Nature of science in *Science in the National Curriculum* of Seychelles: Recommended policy and practice changes

Rosianna Jules and Lindsey Conner, University of Canterbury, New Zealand

Abstract

Nature of science (NOS) is discussed as encapsulating the science education community's consensus on 'what science is'. This is a fundamental component of science education. Document analysis of *Science in the National Curriculum* of Seychelles and *Seychelles National Curriculum Framework* reveals an under-representation of NOS. We argue that the nature of science should be a strong focus of science education in Seychelles because it will help people to increase their understanding of science and the practice of science.

Introduction

The scientific community and communities at large are becoming increasingly more aware of the tentative nature of scientific knowledge. Scientific methods and interpretations have their limitations. They are limited by the technologies we have available to observe the details of the nature of our world and beyond. Unfortunately many people are unaware of this tentative aspect of science, because often science is not made explicit in teaching and tends to be portrayed in the media as a 'truth'. For instance, for so long we have been led to believe that there were nine planets; recently we were told otherwise in the media. Currently, there is debate amongst professional astronomers as to whether Pluto is a planet or not, mainly because, in contrast with other objects considered as planets, Pluto has an erratic orbit. Because Pluto is described as a planet in millions of books, in different languages all over the world, many people still consider that it must be true. However, scientific knowledge changes quickly as technologies develop to allow us to observe our world differently or in more detail.

Many other examples of changes in thinking about our world could be cited here, including the first observations of sperm cells through a microscope and how they were interpreted as containing mini human life forms. Due to changes in microscope resolution and what we know about biases in interpretation, we now know this is not the case. These examples indicate that, as part of science education, people need to develop the understanding that knowledge, especially scientific knowledge, is tentative, temporal and based on interpretation. In the last three decades or so, a number of science educators and curriculum developers have discussed the need to incorporate aspects of the nature of science (NOS) in science education (Lederman & Niess, 1997; Mathews, 1998; McComas, Clough & Almazroa, 1998). While many places around the world, like New Zealand (Ministry of Education, 2007) and North Carolina (Department of Public Instruction, n.d.), have taken the initiative to include the strand "nature of science" in their school science curriculum, this strand is not present in *Science in the National Curriculum* (Ministry of Education, 2001a) of Seychelles.

This article presents a small-scale study about the Nature of Science in *Science in the National Curriculum* (Ministry of Education, 2001a) of Seychelles. This analysis is timely as the science curriculum in Seychelles will be reviewed in 2008. Even though the focus is on *Science in the National Curriculum* of Seychelles, the discussion here provides insights for curriculum developers, teacher educators and classroom teachers in other countries. The paper is in five parts. The first part characterises the societal context for *Science in the National Curriculum* of Seychelles by summarising the status of the science curriculum in Seychelles and tracing its history to the early 1970s. Next we present a selected literature review of aspects of NOS. In the third section we evaluate the present status of NOS in *Science in the National Curriculum* of Seychelles. We then make recommendations, propose suggestions for the inclusion of NOS in *Science in the National Curriculum* (Ministry of Education, 2001a) of Seychelles and discuss the implications. Finally we summarise the main points and assert that the inclusion of the NOS in the school science curriculum will help to provide students with experiences that enable them to understand science conceptually as well as the practice of science and its limitations.

Setting the context: Science curricula in Seychelles

Prior to 1972, science was taught only to the students studying at the Regina Mundi Convent and the Seychelles College. No other school in Seychelles was equipped to teach science. Between 1972 and 1976, the Department of Education made a decision to introduce science in the Junior Secondary Schools and set up a committee to adapt the Scottish science programme (National Institute of Education, n.d.). At the same time the 1972 Faure's Report[1] *Learning to be: The world of education today and tomorrow* established that science should be included as part of the core and compulsory subjects for all in school curricula. Another major influence on the introduction of science for all in Seychelles is believed to have come soon after liberation[2] in 1977 when a socialist government was established. The President declared that, **"**we have to teach the same subjects in all schools use the same books and make sure that all children get the same opportunities" (speech delivered by Mr. F.A. René, on June 29, 1977, cited in Ministry of Education, 1999, p. 5).

