecology

A category of articles that lend themselves well to the the STS teaching approch to science education are articles that discuss the enviroment and ecology. This is an approach to teaching that seeks to develop values and ideas that learners can apply in their interactions with science, technology and society for both their local and global community (Hassard, 2005, p. 399). The STS teaching approach was discussed in section 2.5 in detail. Environment and ecology focuses on the relationship between plants, animals and people to one another, and to their surroundings. In the 1990s, people became more aware of the environment and the effects of science and technology on it. Teachers began to focus on STS and environmental education as a response to the Gaia hypothesis. The hypothesis was a "proposal that the biosphere, like a living organism, operates its own life support systems through natural mechanism" (Hassard, 2005, p. 404). At this time many environmental friendly groups were formed and started preaching the 'save the Earth message'. It is in understanding that the Earth's resources such as water, air energy and climate are interrelated, that people and even learners in South Africa would learn to apply to their day to day life the environmental motto which says "act locally, think globally". The following articles are examples of newspaper articles that maybe used in science classroom to achieve these goals of STS teaching.

Article 5 was about the then recently gazetted regulations on the exploration and the production of oil and gas in South Africa. In this article some environmental activists were stating that the government should have done more work on the effects of gas mining on the environment before the gazetting of mining regulations which they felt would allow companies to cause harm the environment. Article 26 was a lot similar to article 5 in that it also focussed on how the government had mismanaged the process of fracking assessments in South Africa and urged the government to act responsibly in making decisions regarding the issues surrounding fracking. Article 16 also discussed the same

issue of nuclear energy and hydraulic fracking and asks the question: are they twin evils or do they open new vistas of opportunity. Article 28 stated that South Africa would conclude its nuclear energy deal before the end of 2015. This was one of the concluding articles on fracking that had started with debates on the merits and the demerits of the issue in the Star newspaper. These articles may be used as a debate in the Natural Sciences classroom in grade 9 when discussing the energy resources topic or as resource material for a project on the same topic.

Four newspaper articles had news on the climate. These were articles 12, 27, 29 and 43. Article 12 carried the heading "catastrophic climate woes ahead'. Melita Steele, a climate and energy campaigner at Greenpeace was saying that South Africa would have been urgently transitioning away from coal and nuclear energy and embracing a combination of renewable energy and energy efficiency solutions by now had the government been serious about avoiding catastrophic climate change. The article further discussed negotiations and regulations that were underway both nationally and internationally to help curb the predicted climate woes.

Article 27 reported on what climatologists call the 'urban heat island effect'. Normally heat from the sun is stored in the city buildings and tarmac during the day and released during the night. In cases where there are heat waves the night is often too short to allow all the heat to be released so when the sun rises temperatures soar again rapidly to unbearable levels, creating the urban heat island effect that can be fatal to living organisms. The article went on to offer solutions on how to prevent this effect. Solutions included the planting of trees to provide shade in a way that does not prevent a breeze from entering the city. Secondly the article suggested the use of running water through the city to absorb heat from the city's atmosphere. The painting of roofs to reflect the sun rays was also mentioned as a way of keeping homes cooler while the idea of green roofs was suggested for large city buildings. As the term green roof suggests, this is the planting of shrubs and trees on roof tops to reduce the amount of heat that is absorbed by buildings per day.

Article 29 offered a different view from article 27 in that while article 27 discussed high atmospheric temperatures, article 29 carried the heading 'global warming freezes'. The article reported that Russian vessel Akademik Shokalskiy was hired to take 52 passengers, including climate scientists, activists, tourists and journalists from The Guardian and the BBC, on an expedition to the Antarctic. The reporter stated rather strongly that "in climate change, there is a widening gap between science and reality which shows that mankind is not changing the climate in a dangerous .... There has been no global warming in the past 17 years. There has been no increase in extreme weather events. There is no alarming rise in sea levels. The poles are not disappearing".

'Climate change to wipe out health gains' was the title of article 43 reported in the Star newspaper on 23 June 2015. It was reported that the impact of climate change would result in the increasing frequency and intensity of extreme weather conditions such as heat waves, floods, droughts and storms. Since extreme weather disrupts water and food supplies, the article stated that malnutrition

and water-borne diseases such as cholera and diarrhoea would also increase. Respiratory diseases would also increase due to air pollution. The article also stated that the people severely affected by these extreme temperatures would most likely experience mental health challenges such as post-traumatic stress, anxiety and depression. As with other articles on climate change, the writer lastly went on to give suggestions on how to take minimize man's negative impact on the environment.

Education is the vehicle through which a nation can educate the youth to be responsible citizens both for the country and the world at large. It is through STS teaching that knowledge on sustainable development can be disseminated through the society as learners look at their environment and are encouraged to seek ways of taking care of it. A teacher may use newspaper articles to firstly help learners understand their role in the society, secondly to review their personal values and those of the society and lastly to engage learners in problem solving and decision making issues that will allow them to take a stand and act accordingly. The learners' interest and motivation to learn science is often thus captured and held as they discuss a science that is relevant to their context. It is to the furtherance of these goals of science education that the articles discussed here may be used in the natural sciences curriculum in the GET (General Education and Training) phase and in the Life Sciences (Biology) classrooms at FET (Further Education and Training) phase.

