Research Article https://doi.org/10.12973/eu-jer.11.4.2487

European Journal of Educational Research
Volume 11, Issue 4, 2487 - 2496.
ISSN: 2165-8714
https://www.eu-jer.com/

Representation of Nature of Science in Physics Textbooks of Cycle 4 Fundamental Schools in Burundi

Vianney Munezero*
University of Rwanda- College of Education, RWANDA

Lakhan Lal Yadav
University of Rwanda- College of Education, RWANDA

Jean Bosco Bugingo
University of Rwanda- College of Education, RWANDA

Received: April 17, 2022 ▪ Revised: August 18, 2022 ▪ Accepted: October 8, 2022

Abstract: Guided by the analytical framework in the current literature, whereby ten nature of science (NOS) aspects were targeted, this study aims at assessing the extent to which the three physics textbooks for Cycle 4 of Fundamental Schools in Burundi represent the NOS aspects. The quantitative embedded research design which combines the qualitative and quantitative to both the representations of text and images were applied to collect and analyses data. Three physics textbooks used in this study as textbooks I, II and III (grade 7 textbook, grade 8 textbook and grade 9 textbook) were purposively selected. 65 physics lessons were analyzed in three steps including exploring representations of NOS aspects, representations of NOS teaching approaches and accuracy and completeness of NOS aspects. Data were collected using a guide document analysis and a rubric of NOS scoring and were analysed descriptively. The findings found a considerable deficit of NOS aspects in the physics textbooks. The findings also revealed the critical situation where the few lessons poorly represent the NOS aspects and the majority of them do not include the aspects of NOS. Furthermore, this study suggests the in-charge of quality assurance to evaluate and deliberate on the accuracy and completeness of physics textbooks for Cycle 4 of Fundamental Education in Burundi.

Keywords: *Cycle four, nature of science, physics textbooks, scientific literacy.*

To cite this article: Munezero, V., Yadav, L. L., & Bugingo, J. B. (2022). Representation of nature of science in physics textbooks of cycle 4 fundamental schools in Burundi. *European Journal of Educational Research, 11*(4), 2487-2496. https://doi.org/10.12973/eu-jer.11.4.2487

Introduction

The common objective of the majority of nations in science education as described in many recent curriculum reforms is to promote scientific literacy (Mbonyiryivuze et al., 2018; Ojimba, 2013; Vesterinen et al., 2013; Yao & Guo, 2018). Matthews (2004) states that there is no unique way to promote scientific literacy rather than an imperative focus only on scientific products such as theories, laws, and facts. This intention of science education for developing scientific literacy is supported by the nature of science (NOS) concepts (Ayvacı & Özbek, 2019; Vesterinen et al., 2013). The NOS plays a vital role in science teaching and it is included in the international standard documents (Cofré et al., 2014; Erduran & Dagher, 2014; Michel & Neumann, 2016). For that NOS concepts would ideally be reflected in science resource materials for teaching and learning, especially for science textbooks including physics textbooks at all educational levels.

Though no straightforward explanation and a converging meaning of NOS exists, it generally refers to what science is; the epistemological base of scientific enterprise in the lens of the three areas of history, philosophy and sociology of science (Kagumba, 2015; McComas, 2008). The NOS concepts in science education have been advocated to have particular attention because, for all levels, they have an influence on students' motivation and interest in further scientific studies (National Research Council [NRC], 2012) Thus, neglecting the issue of NOS for physics educators may result in problems in students' mentorship about the subject and how scientific knowledge is constructed.

Though the teachers' understanding of NOS and how it affects the teaching of NOS (Halai & McNicholl, 2004) is worldwide an academic debate topic, NOS concepts still have an unvalued role in the science community. In addition, both science educators and science curriculum developers indicated paying little attention to science and a balance between science teaching and the NOS (Osborne et al., 2003). Looking at the key role of teachers in preparing a scientific-based young generation, previous studies (Kagumba, 2015; Yadav & Shrivastava, 2007) highlighted that in learning and teaching of

* **Corresponding author:**
Vianney Munezero, African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science, University of Rwanda- College of Education, Rwanda. ✉ vianmuneze@gmail.com

science both students and teachers need to understand the basic concepts of NOS and its integration through instructional materials. It is up to instructional material developers to give importance to NOS and ensure that learners are necessarily developing an understanding of NOS and use it in science-related activities (Abd-El-Khalick & Lederman, 2000).

A working paper for the EAC state partners (Burundi, Kenya, Rwanda, South Sudan, Tanzania, and Uganda) pointed out an insufficient scientific literacy in both lower and upper secondary schools (World Bank, 2011). Studies carried out in the area of teaching science particularly for physics in Burundi revealed the critical problems that the physics discipline is facing such as lack of didactic materials, adequate school textbooks in line with scientific discovery and incompetence (Banuza et al., 2016, 2017).

It is in the vision of advancing education, that Burundi has introduced education reform in 2013 which calls upon the development of new curriculum, program and school textbooks that should be adapted to current needs of the country (Nahimana et al., 2015). The Fundamental School in the current reform of 2013 in Burundi turns out to be a major change with an important element of promoting scientific skills and competencies of the learners. In the new education reform, Burundi's Fundamental Education comprises 9 years divided into 4 Cycles (Cycle 1: primary school 1 & 2; Cycle 2: primary school 3 & 4; Cycle 3: primary school 5 & 6 and Cycle 4: First three years of the ordinary (junior) level of secondary schools). Later, the new textbooks and materials to be used in teaching and learning were introduced in all schools in 2015 (World Bank, 2018).

