A PILOT STUDY OF THE USE OF AN ANALYTICAL FRAMEWORK FOR A REPRESENTATION OF THE NATURE OF SCIENCE (NOS) IN A GRADE 8 NATURAL SCIENCES TEXTBOOK

Tarisai Chanetsa
University of Johannesburg
South Africa
Email: tzchanetsa@gmail.com

Professor Umesh Ramnarain
University of Johannesburg
South Africa
Email: uramnarain@uj.ac.za

Abstract–This study is a pilot on the use of an analytical framework developed by Abd-El-Khalick, Waters and Le to investigate the extent to which the Nature of Science (NOS) is represented in science textbooks. Science is best defined by its characteristics, otherwise known as the tenets of the NOS. Ten key aspects of the NOS that are related to the basic tenets of science derived by Lederman (2007) formed the analytical framework used in this study. In addressing inter-rater reliability in the analysis, the pilot utilised three coders. All scores were captured in a textbook scoring sheet. Next, the coders compared and contrasted their scores. Any differences in the scoring were resolved through extended discussions by further reference to the textbook materials. The findings revealed that 40% of the analysed units were coded according to the basic NOS tenet 'Scientific theories'. The tenet 'Empirical nature of science' was reflected in 27% of the units. The other tenets of the NOS were poorly depicted in the textbook.

Keywords: Nature of Science, textbook analysis, inter-rater reliability

1.1 INTRODUCTION

This paper reports on the use of an analytical framework developed by Abd-El-Khalick, et al. (2008) for the qualitative and quantitative analysis of the representation of the NOS in science textbooks.

The framework follows a deductive category application model based on the tenets of the NOS as defined by Lederman (2007) and expounded upon by Abd-El-Khalick et al. (2008). In a deductive category application procedure pre-formulated categories are brought into connection with the text. In this case the categories were comprised of the tenets of the NOS.

This paper presents a pilot study on one CAPS compliant science textbook through the use of a detailed scoring rubric to record the extent to which the NOS is represented in the units of analysis comprising complete paragraphs, activities, worked examples, figures with captions, tables with captions, charts with captions, and marginal comments of the sampled chapters.

In using the framework we initially experienced some overlap across the tenets. Clarity was obtained through extensive discussion and the realisation that some tenets are defined relative to others. Initially discrepancies were evident in assigning scores to the NOS tenets, but this was again resolved through discussion. Overall, it can be concluded that the NOS framework that was piloted is a viable and reliable instrument that can be used in the analysis of South African textbooks.

1.2 BACKGROUND TO RESEARCH

The concept of the NOS is one that is naively understood by teachers in South Africa as researched by Bantwini, Kurup, Linneman, Lynch & Webb (2003) possibly stemming from the fact that the NOS can neither be defined by a single term nor statement. Instead the NOS is a combination of at least seven aspects derived from Lederman (1998) and known as the tenets of science. These tenets derived from Lederman are: Empirical; Inferential; Creative; Theory-driven; Tentative; Myth of The Scientific Method; Scientific theories; Scientific laws; Social dimension of science; and Social and cultural embeddedness of science. These tenants are further discussed in Table 1 under the next section on the conceptual framework of the study.

These tenets have formed the basis for curriculum documents all over the world (Lederman, 2007). In South Africa the NOS is represented in Curriculum and Assessment Policy Statements (CAPS) for science subjects, and textbooks should be written to reflect the NOS on which the curriculum

documents are based (Bester, Clacherty, Cowan, Doubell, Lombard, Nkosi, Paarman, Padayachee, Sadie, Schreuder, Slamang, Ungerer, 2013). In order to identify any dependency between textbooks and the curriculum, it is necessary to analyse the textbooks for the extent to which they represent the NOS.

Content analysis of textbooks is common international research but the frameworks used or analytical tools differ. Far less common is research focusing specifically on the extent to which the NOS is depicted in Natural Sciences textbooks. Findings by other scholars in this field are documented here.