5.4.3 Life Sciences

Article 8 reported on how researchers had taken a forearm from a dead rat, washed the donor limb in detergent so only the framework was left, placed it in an incubator-type jar, injected with healthy blood vessels and muscle cells, and fed nutrients and oxygen. It was seen that within three weeks, the blood vessels and muscles had rebuilt and when this 'biolimb' was attached to a living rat, blood quickly flowed through it and the creature could flex its new paw. The researchers hoped to explore the possibility of having amputees eventually grow their own replacement limbs. This article may be used when discussing cell specialisation and mitosis in life sciences at grade 10 to show how the concepts work in scientific research.

Article 18 was report on the use of genetically modified foods with particular reference to maize, a common source of carbohydrates in South Africa. The article discussed the importance of modifying maize seeds in order to keep up with the increasing population's need for food. This article is relevant to the topic of genetics in the grade 12 life sciences curriculum. Lastly, article 24 read 'experts solve mystery of electric fish'. It stated that scientists had discovered how the fish had evolved over years to develop an organ that can produce an electric field. This article can be used on the display board to show interesting diversity in the animal kingdom.

The life sciences curriculum has a large section on evolution. This is a topic that goes against the beliefs of some Christians who believe in creation. This is why researchers such as Aikenhead (1996/7, cited in Aikenhead and Jegede, 1999, p.271) suggested that science learning involved cultural border crossing as a learner crosses from his/her everyday culture into the micro-culture of classroom science. It is this border crossing that often presents a challenge for some Christian learners in science classrooms during lessons on evolution. Faced with such issues of faith and religion, it is a teacher's duty to teach science programs that are characterized by inclusive curricula and culturally sensitive instruction, Shipman et al (2002) urged science teachers to maintain a climate of tolerance in their classroom where individual religious and moral viewpoints are respected. It is in this light that newspaper articles 4 and 14 may be used during the teaching of evolution to provide alternative view to issues of faith in the classroom.

Article 6 was entitled 'science explains the parting of the Red Sea' where software engineer Carl Drews used science to show both where and how this event may have happened. To model the effect of winds on these waters, Drews' study used a computerised ocean model to provide different perspective of an atmospheric and ocean effect that can cause the parting of water bodies and concluded by stating that faith and science can coexist in a neutral environment that allows for different opinions.

In article 14, a young South African biological anthropologist reported to be contributing to the public's understanding of evolution. Brendon Billings was doing a PhD degree on our roots in cognition (intelligence) and is also the chairman of all collections at the School of Anatomical Sciences at Wits Medical School, and curator of the huge Raymond Dart Human Skeletal Collection, the largest collection of human skeletons in southern Africa. This article on the involvement of Brendon Billings in evolution may be used to point learners to the not so common careers in the science field.

In the grade 11 and 12 life sciences curriculum, a large portion is also devoted to the study of the impact of human activities on the environment. I have already shown in section 5.4.2 above how newspaper articles on the environment and ecology may prove useful in discussing these topics in the life sciences classroom. I will therefore not go into a lengthy discussion on this point but rather will turn to an illustration of how newspapers articles may be used in chemistry lessons instead.

5.4.4 Chemistry

The following articles discussed elements, compounds and the behaviour of substances as stated by the definition of chemistry in appendix 1. Articles 11 and 37 reported the same story in the Star and the Citizen respectively. Although the articles differed in their article pictures, they both discussed a number of concepts in chemistry under the heading 'French wine producers turn to science'. The articles stated that a group of wine cooperatives in southwest France had joined forces with leading scientists to liberate the wine flavours most prized by consumers in wine markets, from China to the United States. Chromatography and distillation were described as separating techniques used in wine production. Both chromatography and distillation are discussed in the CAPS grade 10 physical sciences under the matter and materials unit.

The articles also discussed how the project was developing the blackcurrant aroma of their Fer Servadou grape variety wine and the violet aroma of the Negrette variety wine. In line with this concept of developing aromas, article 13 was entitled 'the science of the new car smell', published in the Star on April 16 2015. The article reported on how car manufacturing and selling companies use certain aromas created by their chemical engineers to sell their cars. In the current physical sciences curriculum learners use various organic substances to make esters with different aromas in the laboratory. These articles may therefore be used to link the topic of esterification in grade 12 organic chemistry, to technology in industry. Since the articles link school science and industry, they may be used in STS teaching as well.

Most learners in science classroom dream of being medical doctors, engineers or pharmacists. That is as much as they know about science careers. The said articles can also be useful in making learners aware of the many career choices that one has in the chemistry field.

5.4.5 Physics

Article 3 reported on the airbag crisis that the motor industry was facing. When the article was written, car manufacturers where recalling cars fitted with airbag inflators manufactured by Takata. It had been determined that the inflators were exploding with too much force that would send shrapnel into car cabins killing or injuring passengers. Takata uses ammonium nitrate to create a small explosion that quickly inflates its air bags. This article can be useful as an introductory to a discussion of impulse and collisions in grade 12.