Furthermore, recently an exploratory survey from a local team of reporters pointed out the several challenges that may impede teaching and learning, e.g., students' textbooks and teachers' guides in Fundamental and post-Fundamental schools in Burundi (Ivomo, 2021). Again a recent report on the quality of education in Burundi revealed that though different interventions have been made, still a requirement of revision of official instructions, teachers' guides, textbooks, and other materials, monitoring and evaluation are needed to support the curricula reform (Varly & Mazunya, 2018).

Despite the efforts envisaged by the government for reform education and supplying instructional materials, studies that aim to ensure the accuracy and quality of physics textbooks used in teaching and learning physics for Fundamental Schools in Burundi are still few. Nevertheless, science textbooks have an irreplaceable role in teaching and learning and the study done by Chiappetta et al. (2006) revealed that secondary Science teachers rely on textbooks to a great extent (more than 90%) while organizing and delivering instructions, and assigning work to their learners. Given the irreplaceable importance of science textbooks in learning and teaching, and NOS to promote scientific literacy the empirical studies that at assessing and exploring physics textbooks would be valuable. The present study aims to assess the extent to which the currently used physics textbooks for Cycle 4 of Fundamental Schools of Burundi represent the NOS aspects.

Literature Review

In the past two and half decades, science education endorsed many pieces of research on NOS focused on two fundamental questions related to what NOS is and understanding of teachers and students on NOS, and its aspects that should be included in educational documents taught and learned (Dagher & Erduran, 2016). A synthesis of studies done between 1990 and 2007 emphasizes the statements that have been considered as "consensus views of NOS" and point out the basic NOS tenets (Abd-El-Khalick, 2012; Chang et al., 2010). That study led to the formulation of seven appropriate tenets namely (1) "Tentative Nature of Science", (2) "Observations and Inferences", (3) "Theory – laden", (4) "Creativity and Rationality", (5) "Social and Cultural aspects in knowledge construction", (6) "Scientific Theories and Laws" and (7) "Scientific Methods". Nevertheless, the "consensus views" guided several debates for the science community and one of the issues is a differentiation between scientific inquiry and NOS though seem to be related (Schwartz et al., 2012).

Several studies related to representation of NOS in textbooks from different education settings have been conducted. For instance, a study by Guisasola et al. (2005) noted a complete absence of the NOS characteristics in all analyzed physics textbooks. According to the analysis of three grade 9 textbooks of Natural Science in South Africa, the results show that all three textbooks poorly represented the NOS aspects (Ramnarain & Chanetsa, 2016).

However, according to Linneman et al. (2015) the South African Science Curriculum known as C2005 which is an educational outcomes-based approach, includes the NOS aspects in its expected outcomes as follows "Students will demonstrate an understanding of the changing and contested nature of knowledge in the Natural Sciences." The same author states that if the NOS would be taken with such great value in science teaching and learning particularly physics, its place and emphasis in textbooks would be more than of outcomes and its systematic conceptualization. Indeed, when the science knowledge and understanding would be the general goal beyond the concepts of physics and the science process would also be taken into considerations about methods and strategies of teaching, the NOS aspects need to be well addressed.

A study that aimed at assessing NOS representations in five Chinese high school physics textbooks using the Lederman theoretical framework on NOS revealed that NOS aspects were poorly represented in all five books (Zhuang et al., 2021). Studies done in different countries that aim to investigate on how NOS aspects are represented in science textbooks revealed critical results. For instance, in the studies that assessed the degree to which the elements of NOS were

integrated in chemistry textbooks for Swedish and Finnish senior secondary schools, there was little introduction of NOS aspects (Vesterinen et al., 2013). This agrees with the study done under the same topic for 9th grade chemistry textbooks in Turkey that analyzed the two nationwide textbooks where results showed that both are inadequately representing the NOS aspects (Esmer, 2011).

Furthermore, another study that assessed NOS aspects in biology textbooks for secondary schools in Turkey found results that are similar to the analysis of chemistry textbooks, where the authors of the books neglected the principal elements, and for some, there was misinterpretation and unfair descriptions of NOS aspects (Irez, 2009). However the ethnographic contents analysis for NOS aspects done for the seventh five chemistry textbooks published in the USA, although the introduction of NOS was not the general objective for most of them, they traced well the history of chemistry aspects and provided clear instruction that is conformed with standard documents (Niaz & Maza, 2011).

The current literature is still noting a little effort made and a less attention paid on integration of NOS through instructional materials in the region. For instance, a study by Masilela and Ramaila (2019) on representation of NOS aspects in the Life Sciences textbooks of South Africa showed that the NOS aspects such as laws and theories, tentativeness, empirical, inferential and creativity were not adequately covered. A study on the NOS representation in three textbooks of chemistry in Nigeria also showed that aspects of empirical, tentativeness, social, imagination and creativity were more cited, in implicit manner, in comparison to the aspects of subjectivity, scientific method, and laws and theories (Upahi et al., 2020). A recent study by Bugingo et al. (2022) found a poor and no explicit representation of NOS aspects in advanced–level physics curricula of secondary schools from Burundi, Rwanda, Uganda and Tanzania. To the best of knowledge of the authors of this paper, no study has been carried out to assess the aspects of NOS in science textbooks in East African Community region, it is in this regard, the present study focuses on how the physics textbooks in Burundi reflect NOS aspects.