Following several science programmes and syllabi, subsequent education changes since the 1978 Education Reform, and the 1996/1997 review of the curriculum development process by the Curriculum Development Section (CDS), Seychelles' current and first science curriculum document entitled *Science in the National Curriculum* was published in January 2001 alongside *Seychelles National Curriculum Framework*[3] document. The curriculum is centrally planned (Purvis, 2004) with an emphasis on 'core' traditional academic subjects, that is, biology, chemistry and physics. The curriculum was developed by the five members of the Science Unit of CDS with "necessary support and background information" from 12 science teachers who formed the "Primary and Secondary Science Subject Committee" and others "who participated in workshops" (Ministry of Education, 2001a, p. ii). *Science in the National Curriculum* was progressively implemented in 2002 and, as mentioned earlier, is due for review in 2008 (E. Gedeon, personal communication, June 20, 2007). Gedeon explained that the science curriculum has been supported by on-going development and review of a set of programmes of study (POS)[4] since 2001.

Science in the National Curriculum is designed for all State schools and is organised in six progressive achievement levels as follows: three primary cycles (Cycle 1 – Crèche - P2 ; Cycle 2 – P3 - P4; and Cycle

3 – P5 - P6); and two secondary cycles (Cycle 4 – S1 - S2; and Cycle 5 – S3 - S4). The medium of instruction for science in Cycle 1 is Creole[5] and from Cycle 2 English is used.

School science in Seychelles and elsewhere has multiple aims. One of the goals of the science curriculum in Seychelles is a hegemonic agenda which assumes that the acquisition of scientific knowledge, skills, and values will help students to become increasingly confident and scientifically literate citizens capable of contributing to sustainable environmental, social and economic development through informed decision-making (Ministry of Education, 2001a).

According to the Ministry of Education (2001a):

> Science is essentially an active and continuous process of exploration of the physical and biological aspects of the universe. It comprises a body of knowledge and theories, which provide a framework of concepts that, enable human beings to better understand the world around them. (p.1)

The description of science provided by the Ministry of Education (2001a) acknowledges science both as a process and a product. However, the view of science as a ‘body of knowledge and theories’, where the theories, laws, principles, concepts and facts found in biology, chemistry and physics textbooks tend to be presented as given ‘truths’, does not reflect the multiple aspects of the nature of science, particularly the tentative nature of knowledge. This perception of science and scientific knowledge as final ‘truth’ reflects a relatively narrow view of the nature of science. In contrast, the New Zealand resource website for teachers (*Te Kete Ipurangi*) is very explicit that the nature of science is based on science as a human activity rather than science as a body of knowledge. Their NOS is provided as a number of themes (see Appendix 1).

Nature of science (NOS)

Internationally, the phrase ‘nature of science’ has multiple interpretations advanced by science educators, philosophers, historians, and scientists (Abd-El-Khalick, Bell & Lederman, 1998; Clough, 2007; Lederman & Niess, 1997; Mathews, 1994; McComas et al., 1998). However, there is a common understanding that the phrase ‘nature of science’ generally refers to “the epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge or the development of scientific knowledge” (Lederman, 2004, p. 303). In general, as succinctly put by McComas et al. (1998), “nature of science describes how science functions” (p. 5).

Science educators, according to McComas et al. (1998), portray NOS as “the intersection of issues addressed by the philosophy, history, sociology and psychology of science as they apply to and potentially impact science teaching and learning” (p. 5). For us, the phrase ‘nature of science’ refers to the “characteristics of science and scientific knowledge” (Lederman & Niess, 1997, p. 1) as informed by the philosophy, history, sociology, and psychology of science (Clough, 2007; McComas et al., 1998).

From their study, *The nature of science in international science education standards documents,* McComas & Olson, (1998) concluded that the philosophy of science provides a broad view of philosophical assumptions underlying the nature of science such as the tentative character of knowledge, what science is and how it works. The history of science refers to 'science as a social tradition' encompassing ideas, such as, the impact that social and historical contexts have on the development of scientific ideas and the global implications of science. The sociology of science relates to who scientists are and how they work - for example, the ethical decision making of scientific peer review and the accuracy of their record keeping. The psychology of science, on the other hand, focuses on the characteristics of scientists, like their creativity and openness to new ideas (McComas & Olson, 1998, pp. 49-51). While all four disciplines are crucial to our understanding of scientific knowledge and the scientific community, the greatest influences come from the philosophy and history of science (McComas & Olson, 1998).