Article 15 discussed ultraviolet radiation effects, a topic relevant at grade 10 physical sciences under electromagnetic waves. In chapter 2, section 2.5 I discussed how newspaper articles may be used to improve learners' language proficiency levels. In line with that learners may be given this article as a resource material for a comprehension activity on this topic. This would be an unusual activity in a science classroom which may however enhance learners' understanding of electromagnetic waves.

Article 20 was entitled 'the secret why lightning strike'. The article sought to explain how lightning forms and strikes particular places. This is new knowledge that is still being formulated and can therefore not be taught in the classroom. Similar articles in the sample included articles 21, 25, 44 and 45. These articles collectively discussed the discovery of the Higgs-Boson particle and the dark matter particle which scientists believe to be the particle that gives mass to matter. While the articles fall under physics, they however do not have a direct link with the current South African physical sciences curriculum but they can be displayed on a science board and be used in explaining the tentative nature of science which I discuss in detail in section 5.5 below.

5.4.6 General science

In this study, the term general science was used to refer to articles that could not be classfied into a typical learning area but could be used in any science classroom to improve learners' general science knowledge. Since these general science articles are not specific to any learning area, they may be displayed on science notice boards or they may be used as resources for science motivational talks for the purpose of increasing the scientific literacy of learners and to promote their interest in science issues. The following sections discuss general science articles that simply raise science awareness in the community, articles that deal with gender issues in science and lastly, articles that can be useful in discussing the nature of science.

5.4.6.1 Articles that raise science awareness

Science is a field that is not static. It has a past, a present and a future. In recent years some science textbooks in South Africa now start certain topics with an introductory section that explains how knowledge on the topic was developed. This could be a result of the discussions and research on the role of the history and philosophy of science in teaching scientific concepts. According to Matthews (1992) the history of science is important to science teaching because it humanises the subject and motivates the students. When science is taught without its history, it appears to be a foreign subject for some weird people who were out to make learners' lives at school difficult. The history of science may be useful in helping learners understand the nature of science which may firstly help them better understand scientific concepts and methods. Secondly, understanding how science developed often as an answer to some societal need, may help learners see the relevance of science as they live in this technological age and this may in turn arouse an interest in science as a subject and a profession. To achieve this newspaper articles that were classified under general science may be useful.

Article 1 is an example of such science news. The article carried the heading 'pints and a shot of science please!'. This article described the meeting between scientists and the general public in an

informal venue such as the pub to discuss selected research projects. The organisers hoped that the event would help close the knowldge gap between the reseachers and the public.

Jegede (1994) discussed science in the African context and advocated for a science curriculum that is compatible with the African classroom environment. He even went on to suggest that information be generated about the African environment to explain natural phenomena. In article 35 Minister Pandor concurred with Jegede's sentiments when she discussed science investment in Africa and stated that "it is imperative for Africa's scientists to work in Africa if they are to support development on the continent, if they are to play a role in smooth technology transfer and if they are to drive innovation," (The Citizen, 2014/10/20). In bringing this article to the attention of my learners in the classroom I will be trying to show the importance of working in scientific research in Africa for the common good of the continent as a whole. Article 10 reported on the science projects of two young South African inventors which may be used by power utilities in the country to improve the lives people. In reading this article, learners may realise that they too can play a part in the development of scientific concepts, theories and inventions since science is "mutable and changeable" (Matthews, 1992, p. 18).

5.4.6.2 Issues of Gender in the Sciences

Matthews (1998) also mentioned that discussions on the nature of science in teaching can be used to discuss philosophical issues such as feminism and the role of women in science. Article 17 reported on the speech on gender imbalance in the science field by the current South African minister for science and technology, Naledi Pandor. In her speech she emphasized the need for more participation of women in science in developing countries in general and in South Africa in particular. This point has been made elsewhere by researchers such as Sjoberg (1996) who reported that boys and girls tended to be equally interested in science when they are in primary school. This interest in science however lowered as they entered middle and high school with even fewer girls opting for physics and chemistry. He went on to point out that even their academic achievements in the subjects also differed, with boys generally doing better in physics and girls performing better than boys in biology. Mulemwa (2004) also reported similar findings in some of the African countries such as Malawi where she researched in. Looking at my science classes today, a similar trend is observed.

In China where they seem to have dealt with issues of gender equity, UNESCO (United Nations Educational, Scientific and Cultural Organization) (2008) reported that China had reached its goal of eradicating gender disparities and empowering women by 2005. In 2007 there were 99.52% boys and 99.6% girls in primary school. Despite this high enrolment of girls in schools, China, reported that most girls still prefer to study the social sciences to studying science even though opportunities are there for them to study science. This could also account for the low numbers of girls studying science in developing countries as well.