Methodology

Research Design

The most used research approaches in the study that involve NOS aspects in science textbooks investigation are those related to quantitative methods, with a certain view that they provide the valuable information with emphasis to the focused items. Therefore, as the purpose of this study was to assess the representation of NOS in physics textbooks, quantitative embedded methods which combine the qualitative and quantitative data to both the representations of text and images (Nicholls, 2019) were used. The quantitative methods are used to measure aspects of NOS in the text in terms of frequency and space. This was used for quantifying how frequently the targeted NOS aspects appear across the texts and to show how much (or how little) NOS is considered in a particular topic.

Selection of Study Textbooks

This study involves three physics textbooks that are currently used in teaching and learning physics for Cycle 4 Fundamental Education in Burundi since the school year 2013/2014 all over the country. The current education structure in Burundi includes 9-year basic education, where Cycle 4 is the last and foundation level before advanced level of secondary education which is known as post-Fundamental Education. These three school physics textbooks were conceived and officially approved for use in classrooms since 2015 (World Bank, 2018). The present study focuses on how NOS aspects are explicitly or implicitly represented in the “preface”, “introduction” and in the “content” of the three selected physics textbooks.

The preface defines general objectives of the content to be taught in each grade while introduction presents to the readers the students’ profile, expected competences and lesson’s structure for the three textbooks. The contents from three selected physics textbooks were main focus for extensive and systematic analysis. Three physics textbooks of grades 7, 8 and 9 were purposively selected. Largely, the grade 7 physics textbook contains 20 lessons, grade 8 has 20 lessons and grade 9 has 25 lessons related to physics teaching. The documents analysis involved all the 65 physics lessons in these three grades.

Data Collection

Three researchers and two other research-assistants, who are physics teachers for more than three years, participated in this study, forming two groups. All these persons worked in two groups which were purposively formed based on the expertise on the notion of NOS and proximity rule, the first group having two researchers and one research-assistant and another group having one researcher and one research-assistant. Although, the researchers mainly worked to analyse the textbooks, the research-assistants were used to have regular discussions and have another opinion.

After preparing the instruments for data collection, a pilot study was conducted whereby the researchers and two researcher-assistants rated and analyzed the representation of ten NOS aspects in four (4) lessons randomly selected from grade 7 physics textbooks. The three researchers read selected lessons page by page separately at least three times for each. Then a code from 1-10 was given for each material whereby each code corresponds to NOS aspects as shown in Table 1. To ensure the inter-reliability rate, each group analyzed separately and thereafter a reflective discussion to

connect each discourse with the correct NOS aspect and any discrepancies were discussed. Regarding the NOS representations in the four lessons for the trial study, the agreement was computed using Cohen's Kappa. The trial study agreement results were 74%, 89.6% and 73.3% (Cohen Kappa of 0.714, 0.745 and 0.701 respectively) for the appearance of the ten aspects, approaches and accuracy and completeness. Therefore, after this pilot study, a workshop of the three researchers was organized to validate the referencing materials and analysis rubric. Moreover, before starting data collection, the permit was obtained from various authorities and institutions, including the University of Rwanda, Ministry of National Education and Scientific Research (MENRS)- Bujumbura.

Data Analysis and Analytical Framework

The data analysis process was done in three steps. First, the content of each selected lesson was analysed in which targeted NOS aspects were identified and coded. At this level, a consensus among participants was made. Second, the analysis for the approaches (explicit vs implicit) of the identified NOS representation followed the first agreement on the NOS aspect from the textbook material. The third step was to analyse the accuracy of NOS aspects and the extent of their representation in textbooks (inadequate, mixed, partially informed, and informed), and overall deliberation for the textbook level was done (considerable or poor). After each level of analysis, a reflective discussion was conducted between the three researchers and a level of agreement using the Cohen Kappa. Following the same protocol, the researchers performed the analysis of three selected physics textbooks used to teach the physics course in Cycle 4 of Fundamental Schools in Burundi (for grade 7, 8 and 9 physics textbooks).

In addition to this, both content and textbook levels were taken into account while analysing the selected physics textbooks. First, the analysis was done looking through the appearance, accuracy, completeness and proposed teaching instructional approaches of targeted NOS concepts. On a textbook-level, a generalization was done to determine the degree of consistency flow of NOS aspects throughout the selected teaching materials (considerable or poor). After discussion among the two groups of researchers, final conclusions were made. In fact, there was not much variation among the analyses of different groups discussed above.

The following analytical framework was adapted from Lederman's theoretical model which is described in Figure 1 below.