Padayachee (2012) studied the representation of the NOS in Life Sciences and Biology textbooks in South Africa and targeted four broad aspects of NOS constructs: science as a body of knowledge; science as a way of investigating; science as a way of thinking; and the interaction between science, technology and society. This research used a framework developed by Chiappetta, Sethna and Fillman (2004). The findings of the study revealed that Life Sciences textbooks represented all four NOS aspects in contrast to Biology textbooks which had no representation at all for the interaction between science, technology and society. The framework used by Padayachee is different to the one used for this pilot study. The framework used for this pilot study – as used by Abd-El-Khalick on textbooks in the United States of America – has never been used on textbooks in South Africa. This framework will be explained further in the conceptual framework

Abd-El-Khalick`s research on the representation for the NOS in textbooks in the United States of America was a long term study spanning four decades and involving five series of chemistry books that commanded a significant market share. Of the fourteen books analysed, the study focused on chapters or sections of the chemistry textbooks that covered "scientific method, scientific processes, how science works and topics related to atomic structure, kinetic molecular theory and gas laws" (Abd-El Khalick et al., 2008). These sections were selected due to their obvious relevance to the NOS. It was found that the chemistry textbooks performed poorly in their representation of the NOS and this did not improve over the decades but surprisingly decreased in some instances. This occurred despite a greater emphasis having been placed on the centrality of the NOS in education reform documents (Abd-El Khalick et al., 2008).

1.3 CONCEPTUAL FRAMEWORK

Key concepts forming the basis of this research will be defined in this conceptual framework and their relevance to the study explained so as to provide a clear understanding of the background to the NOS. The definition of the NOS has been dynamically formulated over a period of time by various scholars. The complexity of defining the NOS emanated in it being incorrectly or insufficiently addressed in science textbooks as will be discussed further. In this section concepts that have contributed to the NOS are clarified. These concepts form the basis of the analytical framework (see Table 1).

Table 1: Explication of the NOS aspects in the analytical framework

NOS aspect	Dimensions emphasised in textbook analysis
Empirical	Scientific claims are derived from, and/or consistent with, observations of natural phenomena. Scientists, however, do not have 'direct' access to most natural phenomena: Their observations are almost always filtered through the human perceptual apparatus, mediated by the assumptions underlying the functioning of 'scientific' instruments, and/or interpreted from within elaborate theoretical frameworks.
Inferential	There is a crucial distinction between observations and inferences. Observations are descriptive statements about natural phenomena that are accessible to the senses (or extensions of the senses) and about which observers can reach consensus with relative ease (e.g., objects released above ground level tend to fall to the ground). Inferences, on the other hand, are statements about phenomena that are not directly accessible to the senses (e.g., objects tend to fall to the ground because of 'gravity'). Scientific constructs, such as gravity, are inferential in the sense that they can only be accessed and/or measured through their manifestations or effects.
Creative	Science is not an entirely rational or systematic activity. Generating scientific knowledge involves human creativity in the sense of scientists inventing explanations and theoretical entities. The creative NOS, coupled with its inferential nature, entail that scientific entities (atoms, force fields, species, etc.) are functional theoretical models rather than faithful copies of 'reality'.
Theory-driven	Scientists' theoretical and disciplinary commitments, beliefs, prior knowledge, training, and expectations influence

	their work. These background factors affect scientists' choice of problems to investigate and methods of investigations, observations (both in terms of what is and is not observed), and interpretation of these observations. This (sometimes collective) individuality or mind-set accounts for the role of theory in generating scientific knowledge. Contrary to common belief, science never starts with neutral observations. Like investigations, observations are always motivated and guided by, and acquire meaning in light of questions and problems derived from, certain theoretical perspectives.
Tentative	Scientific knowledge is reliable and durable, but never absolute or certain. All categories of knowledge ('facts', theories, laws, etc.) are subject to change. Scientific claims change as new evidence, made possible through conceptual and technological advances, is brought to bear; as extant evidence is reinterpreted in light of new or revised theoretical ideas; or due to changes in the cultural and social spheres or shifts in the directions of established research programs.
Myth of 'The Scientific Method'	This myth is often manifested in the belief that there is a recipe-like stepwise procedure that typifies all scientific practice. This notion is erroneous: There is no single 'Scientific Method' that would guarantee the development of infallible knowledge. Scientists do observe, compare, measure, test, speculate, hypothesise, debate, create ideas and conceptual tools, and construct theories and explanations. However, there is no single sequence of (practical, conceptual, or logical) activities that will unerringly lead them to valid claims, let alone 'certain' knowledge.
Scientific theories	Scientific theories are well-established, highly substantiated, internally consistent systems of explanations, which (a) account for large sets of seemingly unrelated observations in several fields of investigation, (b) generate research questions and problems, and (c) guide future investigations. Theories are often based on assumptions or axioms and posit the existence of non-observable entities. Thus, direct testing is untenable. Only indirect evidence supports and validates theories: Scientists derive specific testable predictions from theories and check them against observations. An agreement between predictions and observations increases confidence in the tested theory.
Scientific laws	In general, laws are descriptive statements of relationships among observable phenomena. Theories, by contrast, are inferred explanations for observable phenomena or regularities in those phenomena. Contrary to common belief, theories and laws are not hierarchically related (the naïve view that theories become laws when 'enough' supporting evidence is garnered, or that laws have a higher status than theories). Theories and laws are different kinds of knowledge and one does not become the other. Theories are as legitimate a product of science as laws.
Social dimension of science	Scientific knowledge is socially negotiated. This should not be confused with relativistic notions of science. This dimension specifically refers to the constitutive values associated with established venues for communication and criticism within the scientific enterprise, which serve to enhance the objectivity of collectively scrutinised scientific knowledge through decreasing the impact of individual scientists' idiosyncrasies and subjectivities. The double-blind peer-review process used by scientific journals is one aspect of the enactment of the NOS dimensions under this aspect.
Social and cultural embeddedness of science	Science is a human enterprise embedded and practiced in the context of a larger cultural milieu. Thus, science affects and is affected by various cultural elements and spheres, including social fabric, worldview, power structures, philosophy, religion, and political and economic factors. Such effects are manifested, among other things, through public funding for scientific research and, in some cases, in the very nature of 'acceptable' explanations of natural phenomena (e.g., differing stories of hominid evolution have resulted from the advent of feminist perspectives brought about by increased access, participation, and leadership of females in the biosocial sciences).