The status of nature of science in Science in the National Curriculum of Seychelles

Description of the study

The strand 'nature of science' is not present in the science curriculum in Seychelles. In this study, document analysis was used to find out whether NOS is represented in other ways in the *Science in the National Curriculum* (SNC) (Ministry of Education, 2001a) and *the Seychelles National Curriculum Framework* (SNCF) (Ministry of Education, 2001b) documents. In the SNCF, the analysis was limited to the description of science and rationale for science education on page 10 of the document (Ministry of Education, 2001b) while in the SNC document, the study was limited to the introduction (p. 1), the rationale and the aims (p. 2), and the general objectives for the three domains: knowledge, skills and attitudes (pp. 3-6) (Ministry of Education, 2001a). These sections were used because they are the sections that present information about science and science education in Seychelles.

The matrix designed by McComas and Olson (1998) for their review of "a number of leading science education standards documents for their recommendations relative to the nature of science" (p. 41), was used for this study. Each section of the documents was analysed by sentence or statement and matched to relevant statements and assumptions about science and the nature of science from McComas and Olson's (1998) study. McComas and Olson's statements and assumptions were grouped into these four categories: philosophy insights, statements and assumptions; sociological insights, statements and assumptions; psychological insights, statements and assumptions; and historical statements and assumptions. Consistent with the same approach used by McComas and Olson (1998), a statement from the SNC document or the SNCF document was recorded as 'a match' as long as it expressed, reflected or implied the central idea of the statement(s) advanced by McComas and Olson (1998).

Some examples of how the sentences or statements were recorded as a match are given below:

1. ". . .develop an understanding of the changing nature of science, and the assumption on which it rests" from the SNCF (Ministry of Education 2001b, p. 10) was matched to statement 2—*scientific knowledge is tentative* in the *philosophy insights, statements and assumptions* category.

2. “Science is essentially an active and continuous process of exploration” from the SNC (Ministry of Education 2001a, p. 1) was recorded as a match to statement 3—*science will never be finished* in the *philosophy insights, statements and assumptions* category.

3. “. . . be ready to adjust or reject explanation” from the SNC (Ministry of Education 2001a, p. 6) was matched to statement 2—*scientists must be open to new ideas* in the *psychological insights, statements and assumption* category.

4. “. . . make rational decisions on issues relating to wise use and good protection of local, national, global resources and environment . . .” from the SNC (Ministry of Education 2001a, p. 2) was matched to statement 5—*science has global implications* in the *historical statements and assumptions* category

Sometimes an individual statement was matched to more than one statement from the same category. For example, the statement “…scientific accomplishments are the result of the efforts of women and men from diverse races and cultures” from the SNC (Ministry of Education 2001b, p. 10) was matched to statement 1—*all cultures (can) contribute to science* and 2—*science is a human endeavour* in the *sociological insight, statements and assumptions* category.

Qualitative research acknowledges that the researcher as ‘research instrument’ influences the conduct of the study. The researcher influences the research design, the collection of data, the analysis and interpretation of the data (Bogdan & Biklen, 2003, 2007; Janesick 2003) because the “researchers bring their own specific background to the study” (Bogdan & Biklen, 2007, p. 55). We acknowledge that this analysis was influenced by the first author’s recent encounter with the philosophy and history of science. Another researcher sharing the same interest and with more experience may interpret the same data differently.

Findings

The findings of the study are displayed in Tables 1 to 4 according to the four categories: *philosophy insights, statements and assumptions; sociological insights, statements and assumptions; psychological insights, statements and assumptions; and historical statements and assumptions* respectively. An initial interpretation of the four tables of results reveals that many statements about the nature of science advanced by McComas and Olson (1998) were not represented in the two curriculum documents: *Science in the National Curriculum* (SNC); and *Seychelles National Curriculum Framework* (SNCF). The findings for each category of statements are presented below.

Philosophy insights, statements and assumptions

Table 1 shows the philosophy insights, statements and assumptions that were represented in the SNC and the SNCF documents**.** In this category only seven of the 18 statements were identifiable in the SNC and the SNCF documents. Of the seven statements, only two: statement 8—*science aims to be testable,* and statement 18, which claims that vocabulary (namely observation, hypothesis and theory) is important to learn about how science works, were expressed in both curriculum documents.