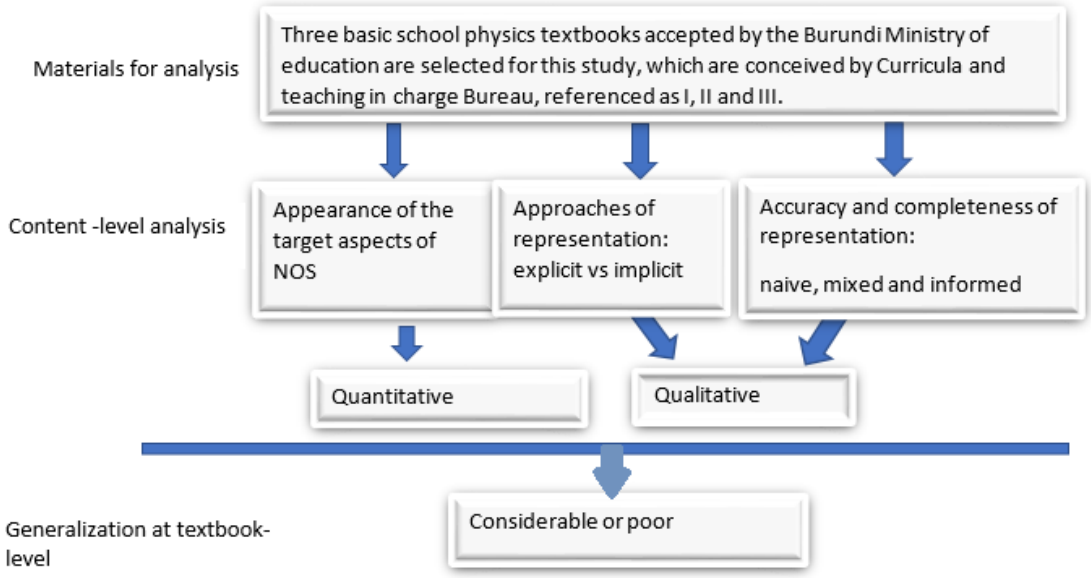

Figure 1. A Theoretical Framework for Textbooks Analysis for NOS Representations Adapted From Abd-El-Khalick and Lederman (2000)

Scoring Rubric About Accuracy and Completeness of Targeted NOS Aspects

A particular NOS aspect can be represented in various forms that do not always have the same standard and may vary for different textbooks and from author to author. This study adopted Abd-El-Khalick et al. (2008) scoring rubric framework of seven levels to use a rating scale to measure the accuracy of NOS aspects and the extent of their representation in textbooks. This rating scale is made in such a way that each NOS aspect is assessed using a score ranging from – 3 to +3 points. An overall combination of each NOS aspect evaluation gives the textbook level score that ranges between –30 to +30. In this study, each textbook material was analyzed separately and identified from any NOS aspect among the ten targeted.

Results

The results from three physics textbooks for teaching physics courses at cycle 4 in Burundi Fundamental Schools are presented in the Table 1 and Figure 2. The analysis concerned 65 lessons of physics from the three physics textbooks for grades 7, 8 and 9 that were analyzed carefully line by line and section by section to identify discourse that emphasize any of the ten NOS targets in this study. The further analysis as reported in the following sections was done on the same identified NOS representations towards the other two dimensions consistent with the approach of representation and accuracy and completeness. The researchers referred code physics textbook I for grade 7, physics textbook II for grade 8 and physics textbook III for grade 9 for further discussion.

The proportion of NOS representation within the three textbooks was explored from the preface and book introduction, as well as the 65 lessons in the selected textbooks. For each NOS and textbook material, a Cohen Kappa was computed, for the majority the agreement was moderate (0.41 to 0.60). The results for all representations that reached the substantial agreement are presented in Tables and chart below.

Table 1. Proportions of Representations of NOS in Three Physics Textbooks for Cycle Four Burundi Fundamental Schools

	Physics textbooks analyzed			
NOS Aspects	**I**	**II**	**III**	**Total**
Tentativeness	1	0	1	2
Empirical	2	2	2	6
Inferential	1	0	1	2
Creative	0	0	0	0
Theory-driven	0	0	0	0
Scientific theories	0	0	2	2
Scientific laws	3	3	2	8
Scientific ethics	0	0	0	0
Social values	1	1	1	3
Social certification and dissemination of scientific knowledge	0	0	1	1
Total	**8**	**6**	**10**	**24**