(Source: Abd-El-Khalick, 2013).

The next section provides an elaboration of the methodology explaining how the pilot study was carried out quantitatively using the analytical tool as refined by Abd-El-Khalick (2013). The findings of the study will be given and discussed accordingly.

1.4 METHODOLOGY

The pilot study adopted a structural document analysis approach. In this approach the content of a textbook is analysed and connected to pre-formed categories in what is known as a deductive category application. Four chapters of a Grade 8 Natural Sciences book approved by the Department of Basic Education were selected for analysis of their representation of the NOS.

1.4.1 Content analysis

According to Krippendorff (1980:17) "content analysis has been defined as a systematic replicable technique for compressing many words of text (or other meaningful matter) into fewer categories based on explicit rules of coding". In this pilot a deductive category application procedure was applied in which pre-formulated categories, in this case the tenets of the NOS, were brought into connection with the text. Each passage of text was qualitatively assigned to one of the categories.

The framework by Abd-El-Khalick (2013) explicitly provides definitions and examples that are typical of Natural Sciences textbooks, and coding rules for each deductive category. Also provided are rules for distinguishing between categories and assigning scores for the extent to which a category is represented. Figure 1 below represents the step model of deductive category application used in this study.

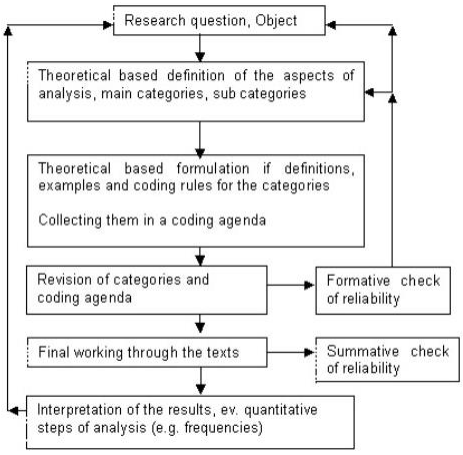

Figure 1: The step model of deductive category application used in this study

Reliability and validity are closely related since valid results "compel one to accept scientific results as evidence" (Krippendorff, 1980, 73) and are therefore reliable. To ensure reliability and validity in this study more than one coder was used for the content analysis as it tends to lend itself to subjectivity. The coders were trained on how to use the framework and had an advanced grasp of the NOS.

1.4.2 Connectedness of target NOS aspects

The analytical framework for analysis based on the NOS tenets explicated in Table 1 contains guidelines by Abd-El-Khalick (2013) to ensure its accurate use. Important to note is the fact that certain tenets of NOS cannot be viewed in isolation but in relation to other tenets. For instance, the 'Empirical NOS' cannot obtain a full score if it remains silent on 'Inferential NOS' and 'Theory-driven NOS'. Secondly, if a textbook proposes the existence of the 'Myth of the scientific method' then this affects the score of the 'Creative NOS'. Abd-El-Khalick (2013) further explains the crucial importance of differentiating between scientific laws and scientific theories as some textbooks erroneously suggest that theories change into law. Of equal importance is the distinction between observations and inferences.