Table 1: The philosophy insights, statements and assumptions represented in the SNC and the SNCF documents

Philosophy insights, Statements and Assumptions	SNC	SNCF
1. Scientific knowledge is stable		
2. Scientific knowledge is tentative		✓
3. Science will never be finished	✓	
4. Science relies on empirical evidence		✓
5. Science relies on logical arguments		
6. Science relies on scepticism		✓
7. Science aims to be objective		
8. Science aims to be testable	✓	✓
9. Science aims to be consistent		
10. Science aim to be precise		
11. Science knowledge is based on observation		
12. Science knowledge is based on experimental evidence		
13. Science knowledge is based on careful analysis		
14. Change in science results from information of better theories		
15. There are many ways to do scientific investigations		
16. Science has inherent limitation	✓	
17. Science is an attempt to explain phenomena		
18. To learn about how science operates, vocabulary is vital		
Observation	✓	✓
Hypothesis	✓	✓
Law		
Theory	✓	✓
Inference	✓	
Models		

(Source: McComas and Olson, 1998, pp. 44-46)

Sociological insights, statements and assumptions
With regards to the sociology of science, as shown in Table 2, three of the statements (statements 1, 2 and 4) were represented in both the SNC and the SNCF documents.

Table 2: The sociological insights, statements and assumptions represented in the SNC and the SNCF documents

Sociological insights, statements and assumptions		SNC	SCNF
1.	All cultures (can) contribute to science	✓	✓
2.	Science is a human endeavour	✓	✓
3.	New knowledge must be reported clearly and openly		
4.	Scientists makes ethical decisions	✓	✓
5a.	Scientists require: accurate record keeping		
5b.	peer view		
5c.	replicability		
5d.	truthful reporting		
6.	Scientists work collaboratively		

(Source: McComas and Olson, 1998, p. 46)

Psychological insight, statements and assumptions
Table 3 shows that there were two out of the four statements in this category common to both documents. These were statement 2, which referred to the scientists' openness to new ideas and statement 4, which dealt with the creativity of scientists.

Table 3: The psychological insights, statements and assumptions represented in the SNC and the SNCF documents

Psychological insights, statements and assumptions		**SNC**	**SNCF**
1.	Observation are theory-laden		
2.	Scientists must be open to new ideas	✓	✓
3.	Scientists must be intellectually honest		
4.	Scientists are creative	✓	✓

(Source: McComas and Olson, 1998, p. 47)

Historical statements and assumptions

As shown in Table 4, this category was rather under-represented in both the SNC and the SNCF documents; only two statements were represented: statement 5—*science has global implications* was common to both documents, while statement 6—*technology has impacted science* was relevant only to the SNC document.

Table 4: The historical statements and assumptions represented in the SNC and the SNCF documents

Historical statements and assumptions	SNC	SNCF
1. New specific ideas have frequently been rejected		
2. The past eliminates current scientific practice		
3a. Change in science occurs gradually		
3b. Change in science occurs through revolution		
4a. Science research are dictated by prevailing paradigms		
4b. Science research is dictated by national and/or corporate interest		
5. Science has global implications	✓	✓
6. Technology has impacted science	✓	
7a. Science is part of intellectual tradition		
7b. Science is part of social tradition		
7c. Science is part of cultural tradition		
8. Science has played an important role in technology		
9. Science has been in the centre of many controversies		
10. Science ideas are affected by their social and historical milieu		
11. Science builds on what has gone on before		

(Source: McComas and Olson, 1998, pp. 47-48)

What is surprising is that the document analysis, as outlined above, revealed no explicit or direct statements about nature of science in the SNC and the SNCF documents. However, there were a few statements in the two documents which related to McComas and Olson's (1998) list of statements about science and nature of science. It should be noted that none of the statements from the SNC and SNCF documents are worded exactly as those listed by McComas and Olson (1998). Moreover, statements from the SNC and the SNCF documents referring to the same statement from McComas and Olson's (1998) list were worded differently. For instance: the statement from the SNC which reflected statement 4—

scientists are creative from the *psychological insight, statements and assumptions* category read as ". . . utilise and value their capacities for creative and critical thinking" (Ministry of Education, 2001a, p. 6) while that from the SNCF document stated that "it [science] . . . promotes creative thinking" (Ministry of Education, 2001b, p. 10).