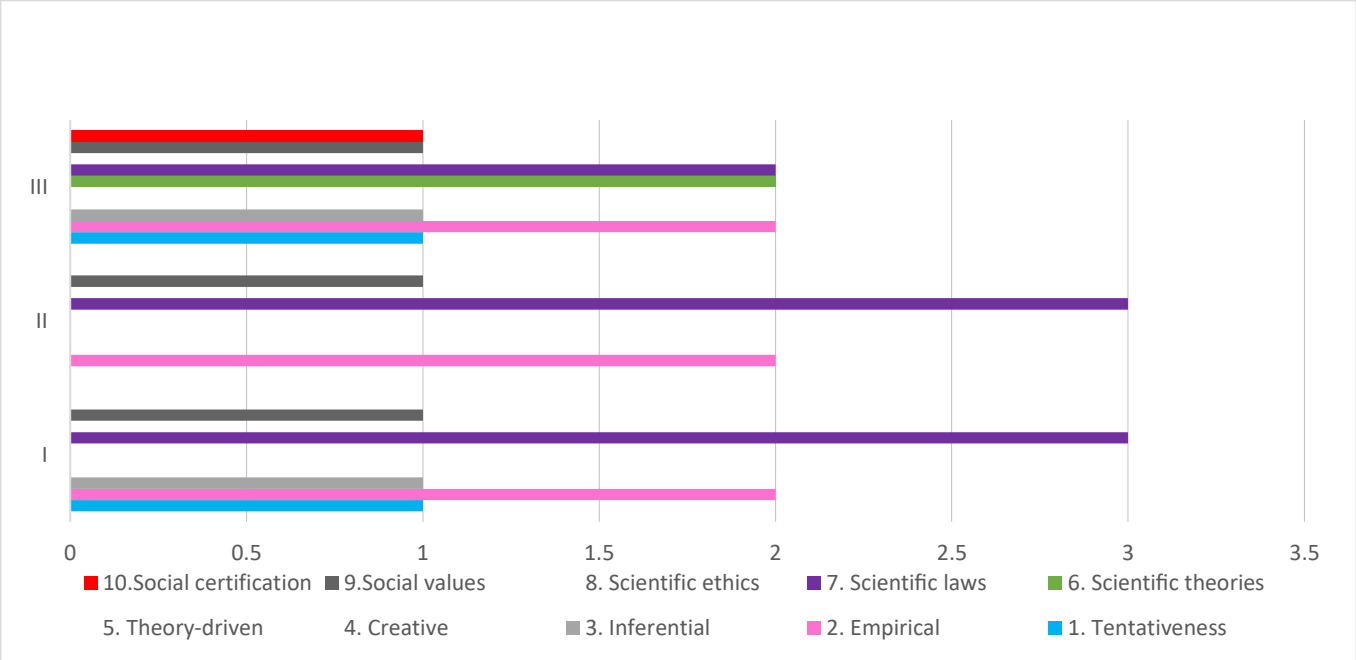

Figure 2. Distribution of NOS Aspects in Three Physics Textbooks for Teaching Physics for Cycle 4 Burundi Fundamental Education

The NOS aspects in all three textbooks are not considered at the same rate. As shown in Figure 2, NOS aspects vary among these textbooks whereby the highest identified NOS aspects are 7 (for textbook III). None of these textbooks has all the ten aspects for instance in the 20 lessons of physics for the textbook I, the researchers found only five "Tentativeness, empirical, Inferential, Scientific laws and Social values" aspects of NOS, Others were neglected or not included. Textbook II includes only three of the ten NOS aspects that are Scientific laws, Empirical, and social values NOS aspects. Even though the numbers of NOS representations change from one textbook to another, there are three that are found in all three textbooks, which include empirical, scientific laws and social values.

Most of the aspects of NOS were presented implicitly except one from textbook III. Table 2 shows how the 10 NOS aspects appeared in the three selected textbooks. The cumulative score for three-textbooks is ranged from 2 to 8 as described in Table 2. This range shows that NOS aspects are portrayed in all three textbooks at a very low level. Only one aspect that is "Inferential" was addressed explicitly and partially informed by one of the three textbooks, while implicitly addressed aspects were 'empirical'; 'scientific theories and ~~-~~scientific laws' in all three textbooks. In general, only five NOS aspects were represented in the three textbooks analyzed other aspects were completely disregarded.

Table 2. Cumulative Score for Three Textbooks on the Aspects of NOS

	Physics textbooks analyzed		
NOS Aspects	**I**	**II**	**III**
Tentativeness	0	0	0
Empirical	0	1	1
Inferential	2	0	2
Creative	0	0	0
Theory-driven	0	0	0
Scientific theories	0	0	1
Scientific laws	0	1	2
Scientific ethics	0	0	0
Social values	0	0	1
Social certification and dissemination of scientific knowledge	0	0	1
Total	**2**	**2**	**8**

Discussion

After going through the preface, introduction and the content in the three physics textbooks analyzed, we noticed that there is a total absence of implicit or explicit statements which can justify the representation of aspects such as creative, theory-driven, and scientific ethics, as described in Tables 1-2. This study shows that even though some NOS aspects appeared rarely in one or two physics textbooks as described in Table 1, but show very poor representation of these aspects, as indicated by their scores in Table 2. Empirical statements found score one in both textbooks II and III, while it is abysmal in textbook I. The statements about inferential were identified in textbooks I and III with a score of 2 in each textbook. The NOS aspects such as scientific theories, social values, and social certification and dissemination of scientific knowledge scored one only in the textbook III.

As shown in Table 2, in Textbook III, only two aspects out of six identified scored 2 that are inferential and scientific laws NOS aspect~~s~~ that were represented explicitly and partially informed. In textbook I, only inferential aspect of NOS scored 2 as represented in the section of electricity it is expressed in brief that the notion of current direction is not an observable concept because none can see inside the wire and the recent understanding of the direction of electric current is something that has been inferred by scientists.

> For example, a statement from physics Textbook III was identified as a representation of inferential aspect. It states that *we cannot "go and see" inside wires, so scientists have decided to choose a "direction of current"* as described in textbook III on p. 387.

While tentativeness appeared once in textbooks I and III as shown in Table 1, but very poorly represented as shown in Table 2. In the excerpt from all three textbooks none that explicitly or implicitly with accuracy express the belief that scientific claims evolve or are being refuted as per new shreds of evidence through technological advancement which may address the "tentativeness" aspect of NOS. In the same manner with the study by Zhuang et al. (2021), these aspects were compared on how they are represented in the five Chinese physics textbooks and even if some textbooks among the five considered include scientific claims related to NOS aspects, they were poorly represented.

Furthermore, most of the targeted NOS aspects scored 1 of the ten identified, which means that agreement from researchers considers the aspect being represented in implicit, informed and consistent representation manner. For example, except scientific law and Inferential that were explicit and partially represented, all other identified aspects were implicitly represented in the three textbooks. The results of this study are similar to the findings reported by Masilela and Ramaila (2019) on representation of NOS aspects in the Life Sciences textbooks of South Africa. In their study NOS aspects such as Laws and theories; Tentativeness, Empirical; Inferential; and Creative were not adequately covered. The findings of this study also converge with those of Park et al. (2019) in which social aspect was poorly represented in analyzed physics textbooks from South Korea. Contrary to it, NOS aspects such as scientific methods, scientific practice and scientific ethics were noted in general relativity theory unit in the examined physics textbooks (Park et al., 2019).