More closer home, article 17 reported that, Minister Pandor had called for more science research that is sensitive to women's needs. In the article she made a comment on a lighter note, on how unsuitable a seatbelt is for a pregnant woman and stated that it is because of the fact that it was designed by men. She therefore urged women to be involved in science research. On the same point Sinnes (2006) suggested that obstacles for equity be removed by making girls aware of their opportunities and by pointing to female role models in science for them to emulate. Sinnes (2006) also advocated for the development of gender-neutral educational material as vehicles of equity in science education. Lastly Sinnes (2006) referred to the gender sensitive approach, which states that science education has failed to accommodate the differences among both sexes. It calls for a science education that addresses the differences between individuals regardless of their sex. I think this would be appropriate at these times, when the issue of one's sex is no longer as simple as it used to be. Teachers are therefore urged to be gender sensitive in their pedagogy and in the selection of learning, and choose material that is inclusive in nature. As a science teacher myself and a female for that matter, I would use articles such as article 17 and other resources in the classroom to encourage my female learners to take up science in order to have a science that is 'designed for women by women'as suggested by an advertisement of a brand of sanitary pads currently selling in some South African shops.

5.5 Nature of Science

General science news articles may also be used to discuss the nature of science in science classrooms. There is a statement that says that one cannot know or handle the future unless one looks at the past. What science is, is what eludes many a student. For both some teachers and students, science has been simply the learning of the facts that scientists in past generations discovered about nature which would be relevant to the curriculum of the time. This is the kind of science education that Brocks (1989, cited in Matthews, 1998) referred to as a "valley of dry bones", i.e a science education that lacks "the spirit of science" (Matthews, 1998, p. 986). The spirit of science is what science is, how it is done, how it is constructed and interpreted in a society and how it informs the values and decisions of a society at a given time.

In chapter 2 section 2.5 I described PCK as a knowledge necessary for teaching. Knowing the nature of science is part of developing a sound PCK. This is important for teachers for this will enable them to plan and conduct their lessons in a way that best fosters understanding of scientific concepts. McComas and Almazroa (1998) stated that the "knowledge of the nature of science can assist learners in learning science content" (p. 517). After a research on the benefits of the inclusion of history and philosophy of science (HPS) in science education, Matthews (1994, cited in Galili and Hazan, 2001, p.348) concurred with them and stated that it improves the understanding of scientific

concepts and methods showing the human side of scientific concepts and reducing the formalism that often accompanies the concepts.

A number of ideas have been postulated to explain the nature of science as shown in McComas and Almzroa (1998). The first idea deals with the empirical nature of science which says that 'scientists collect data to support their interpretation of the world but science does not solely rely on empirical evidence. Empirical evidence supports rather than proves scientific claim'. The goal is to move learners from the naive view that science is only based on observable facts to a more informed view that states that science is not only about observable phenomena but about abstraction as well. Article 20 of the study sample can be used as an example to illustrate this concept of abstraction. The article explained how scientists think lightning builds up and eventually discharges at certain places. No one has ever conducted an experiment to test the claim but as the article says "scientists hope to eventually use such data, along with weather forecasts, to pinpoint when lightning could strike".

On a similar note, the nature of science also has it that experiments are not always crucial to have valid theories. Some scientific concepts are constructs inferred from evidence. According to Lederman et al. (2002) "theories are inferred explanations for observable phenomena or regularities in phenomena" (p. 500). There is need to gain clarity on the clear distinction between observation and inference. The role of experiments is to provide the scientific procedures that are so important in observable phenomena and inference is important in relating unobservable phenomena to the things that can be seen. The example of the theory of evolution is cited. The theory cannot be tested experimentally but due to the observed data that has accumulated for it over the years, the theory has been accepted as a scientific theory. As evidence for the theory keeps increasing major religions in the western world have incorporated it into their understanding of nature. Some teachers and learners hold the naive view on this aspect of the nature of science for they believe that if a theory cannot be proved then it cannot be a scientific theory.

While on this point, it is important to also point to the roles of theories and laws in science where scientific laws describe quantitative relationships between phenomena while theories in science are made up of concepts that are in accordance with common observation. Learners' should be made aware that "theories do not become laws even with additional evidence for them" McComas and Almzroa (1998, p. 513).

The tentative nature of science is illustrated by articles According to McComas and Almzroa (1998) NOS states that 'we are never 100% sure about anything because negative evidence will call a theory or law into question, and possibly cause a modification'. An example is the development of the current model of an atom. A number of people such as Dalton, Thompson, Rutherford and Bohr brought forth ideas on atomic structure and modifications continued until we have the atomic structure as it is known today in our science classrooms. Even today articles 21, 25, 44 and 45 discussed in section 5.3.5, above illustrate this tentative nature of science. Work on the Higgs–Boson particle began around 1960 and in 2012 Peter Higgs co-won the Nobel prize with Francois Englert for their work on

this particle. Work continues on what some call the 'God particle' or the dark matter particle which scientists believe is what holds matter in the universe. Since science is not static, as new evidence is found changes are then made to the theories or laws accordingly. This was the fate of Pluto, as I mentioned earlier in section 5.4.1. For years Pluto was believed to be a planet but since 2006, it has been declared a dwarf planet. This example illustrates this tentative nature of science.

