Implications of Scientific Literacy for Secondary Schools in Uganda

Kedrace Turyagyenda

The revolutionary changes in the practice and culture of today's science and technology calls for major changes in science education and the definition of scientific literacy. It calls for a lived curriculum in which the major instructional standards and intellectual skills enable individuals to cope with changes in science and technology, society and human welfare. Such curriculum would recognize the socialization of science and its relevance to how science impacts on culture, our lives and the course of our democracy. It empowers the students to be involved in their own development and to recognize that they can use what they learn. This article analyses the nation of scientific literacy which uses the lived out curriculum. It also analyses the science education in Uganda where the science curriculum is descriptive, focused on laws, theories and concept of discrete disciplines. It recommends a paradigm shift in science education. This will entail the change in science curriculum and content, methodologies and assessment; and the need to re-tool the science teachers in order to equip them with needed skills so as to produce scientific literate citizens.

Keywords: Scientific literacy, Curriculum reform, Education for development

Introduction

Science education is incomplete if it does not involve students in preparation for and taking action on matters of social and political importance. Miller (1993) characterized this position as transformational education which produces scientifically literate citizens. Hodson (2003) claims that the knowledge, skills and attitudes embodied in the notion of scientific literacy are important to everyone and not just those labelled as scientists. The goal of science education is to equip students with the capacity and commitment to much rigorous, analytical, sceptical, open-minded and reflective approach to science education so that they can take appropriate, responsible and effective action on matters of social, economic and moral-ethical concerns (Hodson, 1999; 2003).

Since early 1990's the most prominent slogan that has had impact on classroom practice is the call for scientific literacy. According to UNESCO (1990), the World declaration on Education for All (EFA), urged governments to review educational provision for achieving Scientific and technological literacy for all. The quotation from which the above statement has been paraphrased reads: "In a world where everyone aspect of life is increasingly dependent upon scientific and technological progress…Education in Science and Technology is

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indispensable for all nationals, to create a scientifically and technologically literate citizenry …" (UNESCO, 1990).

The notion of scientific literacy has since assumed centre – stage in science education debate in several parts of the world. Governments and organizations such as the American Association for Advancement of Science (ASSS, 1993), the Council of Ministries of Education Canada (CMEC, 1997) and UNESCO (1993) have used it to frame major efforts to reform the science curriculum. Scientific literacy has become an increasingly common term in articles and reports on school science education, and the science curriculum. For example, National Science Education Standards (USA) reported "a marked significant milestone in the continuous journey towards achieving scientific literacy for all Americans" (Collins, 1995). The report on "Beyond 2000" (UK) highlighted enhanced scientific literacy (Miller and Osborne, 1998) while the report on "Science in Australia Schools" indicated that the purpose of science education is to develop scientific literacy, which is a priority for all (Goodrum, Hackling and Rennie, 2001). Three important questions need to be answered: What is scientific literacy? Why do we need it? What is its implication to schools in Uganda?

Concept of Scientific Literacy

Although attainment of scientific literacy has been welcomed as a desirable goal for science education, there is still little clarity about its meaning. Scientific literacy is a term that has been used since the 1950s to describe a desired familiarity with science on the part of the public (DeBoer, 2000). Laugksch (2000) argues that the science teachers, science educators, and curriculum developers regard scientific literacy as a kind of code for goals of science education and a frame for their discussion in terms of curriculum content, pedagogy and assessment/evaluation procedures. He further argues that those with responsibility of developing science policy are more concerned with public perception of and support for, the scientific enterprise. Others are concerned with the nature of control and priority setting for science, access to science, or keeping up to date on significant scientific development via media, zoos and museums. The thinking is that all students regardless of gender, ethnicity, religion, geographical location, current attainment levels, can achieve a measure of scientific literacy (Hodson, 2008). From the above discussion, scientific literacy stands for what the general public ought to know about science (Durant, 1993). Therefore, to speak of scientific literacy is simply to speak of science education itself (De Boer, 2000).