The empirical NOS aspect was noted in the analyzed textbook materials and its representation was considered implicit and would require teacher-guided reflections to understand that statement that can be reflected for the other concepts

of science. Among three textbooks analyzed, two textbooks that considered "empirical" aspects, represented in a similar manner, therefore it was given the score of 1 in these two textbooks.

Puisque l'objet tombe (…), il y a une force qui agit sur lui. L'objet est attiré par la Terre (…) Page 57.

Translation: "Since the object falls (...), there is a force acting on it. The object is attracted to the Earth (...)." page 57.

The results of this study show a very low representation of NOS aspects in selected physics textbooks used in Burundi. The results of this study are like that of Li et al. (2020) in which scientific laws and theories, and empirical evidence were rarely discussed in five physics textbooks from junior school in China. Similar results were noted in 18 physics textbooks from the USA by which NOS aspects were found with less attention compared to a lot of effort made in the past several decades to improve learning and teaching of NOS in the USA (Abd-El-Khalick et al., 2017). Regardless of the quality of the identified NOS representations even the quantity of NOS representation is relatively small and vary greatly among the three textbooks. None of the three selected textbooks were found with all targeted NOS aspects. Inconsistency in interpreting scientific ethics presents a serious trait to the three selected textbooks and hence inhibits the promotion of NOS understanding in Burundi.

The inconsistency found in selected textbooks may result from the current Burundi Fundamental School curriculum, which focuses more on promoting scientific literacy defined with a rather ambitiously (Varly & Mazunya, 2018). In general, the results of this study revealed that NOS aspects are poorly represented in selected physics textbooks. Even in textbook III that expresses a great number, compared to the other two, the NOS representations were found in very few lessons of physics. The results of this study agree with the study of Zhuang et al. (2021) which noted poor representation of NOS aspects in physics textbooks used in China.

Furthermore, poor representation of NOS is not found only in physics textbooks but also it has been reported in the different science textbooks. For instance, the similar results that converge with this study were reported in the American physics and biology textbooks (Abd-El-Khalick et al., 2017). In addition, Abd-El-Khalick et al. (2008) also noted a poor picture of NOS aspects in fourteen chemistry textbooks like the results of this study. Therefore, though the NOS concepts play a great role not only for the science content learning but also for effective promotion of scientific literacy, the physics textbooks in Burundi have failed to represent it adequately.

Conclusion

This study aimed at assessing the representation of NOS in physics textbooks. The findings reveal that the NOS aspects were either neglected in the physics textbooks for cycle 4 in Fundamental Schools of Burundi or poorly represented. NOS aspects are mainly represented implicitly in the three physics textbooks analysed. The NOS aspects in three physics textbooks are not represented completely and with accuracy. Some aspects like scientific ethics, creative, theory-driven and tentativeness in science are missing in all three physics textbooks. The findings reveal that all physics textbooks used in Cycle 4 of Fundamental Education of Burundi poorly depict NOS aspects. And this little emphasis given to NOS aspects may result from the authors' negligence of NOS concepts while developing teaching materials but not related to the importance of NOS. Considering a pivotal role of textbooks in the learning and teaching process, it will be very difficult for the learners to appreciate the essence of NOS concepts when science textbooks do not include it.

Recommendations

The necessity for students to learn about the scientific enterprise and its development has been advocated in the current science standard documents (Maurines et al., 2013). Therefore, ignoring the essence of textbooks as the cornerstone and pivot tools in driving reform is a serious concern for the country like Burundi that claims international practices in science teaching.

In view of that, the study comes out with a strong recommendation to science policy makers to review textbooks used for teaching science, particularly for physics so that the emphasis be placed on the integration of NOS aspects. Furthermore, this study suggests the in charge of quality assurance to evaluate and deliberate on the accuracy and completeness of physics textbooks for cycle 4 and other levels. The students and teachers should get sufficient experience to the process of science instead of just its concepts, principles, and facts. The review of science textbooks must take away incorrect views and/or half-truths, emphasizing limitations and strength of science and its nature, with detailed information and scientific integrity (McComas, 1998). This study also recommends for the other researchers to advance further study on the other school materials and investigate on the teachers' understanding of NOS aspects vis a vis to the standards.

Limitations

This study used framework for textbooks analysis for NOS representations, using researchers' expertise. However, it has not considered the education quality assurance and material designers' criteria to approve any school materials such as textbooks and other teaching aids.

Acknowledgements

The authors would like to thank the ACEITLMS for financial support for this study. Besides, the study would have not been possible without the full cooperation and willingness of the participants, researcher-assistants who are the physics teachers.

Authorship Contribution Statement

Munezero: Conceptualization, design, data acquisition, data analysis/interpretation, drafting manuscript and statistical analysis. Yadav: Concept and design, data analysis, editing/reviewing, supervision, and final approval. Bugingo: Data acquisition, data analysis and editing/reviewing.