1.4.3 Units of analysis

The pilot textbook is currently out of circulation and has been replaced by the revised CAPS compliant edition. During its period in circulation from 2006 to 2013, the pilot textbook commanded a considerable market share and was widely used by Grade 8 learners nationally.

Four out of thirteen chapters of the textbook were selected for the analysis, three of which were representative of the following content strands of Natural Sciences: Life and living; Energy and change; Earth and beyond. The fourth chapter analysed was the introductory chapter 'Tools and skills for Natural Sciences', which was purposefully selected due to its probable relevance to the NOS. The units of analysis included complete paragraphs, activities, worked examples, figures with captions, tables with captions, charts with captions and marginal comments.

1.4.4 Scoring rubric

The rubric developed by Abd-El-Khalick (2013) assigns a score to a unit of analysis ranging from +3 to -3 depending on the extent to which that unit represents a target NOS aspect. The rubric draws a distinction between an explicit versus an implicit representation of the target NOS aspect. Research by Abd-El-Khalick et al. (1998) on implicit versus explicit instructional approaches revealed that implicit strategies such as engaging in scientific activities do not translate into an understanding of NOS, whereas an explicit approach is more effective in ensuring comprehension of NOS. An explicit

approach would entail educators differentiating between observation and inference during activities as opposed to the learners having to infer this crucial distinction from their activities.

Below is the scoring rubric used in the analysis providing the distinction between explicit and implicit representation.

Scoring Rubric

- Selected materials from a textbook are not analysed and/or scored independently:
- All such materials (e.g., chart on the 'scientific method' and associated text, narrative on the historical development of atomic structure, sections on the interaction between science and society, or bulleted text, activity boxes, and vignettes relevant to one or more NOS aspects) are carefully read and all NOS aspects addressed in these sections are identified.
- Next, all references and materials targeting the same NOS aspect are grouped together and examined holistically. In other words, the score assigned to a specific NOS aspect within a textbook is based on an examination of all materials relevant to that aspect within the examined textual materials.Scores are assigned in accordance with the following rubric.

Table 2: Scoring rubric

- **Three points = Explicit, informed, and consistent representation of the target NOS aspect**:
  i. Explicit statements that convey an informed representation,
  ii. Consistency across the selected chapters or sections in addressing the target NOS aspect, and
  iii. Consistency in addressing other directly related NOS aspects.
- **Two points = Explicit, partially informed representation of the target NOS aspect**:
  i. Explicit statements that convey an informed, but incomplete representation, and
  ii. Consistency across the selected chapters or sections in representing the target NOS aspect. An incomplete representation derives from the textbook materials remaining silent in terms of addressing other related NOS aspects that ensure a complete informed representation.
- **One point = Implicit, informed, and consistent representation of the target NOS aspect**:
  i. An informed representation of the target NOS aspect could be *inferred* from the textbook materials (e.g., relevant explanations, activities, examples, or historical episodes *lacking* structured, reflective prompts or explicit statements), and
  ii. Absence of other explicit or implicit messages, which are inconsistent with the inferred implicit representation.
- **Zero points = The target NOS aspect is not addressed**:
  i. No explicit or implicit treatment of the target NOS aspect, or
  ii. Not enough materials (statements, examples, historical vignettes, etc.) to make an informed judgment or to convey to the textbook reader a sense about the target aspect of NOS one way or the other.
- **Negative one point = Implicit misrepresentation of the target NOS aspect**: A naïve representation could be *inferred* from the textbook materials.
- **Negative two points = The textbook materials convey mixed explicit and/or implicit messages about the target NOS aspect**:
  i. Implicit, informed representations that could be inferred from some parts of the textbook materials are countered by explicit, naïve statements in other parts, or
  ii. Explicit statements that convey conflicting messages about the same NOS aspect.
- **Negative three points = Explicit, naïve representation of the target NOS aspect**: Explicit statement or statements that clearly communicate a naïve representation of the target NOS aspect.

(Source: Abd-El-Khalick: NOS textbook analysis methods/ UIUC: April 20, 2013/ Scoring rubric)

1.4.5 Reliability

In addressing inter-rater reliability in the analysis, the pilot utilised two coders, in addition to myself. Inter-rater reliability is the degree of agreement amongst raters or how much homogeneity exists between the raters' scores. The coders were selected according to their expertise as science education researchers, having at least a masters' level qualification in science education. All scores were captured in a textbook scoring sheet. Next, the coders compared their scores. Any differences in the scoring were resolved through discussions and by further reference to the textbook materials until a consensus was reached.