Analysis and discussion

The findings reveal that statements about nature of science were not well represented in the SNC and the SNCF documents. The philosophy and history of science, which are the most influential disciplines in our understanding of scientific knowledge and the scientific community (McComas and Olson, 1998), were the least represented in the two curriculum documents. Their under-representation in the *Science in the National Curriculum* document is of major concern because it is this document which guides the teaching and learning of science.

The findings also showed that there were disparities in the way the information regarding science and science education in the SNC and the SNCF documents related to aspects of nature of science. The discrepancies are probably because, as mentioned earlier, the two curriculum documents were both published in January 2001 and designed by two different teams of people.

In general, as shown in the four tables, the nature of science is under-represented in the SNC and the SNCF documents. Consequently, based on the findings and arguments presented, we would suggest the inclusion of the nature of science in *Science in the National Curriculum* of Seychelles in order to provide students with a more authentic experience of science.

Proponents of the current curriculum could argue that the present science curriculum encourages first-hand experiences and the development of science process skills and, as such, it is promoting the nature of science. To gain or ascertain scientific knowledge, an understanding of the processes of science is an essential component of the SNC of Seychelles. Consequently, students are taught about the 'scientific method' and the 'science process skills' such as observing, predicting, hypothesising, measuring, collecting and recording data, controlling variables, communicating, analysing and interpreting, among others, (Ministry of Education, 2001a). However, it should be clear that this mantra 'learning by doing [which] has central place in the science curriculum' (Ministry of Education, 2001a, p. 1), is often just rhetoric because the pedagogical approaches used in science classrooms often do not reflect aspects of NOS explicitly. For example, most, if not all, science teachers and students have been led to believe that all scientific investigations adhere to an identical set and sequence of steps known as 'the scientific method' (McComas, 1996). Hence, both the teachers and the students need to broaden their understandings of the different assumptions inherent in scientific knowledge and scientific processes. Teachers would benefit from professional development that extends their thinking about the multiple ways investigations can be conducted in science.

Furthermore, the inclusion of NOS will have several benefits for the teaching and learning of science. McComas et al. (1998) have identified and discussed five benefits of the NOS in science curriculum and instruction. They claimed that NOS will promote: (i) the learning of science; (ii) understanding of science; (iii) interest in science; (iv) informed decision making; and (v) enhanced instructional delivery.

Recommendations

Five main recommendations emerge from this analysis for science curriculum developers in general and for the Seychelles Curriculum Review Team and the National Institute of Education (NIE) which has the mandate for teacher education, curriculum development, and research. These are:

1. Curriculum developers should ensure consistencies between specific subject documents by having representations on the different teams and/or by establishing a validation team. In the case of Seychelles, the rationale for science in the SNCF document should be compatible with that of the SNC document. This should also be done for the other subjects.

2. The curriculum development team should explore the possibility of including aspects of nature of science in the reviewed curriculum. We recommend that changes to the curriculum document(s) are made in collaboration with science teachers and science teacher educators because teachers are "the key curriculum decision-makers" (McGee, 1997, p.15) and "the most influential factor in educational change" (McComas, et al., 1998, p. 23).

3. Curriculum developers should adopt definitions for science that reflect multiple aspects of the nature of science. They may need some professional development to assist in this process.

4. Research should be carried out to identify the science teachers' knowledge base of NOS and teachers who could serve as pioneers and/or resource persons to lead/support professional development. In the case of Seychelles, NIE should be responsible for this research.

5. As a consequence of changes to the documents, there is a need for on-going professional development for all parties concerned. Hence, NIE should engage in the professional development of its science teacher educators and science teachers.

Suggestions for implementation

We suggest that the most important aspects of NOS are included in curriculum documents and science education. Lederman (2004) has identified seven essential aspects of NOS for science curriculum and instruction. These are:

1. "the distinction between observations and inferences";
2. "the functions of, and relationships between, scientific theories and laws" (p. 304).

The other five aspects refer to the characteristics of scientific knowledge as being:

3. "tentative (subject to change)";
4. "empirically-based (based on and/or derived at least partially from observation of the natural world)";
5. "subjective (theory-laden, involves individual or group interpretation)";
6. "necessarily involv[ing] human inference, imagination, and creativity (involves the invention of explanations)";

7. “socially and culturally embedded (influenced by the society/culture in which science is practice” (Lederman, 2004, p. 304).