References

Abd-El-Khalick, F. (2012). Examining the sources for our understandings about science: Enduring conflations and critical issues in research on nature of science in science education. *International Journal of Science Education*, *34*(3), 353-374. https://doi.org/10.1080/09500693.2011.629013

Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education*, *22*(7), 665-701. https://doi.org/10.1080/09500690050044044

Abd-El-Khalick, F., Myers, J. Y., Summers, R., Brunner, J., Waight, N., Wahbeh, N., & Belarmino, J. (2017). A longitudinal analysis of the extent and manner of representations of nature of science in U.S. high school biology and physics textbooks. *Journal of Research in Science Teaching*, *54*(1), 82–120. https://doi.org/10.1002/tea.21339

Abd-El-Khalick, F., Waters, M., & Le, A. P. (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. https://doi.org/10.1002/tea.20226

Ayvacı, H. Ş., & Özbek, D. (2019). The effect of documentary films on preservice science teachers' views of nature of science. *Journal of Science Learning*, *2*(3), 97–107. https://doi.org/10.17509/jsl.v2i3.17998

Banuza, A., Ndikuryayo, F., Lumonge, D. Z., Masudi, K. J., & Kabungulu, M. C. (2017). La recherche en didactique des sciences en Afrique des Grands-Lacs : Une dynamique vivante [Research in science education in great lakes of Africa: A living dynamic]. *Les Cahiers Du CERUKI*, *52*, 324-337. https://bit.ly/3DPM4n1

Banuza, A., Nijimbere, C., & Ndikuryayo, F. (2016). *De l'espace numérique à sa pédagogisation: Comment améliorer la qualité de l'enseignement des sciences au lycée Cibitoke* [*From the digital space to its pedagogization: How to improve the quality of science teaching in Cibitoke high school*]. Adjectif. https://bit.ly/3rM0lcN

Bugingo, J. B., Yadav, L. L., & Mashood, K. K. (2022). Representation of nature of science aspects in secondary school physics curricula used in East African Community countries. *International Journal of Learning, Teaching and Educational Research, 21*(8), 175-201. https://doi.org/10.26803/ijlter.21.8.11

Chang, Y., Chang, C., & Tseng, Y. (2010). Trends of science education research: An automatic content analysis. *Journal of Science Education and Technology*, *19*(4), 315–331. https://doi.org/10.1007/s10956-009-9202-2

Chiappetta, E. L., Ganesh, T. G., Lee, Y. H., & Phillips, M. C. (2006, April 3-6). Examination of science textbook analysis research conducted on textbooks published over the past 100 years in the United States [Paper presentation]. Annual Meeting of the National Association for Research in Science Teaching, San Francisco, CA, United States.

Cofré, H., Vergana, C., Lederman, N. G., Lederman, J. S., Santibanez, D., Jimenez, J., & Yancovic, M. (2014). Improving Chilean in-service elementary teachers' understanding of nature of science using self-contained NOS and content-embedded mini-courses. *Journal of Science Teacher Education, 25*(7), 759–783. https://doi.org/10.1007/s10972-014-9399-7

Dagher, Z. R., & Erduran, S. (2016). Reconceptualizing the nature of science for science education: Why does it matter? *Science & Education*, *25*, 147–164. https://doi.org/10.1007/s11191-015-9800-8

Erduran, S., & Dagher, Z. R. (2014). *Reconceptualizing nature of science for science education*. Springer. https://doi.org/10.1007/978-94-017-9057-4

Esmer, F. (2011). *Exploring representation of nature of science aspects in 9th grade chemistry textbooks* [Master's thesis, Middle East Technical University]. OpenMETU. https://bit.ly/3CizFWa

Guisasola, J., Almudí, J. M., & Furió, C. (2005). The nature of science and its implications for physics textbooks: The case of classical magnetic field theory. *Science & Education*, *14*(3–5), 321–328. https://doi.org/10.1007/s11191-004-7936-z

Halai, N., & McNicholl, J. (2004). Teachers' conceptions of the nature of science: A comparative study from Pakistan and UK. *School Science Review*, *86*(314), 93-100. https://bit.ly/3qKlqEf

Irez, S. (2009). Nature of science as depicted in Turkish biology textbooks. *Science & Education*, *93*(3), 422–447. https://doi.org/10.1002/sce.20305

Ivomo. (2021). Beaucoup de Fautes Dans des Manuels Scolaires de Burundi [Many mistakes in instructional materials in Burundi]. Ivomo. https://bit.ly/3RPbdSF

Kagumba, R. E. M. (2015). *Uganda science teacher educators: A concurrent mixed methods investigation of perspectives on nature of science, pedagogy, and classroom learning environment* [Doctoral thesis, Western Michigan University]. https://bit.ly/3rDZI50

Li, X., Tan, Z., Shen, J., Hu, W., Chen, Y., & Wang, J. (2020). Analysis of five junior high school physics textbooks used in China for representations of nature of science. *Research in Science Education*, *50*(3), 833-844. https://doi.org/10.1007/s11165-018-9713-z

Linneman, S. R., Lynch, P., Kurup, R., Webb, P., & Bantwini, B. (2015). South African science teachers' perceptions of the nature of science. *African Journal of Research in Mathematics, Science and Technology Education*, *7*(1), 35–50. https://doi.org/10.1080/10288457.2003.10740547

Masilela, T. E., & Ramaila, S. (2019). The representation of the nature of science in south african grade 12 life sciences textbooks. In M. Z. Ramorola & U. I. Ogbonnaya (Eds.), *Proceedings of the South Africa International Conference on Education* (pp. 56-68). African Academic Research Forum.