1.5 FINDINGS

Nine out of eleven target NOS aspects were represented by the four chapters sampled from the textbook. The textbook remained silent on 'Theory-driven' and 'Social dimensions of science'. The cumulative score for the NOS in this pilot was +7 out of a possible range of scores from -33 to +33. Individual scores for the NOS tenets range from -3 to +3 for 11 aspects giving a cumulative score of -33 to +33. The higher the cumulative score, the more explicit, informed and consistent the NOS is represented.

Table 3 below presents the scores assigned to target NOS aspects in the four sample chapters. These scores were agreed upon by the three coders through discussions and with reference to the scoring guidelines. The overall score is derived from the most dominant representation – either the most frequent or the most prominent.

Table 3: Chapter scores on the target NOS aspects

Nature of science aspect	Tools and skills for NS	Life and living	Energy and change	Earth and beyond	Overall score
Empirical	+2	+2	+2	+2	+2
Inferential	+1	0	+1	+1	+1
Creative	+1	+1	-2	+1	-2
Theory driven	0	0	0	0	0
Tentative	+1	0	0	0	+1
Myth of 'The scientific method'	-2	0	-2	0	-2
Scientific theories	+1	+1	+2	+2	+2
Scientific laws	0	0	-1	+1	+1
Social dimension of science	0	0	0	0	0
Social and cultural embeddedness	+1	0	0	+2	+2
Science vs pseudoscience	0	0	0	+2	+2

To obtain the above mentioned scores, units of analysis had to be qualitatively analysed, placed into the deductive categories of the NOS tenets then finally scored based on Abd-El-Khalick`s guidelines. Below is an exemplar table of some units analysed in the pilot, the target NOS represented and the corresponding scores:

Table 4: Chapter excerpts corresponding to target NOS aspects scores

NOS aspect	Score	Quote/ example
Empirical	+2	"Unless we use extremely powerful telescopes, we cannot see the planets that move round other stars" (Soobramoney & Vermaak, 2006:81)
Inferential	+1	"The conclusion of the investigation would be that it is the water in the rain that helps the plant to grow" (Soobramoney & Vermaak, 2006:13)
Creative	-2	"You need to test your hypothesis by designing and carrying out an investigation. One possible way of testing the above hypothesis would be to use two plants of the same type. Keep the plants in the same environment. Water the one plant, but not the other" (Soobramoney & Vermaak, 2006:13)
	+1	Learners are to design and make an alien " use your imagination when designing your organism and be creative" (Soobramoney & Vermaak, 2006:89)
Tentative	+1	A historic account of how the microscope has been developed by various scientists.
Myth of "The scientific method"	-2	"The scientific method is the way in which scientists go about answering questions and discovering new things" (Soobramoney & Vermaak, 2006:12).
Scientific theories	+2	A variety of consistent systems of explanations. "You are going to go outside. One of you will be blind folded. Predict the challenges you will both face in getting from point A to point B" (Soobramoney & Vermaak, 2006:77). This is an example of the predictive function of scientific theories.
Scientific laws	+1	"As the concentration of these gases continues to rise, they trap too much heat in the atmosphere and cause the temperatures on earth to rise" (Soobramoney & Vermaak, 2006:88).
Social and cultural embeddedness	+2	An account of how the San people believe the milky way came about.
Science vs pseudoscience	+2	The San believed that "the purpose of the milky way was to keep the sky from collapsing on Earth" (Soobramoney & Vermaak, 2006:79).

1.5.1 Discussion of findings

The cumulative score of +7 for the pilot is consistent with prior research findings by Abd-El-Khalick (2008) on high school chemistry textbooks indicating the general lack of attention to NOS aspects in textbooks. Similar findings emerged for South African textbooks analysed by Padayachee (2012).

In the chapter dedicated to 'Tools and skills for Natural Science', an entire subtopic is dedicated to the scientific method which explicitly confirms the 'Myth'. This error is consistent throughout the analysed chapters and could possibly be erroneously represented throughout the entire textbook. It should be noted however that although the pilot chapters confirmed the 'Myth of the scientific method', some creativity was explicitly allowed for in some units. Despite these explicit statements pertaining to creativity, the 'Creative NOS' could not get a full score because of explicit presentations of the 'Myth'.