Scientific literacy can be categorized as functional, civil, cultural and practical knowledge necessary to solve life's everyday problems (Shamos, 1995; Bybee, 1997)

According to National Science Educational Standards (USA,1996), scientific literacy means that a person can ask, find or determine answers to questions derived from curiosity about everyday experience. It further implies that such a person is able to read with understanding in a popular press and engage in social conversation about the validity of the conclusions. Scientific Literacy implies that the person can identify scientific issues underlying national and local decisions and express positions that are scientifically informed. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately for personal decision-making and participation in civic and cultural affairs, and economic productivity. Hence, a scientifically literate citizen should be able to evaluate the quality of scientific information on the basis of the source and the methods used to generate it.

Scientific literacy presupposes a reasonable level of literacy in its fundamental sense (Wellington and Osborne, 2001; Fancy, 2005) in order to engage in science, contribute to debate about science and access science education. Science knowledge cannot be articulated and communicated except through text and transfer of understanding from one context to another. Thus it involves analysis, interpretation and evaluation. Despite the often considerable substantive content and the highly specialized language of science, the abilities required to extract meaning from any text are the very ones needed to understand science.

A study on the relationship between student scores on traditional measures of attainment and the ability to interpret media reports on scientific matters conducted by Norris and Philips (2003) concluded that understanding science texts reside in the capacity to determine when something is an inference, a hypothesis, a conclusion or an assumption. It also requires the capacity to distinguish between an explanation and the evidence for it, and to recognize when the author is asserting a claim to "scientific truth", expressing doubt or engaging in speculation. Without this level of interpretation, the reader will fail to grasp the essential scientific meaning because it is not just a matter of recognizing the words and using them appropriately but also the ability to comprehend, evaluate and construct arguments that link evidence to ideas and theories. Thus teaching about the language of Science and its use in scientific arguments should be a key element in science education at all levels. This augment is supported by Hodson (2008) and Treagent (2006). These authors seem to suggest a science education very different from the traditional uncritical and unquestioning approach that presents science as dogmatic, fixed and certain. Their argument is that science should be looked at more holistically using general knowledge acquired in education.

Benefits of Scientific Literacy

Promoting science literacy has a number of benefits to science itself, the individuals and society as a whole. The benefits of Science itself include; increased number of recruits in science fields, greater support for scientific research and more realistic public expectations of science (Hodson, 2008).

Individual Benefits of Scientific Literacy

In many countries the number of school children studying science and the number of graduates teaching sciences have been falling. The subject is often seen as 'boring', or 'too hard' or both. Scientific literacy would minimize such bias and increase the benefits at individual level.

In addition, individuals benefit from scientific literacy irrespective of educational and social background, because everybody in society needs application of science and technology in order to cope with challenges of modern world and live a meaningful productive life. Scientifically literate individuals have access to wide range of employment opportunities, are well positioned to respond positively and productively to the introduction of new technologies, and to make beneficial personal decisions about science-based choices.

According to National Research Council (1996: 2) "more and more jobs demand advanced skills, a requirement that people be able to learn, reason, think creatively, make decisions and solve problems. An understanding of science contributes in an essential way to those skills". Hodson (2008) further argues that those who are scientifically literate are better able to cope with demands of everyday life in an increasingly technology-dominated society, better positioned to evaluate and respond approximately to the supposed "scientific evidence" used in advertising agencies, and better equipped to make important decisions that affect their health, security and economic well-being.

Scientific literacy helps people to understand scientific information discussed and debated in the public media. For example newspapers are full of headlines on global warming and the associated economic threats, cloning, fossils in meteorites, genetically engineered foods, exotics materials, medical advances, DNA evidence and new drugs. All these deal with issues that directly affect people's lives. As a consumer, business professional, and as a citizen, a person will have to form opinions about these and other science-based issues if one is to participate fully in modern society. Personal decisions, for example on diet, smoking, vaccination, screening programs or safety in the home and at work will be facilitated by some understanding of the underlying science. The Royal Society (1985) revealed that an uninformed public is very vulnerable to misleading ideas on, for example, diet or alternative medicine.

Understanding Science enriches people's appreciation of everyday activities. Scientific knowledge helps people to appreciate the order in the universe, the beauty of creation; all animals and vegetation around them. As Dawkins (1998) noted, science is progressively revealing the order and beauty of the universe from elementary particles up through the atom, the molecule, the cell, man, the earth with all its teeming life, solar system, meta galaxy and the vastness of the universe itself. All those contribute to the feeling of awe and wonder that science can give humanity.