Perhaps the best way to ensure the successful inclusion of these aspects of NOS in the science education and consequently in the SNC document is to follow Black and Wiliam’s (1998) “four-point scheme for teacher development” (p. 146) which includes: step 1: learning from development—the formation of a small network of schools to pilot the implementation; step 2: dissemination—sharing success stories, and giving support and encouragement to other schools; step 3: reducing obstacles—the examination of all features which could affect the implementation; and step 4: research—the engagement in contextual classroom research. Piloting the implementation of NOS in a sample of primary and secondary science classrooms and disseminating success stories will provide other teachers with:

> A variety of living examples of implementation, as practiced by teachers with whom they can identify and from whom they can derive the confidence that they can do better. They need to see examples of what doing better means in practice. (Black & Wiliam 1998, p. 146)

The way the different aspects of NOS are introduced to students, teachers and teacher educators is very important. Clough (2007) argued that some characteristics regarding the nature of science have been reduced to a set of tenets of established scientific knowledge that can easily be distorted, misinterpreted by researchers, teachers and students. As such the tendency is that instead of investigating and understanding those tenets, the tenets become knowledge to be taught and known by students (Clough, 2007). This view was also emphasised by Eflin et al. (1999, cited in Clough, 2007) who claimed that “just as science educators stress that science is more than a collection of facts, we emphasize that a philosophical position about the nature of science is more than a list of tenets” (Eflin et al., 1999, p. 112, as cited in Clough, 2007).

Clough (2007) has thus proposed that the established tenets should be converted into questions about the nature of science. This approach, according to Clough (2007), would explicitly and directly confront students’ naïve views of the nature of science. In agreement with Clough’s alternative approach to introduce NOS to students, we propose that due consideration is given to pedagogical approaches specific and relevant to teaching and learning about the NOS. In particular, it seems that the use of different forms of questioning could have merit.

Implications

The inclusion of NOS in *Science in the National Curriculum*, like any other curriculum change, will have implications for science teachers at all levels (pre-service and in-service science teachers including science teacher educators). We now discuss some of the major issues, although we acknowledge that other issues will arise.

Implications for science teachers

Most teachers and teacher educators may be unaware of the multiple aspects of NOS since NOS was not explicitly emphasised as part of their schooling or teacher education. As McComas (1996) remarked, pre-service teacher education programmes and the science textbooks used in these programmes make little or no reference to NOS. The language of the philosophy of science, for instance, may be unknown to many if not all science teachers, teacher educators and curriculum developers in Seychelles. In the first author's case, after many years of teaching, her first encounter with the philosophy of science was in a course entitled *Introduction to the philosophy of science*, offered as a choice but not as a compulsory requirement of her programme of study for a Master of Science Education degree. This experience, with the assistance of Dr Philip Catton (the lecturer), indicated that the philosophy of science does have implications for science education that are important to identify, discuss and take into account.

According to Matthews (1994), science education without some consideration of the philosophy of science "results in a distorted science education" (p. 84) and this, according to McComas (1996), is possibly the main cause of misconceptions in science. Consequently, we suggest that as an initial step, the National Institute of Education should provide professional development for its science personnel (science teacher educators and curriculum developers) who will then be able to spread this innovation. NIE personnel should hold meetings and on-going workshops that focus on NOS to increase the awareness amongst existing teachers. Pre-service science teachers will gain an awareness of NOS through their respective, modified teacher-training programmes.

Implications for primary and secondary science teacher-training programmes

With this innovation, both the primary and the secondary teacher-training programmes presently being offered should be reviewed to integrate multiple aspects of NOS. While the teacher education programmes currently focus on the philosophy of education, we strongly propose that the nature of science, especially the philosophy and history of science, should be compulsory components of the science teacher education programmes.

Implications for teaching and learning of science

The current textbooks used for science teaching in Seychelles assume that science knowledge is static and that science knowledge is the information as written in textbooks. This relates to the present definition of science in *Science in the National Curriculum* of Seychelles and therefore this statement should be reviewed to include broad aspects of NOS. Curriculum developers could adopt a description for science that encompasses the three aspects put forward by Lederman and Niess (1997): "Body of knowledge, process/method, and a way of constructing reality (i.e. nature of science) that distinguishes it from other disciplines or ways of knowing" (p. 1).