The nature of science also has it that science is subjective. This aspect says that science is subjective (theory laden) in nature. Scientist can look at the same data and yet come up with different interpretations and conclusion. Differences can occur due to the different frameworks the scientists may be working from. These may include prior knowledge, educational training and philosophical perspectives. While most news articles have reported on how global warming is causing the sea level to rise as the ice caps are melting, article 29 reported that this is in fact not true. The author stated that "in climate change, there is a widening gap between science, which shows that mankind is not changing the climate in a dangerous way, and the well-funded superstition that pretends that it is. Basic physics shows carbon dioxide can never have more than a small effect on global temperatures. There has been no global warming in the past 17 years. There has been no increase in extreme weather events. There is no alarming rise in sea levels. The poles are not disappearing" (The Citizen, 07/01/2014). Since scientists are human they bring their humanity into the way they learn, think and interpret the same set of data as shown by this article. It is the scientist's prior knowledge of concepts and any other framework that may aid or cloud their interpretation and hence their explanations of the data. A science teacher may then use this difference in opinion on global warming effects to show learners that "scientific theories are well established, highly substantiated, internally consistent systems of explanations" (Suppe, 1977 cited in Lederman et al., 2002, p. 500) and not one scientist's point of view.

Science is therefore a culture on its own and as a culture it is therefore both socially and culturally embedded. It is affected by "the social fabric, power struggles, politics, socioeconomic factors, philosophy, and religion" Lederman et al. (2002). Science is thus socially constructed as scientists work together, review each other's work and improve on the work in the science community. Some findings in science may not easily be accepted by the scientific society itself and the society at large.

Understanding the nature of science will also help learners think critically about issues and learn to make decisions of their own and thus avoiding indoctrination in science education. Matthews(1998), along with other advocates for the inclusion of the history of science in science education went on further to point out that the times we live in call for discussions on research ethics, environmental ethics and the recognition of other sciences besides the western science. Articles reporting on ecology and the environment discussed in section 5.1 above are often better suited to bring this across to the learners.

Lastly, it is the spirit of science that comes from understanding the nature of science that inspires people to want to discover, to understand the world and to create and improve scientific concepts.

The kind of science I think a teacher may bring into the classroom through the science news articles that learners may be exposed to in the media at large and in the newspapers in particular. It is the spirit that drives people to do science.

The foregoing has been a discussion of how science news articles from newspapers can and may be used to enhance learning in science classrooms. In some places I have shown how various articles may be integrated in the science content and in other places I have shown how articles may be used to teach other aspects of what Haralambos (1991) called the 'hidden curriculum' of school. In a school, the evident curriculum is often very clear on paper, yet there is however a salient curriculum that is taught by socialization, visualization and imitation as life happens in a school. School is responsible for the teaching of values, political socialization and social issues such as gender, race, self-worth, to name but a few. Newspaper articles may thus also be used to deliberately teach these values as illustrated above. I turn now to chapter 6, the concluding chapter where I present a summary of the study and its limitations. I will go on to reflect on the study and make recommendations based on the study findings.

Chapter 6

Conclusion and Recommendations

6.1 Introduction

Chapter 1 described the background and the purpose of this study while chapter 2 was a discussion of the literature from which this study drew from. Chapter 3 discussed the research design, and methodology employed to gather the data that was subsequently presented and analysed in chapter 4 and 5. This chapter brings the study to a conclusion by providing a summary of the study, followed by a discussion of the study implications. I then proceed to make recommendations based on the study findings.

6.2 Summary

A content analysis of scientific news published in two South African namely the Star and the Citizen, was conducted for the period of January the 1st of 2014 to the 30th June 2015. The study set out to answer the following questions:

- Which science fields received the most coverage in the Star and the Citizen newspapers from January 2014 to June 2015?
- How was the science portrayed in the two papers?
- What school science could be learnt (if any) in the newspapers during the selected time?

Once a quantitative content analysis was conducted to answer the first research question, data were analysed qualitative to determine how science news was portrayed. This section of the study was conducted using framing as the theoretical framework which theorises that texts are often viewed or interpreted differently by people depending on their multi-faceted individual context. Lastly, the science news was analysed for its relevance to the South African school science curriculum for grades 9-12, Natural Sciences, Life Sciences and Physical Sciences. A comprehensive report of the study findings with regards to these research questions was given in chapter 4 and 5. Here I simply provide an overview of the findings.

6.2.1 Question 1

The science fields that received the most coverage in the two papers collectively included physics with 23% of the 44 articles. This was followed by chemistry and general science articles with 18% each. Other fields covered included environment and ecology, astronomy, earth sciences and archaeology and anthropology. Past studies such Rooyen (2002) and Turner (20080) both determined that health and medicine received the most coverage in their respective studies. The fact

might have been true for this study, had I not decided to exclude health and medicine science articles from the sample.