Societal Benefits of Scientific Literacy

Scientific literacy also benefits society in general. It increases economic development, enriches the intellectual life and cultural health of nations in general, promotes responsible citizenship and enhances democracy. A great deal of financial support for fundamental scientific research is got from public funds. Shorthand (1988) argues that confidence in scientists and the public support for science depends on at least a minimum level of general knowledge about what scientists do. However increased scientific control does not necessarily translate into increased support for scientific research, rather it may make the public more critical of what scientists do. This in itself is positive because it will continually encourage scientists to do an excellent work in their research and publications. Therefore (Hodson 2008) argues that what is required is the scientific literacy that is allied to political literacy and a commitment to socio-political environment that will necessitate a curriculum oriented towards citizens action (Hodson, 2003).

Scientific literacy is regarded as a form of human capital that sustains and develops the economic well-being of a nation (Hodson, 2008). It is common knowledge that continued economic development brought by enhanced competitiveness in international market depends on science–based research and development, technological innovation and steady supply of scientists, engineers and technicians. All of this ultimately depends on public support for state-funded science and technology education in schools. American Association for Advancement of Science (1989) noted that the potential of Science and Technology (S&T) cannot be realized unless the public in general comes to understand Science, Mathematics and Technology and to acquire scientific habits of mind. Without a scientifically literate population, the outlook for a better world is not promising.

Hurd (1998) established a link between school science education and a culture of life-long learning as the key to the country's prosperity. The government of Canada (1991) declared that "Our future prosperity will depend on our ability to respond creatively to the opportunities and challenges posed by rapid change in fields such as Information Technology (IT), new materials, biotechnologies and telecommunication. To meet the challenges of technologically driven economy, we must not only upgrade the skills of our workplace, we must also foster a lifelong learning culture to encourage the continuous learning culture needed in an environment of constant change". The issues raised in his declaration are real and must be confronted by every nation if such a nation is to remain competitive in this globalised world.

Hodson (2008) argued that democracy is strengthened when all citizens are equipped to evaluate socio scientific issues and make informed decisions on matters of personal and public concern regardless of whether they are lawyers, parliamentarians, business people, journalists, civil servants, teachers, police officers and any other category. Scientific literacy will also help scientists to make better decisions because their judgment will focus more attention on economic, social, cultural, political and moral-ethical dimensions of their work rather than just the technical issues. This seems to suggest that scientific literacy for active citizenship, economic development and social reconstruction lies more on science literacy rather than it does in learning science per se. It is worth noting that science required for solving the problems of everyday life such as raising a child born with Down syndrome or managing a domestic energy budget with low or fixed income (Layton et al, 1993; Jerkins, 1999) is very different from the science presented in school curriculum. This argument was reinforced by studies conducted by in science –based industries by Law (2002), Chin et al (2004) and Duggan and Aikenhead (2005). They all concluded that most of the necessary science used by workers in science-based industries was learnt on-the-job rather than in school.

Chin et al (2004) and Aikenhead (2005) further noted that school science is focused predominately on declarative knowledge (knowing what) or learning facts while workplace knowledge (knowing how) is focused on application. These studies raise important questions about the purpose of scientific literacy and its implication to schools. No school curriculum can equip citizens with thorough first-hand knowledge of all the science underlying important issues. Moreover much of the science knowledge learnt in school especially biological sciences will be out of date within a few years of leaving school. However, science education can enable students to understand the significant knowledge presented by others and to evaluate the validity and reliability of that knowledge. If students acquire good learning habits and attitudes towards science during the school years, it will be relatively easy for them to acquire additional scientific knowledge later on as and when need arises, provided that they have also acquired the language and skills to access and evaluate relevant information from diverse sources.

Responses to Scientific Literacy

If scientific literacy is to be achieved and effectively utilized by all citizens, each country has to put in place specific strategies. These will have implications to the science curriculum, methods of teaching and assessment systems. A summary of the responses by the United Kingdom (UK), Netherlands and United States of America is highlighted below.

UK Response to Scientific Literacy

A science course known as "Twenty First Century course" with an emphasis on scientific literacy was developed and piloted tested in 78 schools from September, 2003. This course targeted 15-16 years old. The curriculum and teaching materials were developed by the Twenty First Century Science Project in which Nuffield Curriculum centre played a key role. By September 2006, around 1000 schools had chosen to do that course for their General Certificate Secondary Education (GCSE), an indication that more and more schools had appreciated it. The main aim of the course was to provide students with a 'toolkit' for accessing, interpreting and responding to Science as they encounter it in everyday life such as health, medicine, environment, risk and risk factor, issues that involve other kinds of knowledge and values. An evaluation of this program revealed that students' attitude to science and teachers' classroom practices and teaching approaches had improved.