The pedagogical approaches used in teacher education also need to be considered for successful implementation of this innovation. Hence, in pre-service science teacher education, as Meichtry (1998) suggested, teacher educators should model effective and appropriate pedagogical strategies for making NOS explicit with primary and secondary students. This will provide "'real science experience for pre-service teachers to construct their own knowledge of the nature of science, (Meichtry, p. 231) and provide opportunities to reflect "on new understandings, and making connection between" their own learning and that of the prospective students. By experiencing pedagogy that focuses explicitly on NOS, they will gain "insights about the ways their future students experience learning" (Meichtry, 1998, p. 231).

Conclusion

Many science educators have shown concern about the lack of inclusion of NOS in science education at multiple levels. An analysis of the science curriculum and curriculum framework of Seychelles revealed that NOS is under-represented in these documents. In order to broaden students' understandings about science knowledge and scientific processes, aspects of NOS need to be described in *Science in the National Curriculum* of Seychelles. Further, pedagogies that explicitly work with these definitions to clarify them in multiple contexts will foster more authentic students' science learning experiences at multiple levels. Using knowledge of NOS in science education not only promotes the learning of science content and understandings about science, but also could stimulate interest in science and expand the ways people consider science when making important decisions (McComas, et al., 1998). Suggestions for the inclusion of aspects of NOS in the science curriculum and science education in Seychelles have been proposed. It is clear that teachers will be those who are most affected by this innovation as they will have "to master not only . . . the subject matter and the techniques of making it interesting and intelligible to students, but [they] also [have] to get . . . the understanding of the nature of science" (Matthews, 1998, p. xiii). Moreover, it should be noted that the change will take time. As Battista (cited in Bentley & Fleury, 1998, p. 277) remarked "teachers themselves are the products of an old curriculum and have developed beliefs incompatible with the spirit and the substance of these innovations".

Notes

1. Faure et al.'s report *Learning to be: The world of education today and tomorrow* is a UNESCO funded World Education report published in 1972. In this report Faure et al. considered that, "it was essential for science and technology to become fundamental, ever-present elements in any educational enterprises for them to become part of all educational activities designed for children, young people and adults" (Faure et al., 1972, p. xxvi).
2. Liberation was the result of a coup on the 4-5 June 1977. The Seychelles People United Party (SPUP) – a Socialist oriented party - overthrew the Seychelles Democratic Party (SDP) – Capitalist oriented, which had ruled the coalition government since Independence on 29th June 1976.
3. The curriculum framework outlines the seven underlying principles which guide all curriculum development and direct teaching and learning. It states the assessment policy, specifies the eight essential learning areas and broadly describes the main learning objectives for each and outlines the eight categories of essential skills to be "developed by all students" and the "desirable attitudes and values to be promoted through the curriculum" (MOE, 2001b, pp. 2-3).
4. The POS are modular publications serving as teachers' guides. They define very specific objectives, skills, time allocation, teaching and learning strategies, and so forth for a given topic or section in the subject-based curriculum documents (MOE, 2001b, pp. 2-3).
5. Creole (the mother-tongue), English and French are the three spoken languages in Seychelles – all three officially recognised. They are all compulsory school subjects taught up to Secondary 5 with the exception of Creole which is only taught from Crèche to Primary 6. Creole has a French-based dialect mixed with words and syntax from the traditional African and Asian languages spoken by slaves.

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Appendix 1: Themes related to the nature of science (*Te Kete Ipurangi*).

1. Scientists turn their science ideas into questions that can be investigated
2. Scientists' observations are influenced by their science ideas
3. Scientists' investigations are influenced by their communities
4. Scientists' predictions are based on their existing science knowledge
5. Scientists design investigations to test their predictions
6. Many different approaches and methods are used to build scientific investigations
7. When scientists carry out investigations they aim to collect adequate data
8. Scientists think critically about the results of their investigations
9. Scientific explanations may involve creative insights
10. There may be more than one explanation for the results of an investigation
11. Scientific explanations may be in the form of a model
12. When an explanation correctly predicts an event, confidence in the explanation as science knowledge is increased
13. Scientific explanations must withstand peer review before being accepted as science knowledge
14. New scientific explanations often meet opposition from other individuals and groups
15. Over time, the types of science knowledge that are valued change
16. All science knowledge is, in principle, subject to change
17. Open-mindedness is important to the culture of science
18. Scientific progress comes from logical and systematic work, and also through creative insights
19. Science interacts with other cultures.