6.2.2 Question 2

It was determined that the two papers placed emphasis on the social progress (24.7%) and the economic development and competitiveness (26%) frames in their portrayal of science news. The scientific and technical uncertainty frame followed with (20.1%). While these three frames seemed to be the more prominent frames in the newspaper articles, other frames were also present in the texts. These included the public accountability and governance frame which accounted for 13.6%, conflict and strategy 5.5%, runaway science 4.1%, morality and ethics and middle way/alternative path both accounted for 2.7% of the identified 73 frames.

Previous studies also showed that texts often are framed in more than one frame. The studies by Davis and Russ (2015) and Zamith et al (2012) are such examples. Zamith et al (2012) reported that US and South American newspapers primarily framed climate news in public accountability and governance frame, followed by the conflict and strategy. This present study reported similar findings to both Davis and Russ (2015) and Zamith et al (2012) who reported that the middle way/alternative path and morality and ethics frames were less prevalent in texts.

The study also determined that science articles in the Star and the Citizen were treated more as news articles than features. Rooyen (2002) reported similar findings and suggested that the trend is due to the fact that news articles sell papers more than features. While this was true for hard copy papers it is not quite the same for online newspapers which may be accessed freely. For online papers other factors beyond this study may be involved.

6.2.3 Question 3

The discussion in chapter 5 showed the extent to which science news articles may be used in the classroom. Science news article use varied from raising science awareness to the enhancement of the science learning process. Articles were seen to be useful in the teaching of the following grade 9-12 subjects and concepts:

- Astronomy in Natural Sciences
- Life sciences/ Environment and ecology
- Chemistry
- Physics
- General science

This present study also confirmed some of Jarman and Mcclune (2002) findings with regards to the use of science newspaper articles, as illustrated in section 5.4. This current study also determined that the science articles could be used to:

- Link school science and everyday life
- Explain scientific concepts
- Explain the nature of science
- Stimulate interest in science
- Promote thinking and debates
- Promote general literacy and scientific literacy
- Provide variety to science learning experiences

6.3 Discussion

As stated previously in section 2.5, the goal of science education is "to prepare future scientists for their professional roles and to prepare citizens for life in a society where science impinges upon private and civic decisions" (Feinstein, 2015, p. 149). This study therefore set out to bridge the gap between science education and science communication by looking at how the two fields can benefit from each other to achieve this goal of science education.

The findings of this study summarized above, show that the Star and the Citizen newspapers significantly contributed towards achieving this goal for the stated period of time. Firstly, the presence of science articles that can be used in school science subjects shows that the science news reported in the newspapers was real science content that could generally be understood by both learners and others.

Secondly, the frames that the two papers used to portray science news also spoke to the goal of a scientifically literate society. The social progress and the economic development and competitiveness frames both seek to improve the quality of people's lifes through science and technology. The scientific and technical uncertainty frame shows science in the making. According to Bauer (1992) science news articles often lack a distinction between textbook science and frontier science where "textbook science is the settled scientific knowledge on which (in natural sciences) one can build one's own work. In contrast, frontier science is science as it is actually being conducted whose results have just been obtained and are still uncertain and unconfirmed" (Bauer, 1992, p. 37). Even more recently Scudellari (2015) brought to light some science misconceptions that the media has been perpetuating for years and yet they lack strong scientific evidence. These include the myth that regular screen tests and early detection of cancer saves lives. She reported that this was not yet a proven fact. Scudellari also referred to the idea that people learn best when taught in their preferred learning style as another myth. I have held this belief for years as teacher and it was quite interesting to discover that this is actually also not as true as I had been made to believe. In this article, she then

concluded that effective communication between scientists and the public is the key to preventing the spreading of scientific myths and misconceptions. Teacher education programmes should therefore equip teachers to be able to use such articles to point to the nature of science and how science in progress should not be taken as 'gospel'. In recent years health science has it that male circumcision reduces the risk of contracting the HIV virus. Some circumcised people may have altogether abandoned the use condoms in the belief that they were now safe. A teacher may use such articles to point to the uncertainty frame to correct a misconception.

The presence of these and other frames such as the public accountability and governance frame, conflict and strategy, runaway science, morality and ethics and middle way/alternative path frame all speak to the second part of the goal for science education which is to enable people to make informed decisions on science issues in the society. This is quite relevant to the STS strategy of teaching science discussed in sections 2.5 and 5.4.2, which gives learners access to a science education that focuses on the acquisition of knowledge, the development of technological inquiry, problem solving and decision-making skills while developing values and ideas that learners can apply in their interactions with science, technology and society (Hassard, 2005).

To achieve these goals, science teachers need time which is often not afforded them. In South Africa as with some other countries, the science curriculum is set, with a detailed schedule that clearly states what a teacher is supposed to teach per day. When the government education officials visit the school they are not worried about how one has taught the content. Their focus is whether the syllabus has been completed. Examination pressures tend to cause teachers to teach only the material that is relevant for examinations, yet science education should be more than just grades. In a survey of the use of newspaper articles in science classrooms, Jarman and Mcclune (2002) determined that some teachers in their study, stopped using newspaper articles in their classroom due to time constrains. The other disadvantage of using newspaper articles is that the articles do not conveniently appear when one is teaching a topic. However, this can often be solved by technology which enables teachers to access and to store articles easily.