Netherlands Response to Scientific Literacy

A new subject called "Algemene Natuurwestern schppen"(ANW) was introduced for all students in senior secondary education in 1998. Its main aim was public understanding of science. The emphasis was on providing knowledge and skills for assessing, interpreting and responding to science as it is encountered in everyday life. This was reflected through the curriculum and emphasis on scientific literacy, and the methods of teaching. The content areas included a lot about health, environment risks and risk factors, issues that involve science and technology and other key issues (De Vos & Reiding, 1999; Eijkelhof & Kapteijn, 2000).

In both UK and the Netherlands, the main challenge has been the designing of a science course with scientific literacy emphasis and at the same time providing adequate depth for students who wish to follow science careers. As a result, different models have been developed and are being tried out. Similarly, teachers have faced the challenge of the shift from disaggregated factors as previously provided in separate science subjects to the integration of science knowledge to make sense in everyday life. This has had impact on the pedagogy and assessment of science. Therefore teacher's continuous professional developed has been adjusted to meet the new challenge faced by the teachers.

United States of America (USA) Response to Scientific Literacy

Science for all Americans was launched. It was based on the belief that all citizens need to live interesting, responsible and productive lives in a culture shaped by science and technology (American Association for Advancement of Science, 1997). It was also believed that the science literate person is one who is aware that science, mathematics and technology are interdependent human enterprises. Such a person understands key concepts and principles of science, is familiar with the natural world and recognizes both its diversity and unity, and uses scientific ways of thinking for individual and social purposes (American Association for the Advancement of Science, 1990). Consequently the National Science Education Standards (NSES) were established. The standards apply to all students regardless of age, gender, cultural or ethnic background, disability, aspirations or interests and motivation in science. It was envisaged that all students can develop the knowledge and skills described in the standards, even though some may go well beyond those levels.

Situational Analysis of Science Education in Ugandan Schools

The current education system in Uganda can be described as a 7- 4-2-3 system. There are seven years of basic primary education under Universal Primary Education(UPE), four years of lower or Ordinary level ('O' level) secondary education under Universal Secondary Education(USE), two years of Advanced ('A' level) secondary education and a minimum of three years of University undergraduate education. However, there are alternative education programs in Technical, Vocational and Teacher education training which can be accessed after each school level. Science education is compulsory for all learners at primary and lower secondary levels. Although science at primary level is integrated, science education at secondary school level is disintegrated into specific disciplines under Biology, Chemistry and Physics. The curriculum used by all schools is developed by the National Curriculum Development Centre (NCDC) and the national examinations at the end of each school level are conducted by the Uganda National Examinations Board (UNEB). At the end of Primary and Lower Secondary levels learners sit Primary Leaving Examinations (PLE) and Uganda Certificate of Education (UCE) respectively. The outcome of these examinations is used as a measure of competence acquired by the learner in specific disciplines at each level. Does the science education provided in Uganda result in scientifically literate citizens?

Performance at Secondary

The analysis based on performance in national examinations reveal that science and mathematics at lower secondary has been unsatisfactory as demonstrated by the tables below. The period 2005-2009 was selected for lower secondary because the policy of compulsory science for lower secondary started in 2005.

Table 1: Percentage Passes at Distinction Level in UCE Science Subjects (2005-2009)

Subject	2005	2006	2007	2008	2009
Mathematics	1.1	1.8	1.9	1.9	3.2
Chemistry	3.9	2.5	0.4	0.4	0.6
Physics	2.1	1.0	0.7	0.7	0.7
Biology	1.0	0.2	0.5	0.5	1.0

From Table 1, the average percentage pass from 2005 to 2009 was 2% in Mathematics, 1.6% in Physics, 1.4% in Chemistry and 0.6% in Biology.

This analysis indicates that performance of learners at distinction level in science and mathematics subjects at the end of lower secondary is poor in all the science subjects especially Biology.