Interesting to note is that all the sampled chapters explicitly represented the 'Empirical NOS' to the same degree but failed to get a full score of +3 due to the failure to distinguish between observations and inferences whilst remaining silent on the 'Theory-driven NOS'.

An inference of a scientific law was made in only one of the chapters and the text offered no distinction between scientific laws and theory. The lack of a representation of scientific laws could possibly be attributed to the grade level the textbook targets. The text however is consistent in its system of explanations contributing to scientific theories but unfortunately remains silent on the generative and guiding functions of theories thus failing to obtain a full score for this aspect of the NOS.

The social dimension of science is not reflected at all in the text thus suggesting to learners that scientific discoveries and claims are absolute and cannot be challenged. This implies the absence of a whole community of practice for communication, criticism and collaboration of scientific knowledge.

Natural Sciences merges four disciplines of science into four content strands. This pilot study analysed chapters from three strands, which revealed that the 'Life and living' strand represents the NOS to the least extent whilst the 'Earth and beyond' strand has more to offer in terms of representation. This could possibly be attributed to the differences in the subject matter of the disciplines – Life and living studies different forms of life or living matter whilst Earth and beyond focuses on the structure of the Earth and space.

1.6 CONCLUSION

The use of the analytical framework for analysing South African science textbooks was found to be feasible thus prompting its further use in studies of a larger magnitude. Currently it is being used in the analysis of three revised CAPS compliant textbooks. The success of the framework depends on inter-rater reliability which can be achieved through extensive training of expert coders holding a high level of science education at tertiary level and an understanding of the framework. The findings reveal that the NOS is represented to differing degrees in accordance with the strand which is being represented. However, further analysis of entire textbooks will be necessary to verify these findings.

REFERENCES

Abd-El-Khalick, F., Bell, R., & Lederman, N. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education*, 82, 417 – 437.

Abd-El-Khalick, F., Waters, M., & Le, A. (2008). Representations of nature of science in high school chemistry textbooks over the past four decades. *Journal of Research in Science Teaching*, 45 (7), 835 – 855.

Abd-El-Khalick, F. (2013). Target nature of science aspects. *Nature of science textbook analysis methods*, 1 – 2. Illinois: University of Illinois at Urbaba-Champaign.

Abd-El-Khalick, F. (2013). Coding and scoring instructions. *Nature of science textbook analysis methods*, 1 – 2. Illinois: University of Illinois at Urbana-Champaign.

Bantwini, B., Kurup, R., Linneman, S.R., Lynch, P., & Webb, P. (2003). South African science teachers' perception on the nature of science. *African Journal of Research in SMT Education*, 7, 35 – 50.

Bell, R.L. (2008). Teaching the nature of science through science process skills: Activities for Grades 3–8 (1 ed.). New York: Longman.

Bester, M., Clacherty, A., Cowan, J., Doubell, S., Lombard, G., Nkosi, E., Paarman, S., Padayachee, K., Sadie, R., Schreuder, L., Slamang, M., Ungerer, E. (2013). Platinum Natural Sciences: Maskew Miller Longman: Cape Town.

Chiappetta, E.L., Sethna,G. H. & Fillman, D.A. (2004). Procedures for conducting content analysis of science textbooks of the nature of science. Texas: University of Houston.

Lederman, N.G. (1998). The state of science education: Subject matter without context. *Electronic Journal of Science Education,* 3(1). Retrieved August 20, 2013, from http://wolfweb.unr.edu/homepage/jcannon/ejse/lederman.html
Lederman, N.G. (2007). Nature of science. Past, present, and future. In S.K. Abell, & N.G. Lederman, (Eds.), *Handbook of research in science education* (pp. 831-879). Mahwah, New Jersey: Lawrence Erlbaum Publishers.
Krippendorff, K. (1980). Content analysis. An introduction to its methodology (2nd ed.). Thousand Oaks. CA: Sage.
Krippendorff, K. (1980). Validity in content analysis. In E. Mochmann (Ed.), *Validity in content analysis* (1st ed.). New York: Campus
Mayring, P. (2000). Qualitative content analysis. *Qualitative social research,* 1 (2), 20 –28.
Padayachee, K. (2012). *A study of the analysis and use of life sciences textbooks for the nature of science*. Masters dissertation. Johannesburg: University of Johannesburg.
Soobramoney,B. & Vermaak, M. (2006). *Natural sciences learners` book grade 8.* Gauteng: Heinemann Publishers.