Over the years I have met teachers who claim that they do not need to plan for their lessons. They believe they know all they require to teach their subject matter. In section 5.4 I showed that subject matter knowledge has its place in teaching. What is central to teaching is the imparting of knowledge to learners. This is where lesson planning is important. Science news articles collected overtime may then be incorporated into the relevant lesson for the desired learning goal.

6.4 Limitations

- The study was limited to two newspapers within Gauteng namely the Star and the Citizen. Its findings cannot therefore be used as a general view of science coverage in South Africa.
- Since the study was also time bound in that it covered science articles between the 1st of January 2014 to the 30th of June 2015, its findings on how newspapers portrayed science news are also time specific and cannot be generalised to other time frames and newspapers in South Africa.
- The findings of how interesting science news articles were as reported in section 5.2 and how relevant the science reported was to the school science in section 5.3, were solely based on my personal opinion of the articles. They cannot be taken as the general view of science article readers in South Africa

6.5 Further Research

Previous studies such as Turner (2008) and Rooyen (2002) have suggested that content analysis of newspapers should be conducted regularly to assess science coverage at different intervals. In light of this current study limitations described above, I echo the same sentiments. It is important for both the science education and the science communication fields to periodically know the amount and type of science that newspapers cover in order to keep the society informed of any science and technological issues that so impact our existence.

As Gallagher (1971, p. 330) wrote, "for the coming generation of learners, who will live in a world deeply affected by science, a knowledge of the processes and concepts of science and their interrelations with technology and society will be prerequisites to knowing and functioning in the culture in which they will be living". While this was written in 1971, the statement may well have been written for today's learners and even those to come. Science education should constantly evolve as the learners and the science to be learnt. To remain static is to lose many a capable learner in the classroom. Science education researchers should therefore seek to determine:

- the use of other types of media to enhance science learning.
- the possibility using social media for science learning, e.g blogs.
- if science learning improves with media use in the classroom.
- and if learning does improve , to what extent does the learning occur?
- how science news articles can be used to correct science misconceptions.

While I am aware that some of these recommendations have been tried and one might feel that the recommendations are inventing the wheel, I will therefore hasten to point out that fine wheels are

simply wrought out of small improvements of the previous one. So it is with research work, often previous studies are improved or modified to collectively add to one body of knowledge. So, much work can still be done on learning science through the media, I therefore believe that this study has added to literature on science learning and teaching.

6.6 Reflections

My past experience as a science learner was a painful one. I remember sitting in a chemistry class listening to my teacher and wondering what she was on about. Nothing made sense at all. For starters, my teacher spoke English with a British accent I could not understand, secondly there was nothing in the lesson content I could identify with as a black child from the ghetto, imagine walking into class and the teacher simply says we are discussing phase equilibrium and half the class is saying '*phase equiwhat?*'. Then the teacher would proceed to deliver the lesson in the most boring manner ever. It was torture listening to her. Looking back, I wonder if the teacher simply thought I was just one learner who could not learn chemistry. She never understood the challenges I faced in her classroom. It is from this experience that as a science teacher at a high school in Johannesburg, I try to make my science lessons clear, interesting and as relevant to their context as possible to allow my learners better access to science knowledge.

It is essential that science teachers not only understand how pupils learn and ways to promote learning, but they must also engage them in science. Piaget once said "education for most means trying to lead the child to resemble the typical adult of his society.....but for me and no one else, education means making creators.... you have to make inventors, innovators and not conformists" (Bringuier, 1980, p. 132). This is the essence of science teaching. Hence Lederman et al. (2002) agrees that the development of science knowledge requires "a great deal of creativity on the part of scientist" (p.500). This study has shown that science newspaper articles may be one such tool to bring about creativity to science classrooms. I believe this will awaken and hold the interest of learners in science.

I have always viewed the phrase by George Bernard Shaw which says, 'he who can, does and he who cannot, teaches,' with mixed feelings. This study got me thinking about the various forms of knowledge a teacher has to have to be a competent teacher. Teaching requires much thought and deliberation on how to weave one's SMK, PK and PCK to be able to teach effectively as described in section 5.3. This is not a task for the weak in mind but for the strong-minded, strong-willed men and women who dare to inspire the minds of our young ones to greater heights. Aristotle in Shulman (1986) said that "the ultimate test of understanding rests on one's ability to transform knowledge into teaching" (p.14). This study opened up my eyes to yet another strategy to teaching science, i.e using science articles from newspapers. I walk away from this study thrilled by Shulman's counter remark which says "Those who can, do. Those who understand teach."(1986, p. 14). I believe I now understand and have become a better science teacher than I was prior to this study.