Matthews, B. (2004). Promoting emotional literacy, equity and interest in science lessons for 11–14-year-olds; the 'improving science and emotional development 'project. *International Journal of Science Education*, *26*(3), 281-308. https://doi.org/10.1080/0950069032000097406

Maurines, L., Fuchs-Gallezot, M., Ramage, D., & Beaufils, D. (2013). La nature des sciences dans les programmes de seconde de physique-chimie et de sciences de la vie et de la terre [The nature of sciences in the physics, chemistry, life and earth sciences curricula in grade 12]. *Research in Didactic of Science and Technology/ Recherches en Didactique des Sciences et des Technologies*, *7,* 19-52. https://doi.org/10.4000/rdst.674

Mbonyiryivuze, A., Kanamugire, C., Yadav, L. L., & Ntivuguruzwa, C. (2018). Reforms in science curricula in last six decades: Special reference to physics. *African Journal of Educational Studies in Mathematics and Sciences*, *14*, 153–165. https://bit.ly/3RK6DEE

McComas, W. F. (1998). The principal elements of the nature of science: Dispelling the myths. In W. F. McComas (Ed.) *The nature of science in science education* (pp. 53-70). Kluwer Academic Publishers. https://doi.org/10.1007/0-306-47215-5_3

McComas, W. F. (2008). Seeking historical examples to illustrate key aspects of the nature of science. *Science & Education*, *17*(2), 249–263. https://doi.org/10.1007/s11191-007-9081-y

Michel, H., & Neumann, I. (2016). Nature of science and science content learning. The relation between students' nature of science understanding and their learning about the concept of energy. *Science & Education, 25*(9), 951–975. https://doi.org/10.1007/s11191-016-9860-4

Nahimana, V., Mukene, P., & Rurankiriza, J. M. (2015). *Republique du Burundi, plan sectoriel de developpement de l'education et de la formation PSDEF 2012-2020* [*Republic of Burundi, sector plan for the development of education and training*]. Government Publishing Service. https://bit.ly/3BN4R0y

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. The National Academies Press. https://bit.ly/3UkKBKT

Niaz, M., & Maza, A. (2011). *Nature of science in general chemistry textbooks*. Springer. https://doi.org/10.1007/978-94-007-1920-0

Nicholls, J. (2019). Methods in school textbook research. *History Education Research Journal*, *3*(2), 11–26. https://bit.ly/3Bpf02i

Ojimba, P. (2013). Science education reforms in Nigeria: Implications for science teachers. *Global Advanced Research Journal of Peace, Gender and Development Studies*, *5*(2), 86–90.

Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R. (2003). What "ideas-about-science" should be taught in school science? A Delphi study of the expert community. *Journal of Research in Science Teaching*, *40*(7), 692–720. https://doi.org/10.1002/tea.10105

Park, W., Yang, S., & Song, J. (2019). When modern physics meets nature of science. *Science & Education*, *28*(9), 1055-1083. https://doi.org/10.1007/s11191-019-00075-9

Ramnarain, U. D., & Chanetsa, T. (2016). An analysis of South African Grade 9 natural sciences textbooks for their representation of nature of science. *International Journal of Science Education, 38*(6), 922-933.

https://doi.org/10.1080/09500693.2016.1167985

Schwartz, R. S., Lederman, N. G., & Abd-el-Khalick, F. (2012). A series of misrepresentations: A response to Allchin's whole approach to assessing nature of science understandings. *Science & Education*, *96*(4), 685-692. https://doi.org/10.1002/sce.21013

Upahi, J. E., Ramnarain, U., & Ishola, I. S. (2020). The Nature of Science as represented in chemistry textbooks used in Nigeria, *Research in Science Education*, *50*, 1321-1339. https://doi.org/10.1007/s11165-018-9734-7

Varly, P., & Mazunya, M. (2018). *Burundi ASA: Study two report on the quality of education.* (Report No. P161127). https://bit.ly/3LwJzHH

Vesterinen, V. M., Aksela, M., & Lavonen, J. (2013). Quantitative analysis of representations of nature of science in Nordic upper secondary school textbooks using framework of analysis based on philosophy of chemistry. *Science & Education*, *22*(7), 1839–1855. https://doi.org/10.1007/s11191-011-9400-1

World Bank. (2011). *A regional exploration of pathways toward harmonization of math and science curriculum in the East African Community*. https://bit.ly/3eH2FP5

World Bank. (2018). *The Republic of Burundi for an early grade learning project*. https://bit.ly/3ScjqjC

Yadav, L. L., & Shrivastava, M. (2007). Teaching and learning of the nature of science and technology: A look from a developing country. *The International Journal of Learning*, *14*(2), 119-126. https://doi.org/10.18848/1447-9494/CGP/v14i02/45191

Yao, J. X., & Guo, Y. Y. (2018). Core competences and scientific literacy: The recent reform of the school science curriculum in China. *International Journal of Science Education*, *40*(15), 1913–1933. https://doi.org/10.1080/09500693.2018.1514544

Zhuang, H., Xiao, Y., Liu, Q., Yu, B., Xiong, J., Bao, L., & Yu, B. (2021). Comparison of nature of science representations in five Chinese high school physics textbooks. *International Journal of Science Education*, *43*(11), 1779–1798. https://doi.org/10.1080/09500693.2021.1933647