Table 2: Percentage Failure (F) Rate in UCE Science Subjects (2005-2009)

Subject	2005	20006	2007	2008	2009
Math	33.8	26.0	33.0	17.6	26.6
Physics	30.8	37.3	58.1	58.7	58.1
Chemistry	50.3	50.0	66.8	70.6	60.1
Biology	38.2	48.0	37.6	40.6	46.8

The average failure rate over the period 2005-2009) was 27.4% in Mathematics, 48.6% in Physics, 59.6% in chemistry and 42.2% in Biology. The failure rate especially in Physics and Chemistry (physical sciences) seem to have progressively increased over the period under analysis. The analysis above shows a high failure rate in science and mathematics at the end of lower secondary education.

The level of proficiency in Biology (science) has also been low even at senior two level. Uganda has been conducting National Assessment of Progress in Education (NAPE) in secondary schools at senior two level since 2008. The assessment covers the subject areas of English Language, Mathematics and Biology. The achievement of a student is a subject is rated proficient if he/she demonstrates competence with minimum performance level that was desired of the student. Table 2 below gives the performance for the years 2008-2010.

Table 2: Students Rated Proficient in NAPE (2008-2010) (%)

Subject/ Year	2008	2009	2010
Eng. Language	81.9	76.0	67.5
Mathematics	69.4	58.8	49.7
Biology	36.7	36.3	30.4

From Table 2, it is evident that the highest proficiency rates have been in English Language and the lowest has been in Biology (science) although there has been a general decrease in all the three subjects over the years. The consistently low level of proficiency in Biology at senior two is consistent with the achievement at senior four (end of cycle). This implies that students go through lower secondary without acquiring the necessary knowledge and skills in Biology. It further implies low levels of scientific literacy.

The Government of Uganda has made efforts to improve science education in order to produce a science literate population that can contribute towards national development (Government White paper on education, 1992 and Uganda Vision 2025). The efforts of government have translated into policies and programmes intended to improve science knowledge and skills such as the launching of the policy (2005); rehabilitation and construction of school science laboratories and provision of science kits; recruitment of more science teachers, in-service training for secondary science and mathematics teachers (SESEMAT), introduction of e-learning; and affirmative action on financing science courses in government universities and tertiary institutions (Ministry of Education and Sports, MoES, 2006). However, the analysis above reveals that those efforts have not yet translated into good performance by the students. Would the focus on science literacy rather than subject-based science improve the situation?

Implications of Science Literacy to Schools in Uganda

If science literacy is to be achieved, special strategies have to be adopted by schools. These will have implications to the science curriculum, methods of teaching and assessment, and teacher training and continuous professional development.

Implications to the Science Curriculum

The current curriculum presents science subjects in disaggregated form as separate disciplines. Science is structured through the curriculum content into topics and sub-topics and communicated through restricted models mainly confined in a laboratory/classroom. To achieve scientific literacy, the curriculum has to be reviewed so that it provides a frame work for the science course with scientific literacy emphasized. This will enable the learners to acquire ideas and skills useful for accessing, understanding, interpreting, explaining and responding to the science they encounter in everyday life. The curriculum content should be revised to include but not limited to understanding science itself, the nature of scientific knowledge, the methods of scientific inquiry and how science and society inter-relate.

Implications for Pedagogy and Assessment

The findings of a qualitative study conducted by the Ministry of Education and Sports (MoES) and Kyambogo University in 2003 revealed that the teaching practices were largely teacher-centred, theory oriented (talk and chalk) and dominated by factual materials and dictation of notes. Therefore, science is perceived as abstract and hard.

To overcome this secondary science and mathematics teachers (SESEMAT) programme was introduced by the Ministry of Education and Sports (MoES) with technical assistance from the Government of Japan through Japan International Corporation Agency (JICA) in August 2005. The programme focused on promoting pedagogical shift, which involves changing from theoretical content-based instruction to activity experiment-based, from teacher-centred to learner-centred; bias to encouragement; large scale experiments to appropriate experiments involving improvisation. Although a formal evaluation of the SESEMAT programme has not yet been done, it is not likely to achieve the intended paradigm shift because the same old content is being taught and examined summatively.