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Appendix A

Summary of Science Fields

- **Anthropology & Archaeology:** The study of man's nature and development. The study of the buried remains of ancient time
- **Astronomy:** The science of space, the sun, the moon and the stars.
- **Biomedicine:** The science of clinical medicine, biochemistry and basic biology
- **Botany:** The study of plants.
- **Zoology:** The study of animals.
- **Cell & Molecular Biology:** The science of the microcosmos, including living cells and their properties.
- **Chemistry:** The study of the elements, compounds and the behaviour of substances.
- **Earth science:** A broad term, which includes geology (the study of rocks and minerals) and oceanography (the physics and chemistry of the oceans, marine biology and the exploitation of the ocean's resources).
- **Environment & Ecology:** The study of the relation of plants, animals and people to one another and to their surroundings.
- **Mathematics:** The science of numbers.
- **Paleobiology:** The study of fossils.
- **Physics:** The study of matter and natural forces.
- **General science:** Science discussed as a general topic.

Adapted from Rooyen (2002).

Appendix B

Coding Manual

Summary of frame definitions

Frame	Defines science issues as
Social progress	A means of improving quality of life or solving problems; alternative interpretation as a way to be in harmony with nature instead of mastering it.
Economic development and competitiveness	An economic investment; market benefit or risk; or a point of local, national, or global competitiveness.
Morality and ethics	A matter of right or wrong; or of respect or disrespect for limits, thresholds, or boundaries.
Scientific and technical uncertainty:	A matter of expert understanding or consensus; a debate over what is known versus unknown; or peer-reviewed, confirmed knowledge versus hype or alarmism.
Runaway science	A need for precaution or action in face of possible catastrophe and out-of-control consequences; or alternatively as fatalism, where there is no way to avoid the consequences or chosen path.
Public accountability and governance:	Research or policy either in the public interest or serving special interests, emphasizing issues of control, transparency, participation, responsiveness, or ownership; or debate over proper use of science and expertise in decision making ("politicization").
Middle way/alternative path	A third way between conflicting or polarized views or options.
Conflict and strategy	A game among elites, such as who is winning or losing the debate; or a battle of personalities or groups (usually a journalist-driven interpretation).

Nisbet's framework (2009, p. 18)

Appendix C

Coding Schedule

1	Name of Newspaper		
2	Date of Publication		
3	Field of Science		
4	Social progress		
5	Economic development and competitiveness		
6	Morality and ethics		
7	Scientific and technical uncertainty		
8	Pandora's box/Frankenstein's monster/runaway science		
9	Public accountability and governance		
10	Middle way/alternative path		
11	Conflict and strategy		

Application in Science Education

	Grade	Topic
1		
2		
3		
4		
5		

Appendix D

Coding Sheet

Article ID :

Article Title:

Date:

Total Number of words:

Type of Science Reported:

Treatment
1. General News
2. Feature
3. Commentary/ Criticism
4. Other

Frames: public accountability and governance
Evidence of frame presence in texts   •

Application in Science Education

	Grade	Learning area/Topic	Correctness of Content
1			
2			

General Reaction (1 = negative.....5 = positive)
How interesting was the article?
1 2 3 4 5
How clear understandable was the writing?
1 2 3 4 5
Is this a story I would choose to use in my science classroom
1 2 3 4 5

Appendix E

List of study articles

Article Number	Article Title
1	Pints and a shot of science, please!
2	Boy, 13, cracks rocket science at MIT
3	Rocket science for airbag crisis
4	Tumbling Science on its head
5	Fracking rules 'flawed and lack science'
6	Science explains the parting of the Red Sea
7	Spectacular displays turn pupils on to science
8	Science fiction coming to life'
9	SA's maths, science teaching 'in crisis'
10	KZN science boffs build on success
11	French wine producers turn to science
12	'Catastrophic' climate woes ahead
13	The science of the 'new car' smell
14	Meet SA's own bone detective
15	Regular tanning not only may raise the risk of skin cancer but also may be addictive.
16	Nuclear energy and hydraulic fracking: Are they twin evils or do they open new vistas of opportunity,
17	Women scientist in Africa still a minority
18	How will the universe end?
19	Use Earth's heat, scientists suggest
20	The secret of why lightning strikes
21	LHC in new hunt for dark matter (citizen)
22	Science unveils master painters' secrets
23	1 000kg of SA pangolin seized
24	Experts solve mystery of electric fish
25	New particle in physics may be found this year
26	Fracking – the final frontier
27	Low- and hi-tech solutions emerge for urban heat peril
28	Nuclear deal complete before '16 – Joemat-Petterson
29	Global warming freezes
30	German institute invests in SA telescope project
31	SA launches first Meerkat antenna
32	SALT benefits small South African town
33	Two more planets in our Solar System, say astronomers

34	NASA pushes back against proposal to slash climate budget
35	Africa needs science investment – Pandor
36	SA, UK sign science agreement
37	French wine producers turn to science for flavour
38	Germany's Bayer to float chemicals division
39	Bio-economy strategy launched in Pta
40	Chemicals that could cause cancer
41	Star Astronomy investments drive human capital development
42	Expect more tremors, say seismologists
43	Star Climate change to wipe out health gains
44	Experiments give shape to Higgs