The teacher training methods will have to be adjusted so that there is proper management of small groups and whole class of discussions; making use of the news media and other informal sources to keep up to date; drawing out an idea about science from a case study and helping students to see how to apply it to other cases. Teaching for scientific literacy should include the world outside the classroom so that the learner interacts with compound, garden, at home, museum, zoo, and industry. This enhances investigative teaching and learning; engages the learners; portrays science as exciting; stimulates further learning, personal development, responsibility and socialization; and generates positive learning outcomes among students (Nuridy, 1999).

Assessment in education is the process of determining the extent to which a student has achieved the objective in the curriculum the teacher has set out to achieve. From the assessment score, inference can be made about the student knowledge or understanding that is not directly observable (Pellegrimo, Chudowsky & Glaser, 2001). The current assessment system at primary and secondary school is summative in nature and mainly paper-and-pencil semi- structured and essay questions done at the end of the course. The students' performance is in the examination, in a subject, is judged by the score obtained in the examination. The results have mainly been used to serve the summative function of assessment such as certification (grading), classification and selection purposes as admission criteria to the next level of education.

Several criticisms have been raised against the current summative system. The examination is a 'one-shot' examination that comes at the end of the course; it does not test all the student knows, has learnt or can do; does not provide feedback that can improve teaching and learning; and does not take into account the performance of the student during the course of instruction. Summative assessment generally tests the knowledge of science. Consequently, the students and teachers see the examination as an end in itself and not a means of improving the teaching, learning and performance.

However, assessment for scientific literacy will involve testing the knowledge of science and the "knowledge about science". Knowledge of science refers to knowledge of natural world across the major fields of physical sciences, biological sciences and space science and science-based technology. Knowledge about science refers to the knowledge of the means (scientific inquiry) and goals (scientific explanations) of science (Osborne 2006). Continuous assessment would be a more appropriate system. Continuous assessment is a systematic, objective and comprehensive process of collecting information about the student learning during the course of study through periodic testing to determine the extent of learning the objectives set out to in the teaching course (Bajah, 1990; Nitko, 1996). Continuous assessment can, therefore, be both formative and summative in nature based on the formal school curriculum. Through the formative assessment scientific inquiry and scientific explanation skills will be tested.

Implications for Teacher Training

In Uganda, primary teachers do a course of two years at Teacher training colleges after Lower Secondary. They study a wide range of subjects which they subsequently teach in primary schools. They follow structured curriculum. Secondary school teachers train for two years at National Teachers training colleges or three years at university after 'A' level. They study two specialized teaching subjects. Currently, primary teachers under take in-service training through the Centre Coordinating Tutor(CCT) system within Teacher Development Management System(TDMS). The secondary school science and mathematics teachers under take in-service trainings through SESEMAT (referred to above).

While primary science is an integrated course of study, secondary school science is studied in separate subject of Biology, Chemistry, Physics, Mathematics and other science application subject such as Agriculture, Technical Drawing and Computer studies. The science teachers also train and teach those specialized subjects according to the curriculum. Their teaching is basically driven by the examination oriented nature of the education system. Therefore, the science teachers may not adequately guide the learners to acquire holistic and integrated scientific knowledge and skills. Therefore, there need to review courses at the training colleges and universities and to re-orient the teachers already is schools through In-service Education and Training (INSETS) so that the teachers' scientific literacy training needs are identified and addressed through regular Continuous Professional Development (CPD) seminars and workshops and be given consistent support supervision. As the select committee of the House of Lords Science and Technology (2001) observed, "… the content knowledge required to teach today's science, rather than yesterday's changes much faster than the content knowledge of most other subjects." Therefore, science teacher need to continuously be updated through CPDs. This will necessitate the reviving of Teacher's Resource (TRC's) and constructing more so that science teachers regularly get time away from the everyday pressures of school life for professional development, exchanging experiences, updating their subject knowledge and giving feedback to the trainer's especially contemporary science and controversial science issues that appear in the public press (Holman, 2006).

Conclusion

Scientific literacy has assumed centre stage in the science education debate. It is generally acknowledged that everyone needs some level of scientific literacy in order to cope with the present world that is driven by science and technology developments. Scientific literate citizens will contribute to the civic, social and political debates on issues related to health, diet, climatic and environmental changes and make reasonable personal decisions on such issues. Since scientific literacy is important for all people and not just the scientists, it has implications to school science education globally, Uganda inclusive. It will need review of the curriculum content, teaching methodologies, assessment systems and teacher training approaches that emphasize scientific literacy.

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