An overview of science education in the Caribbean: Research, policy and practice

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Citation:

Sweeney, A. E. (2003). An overview of science education in the Caribbean: Research, policy and practice. Science Education International, 14(2), 43-55.

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Abstract:

The typically defined "developing countries" of the Caribbean[1] share with the more fully developed industrialised nations the need to educate and prepare their citizens to be competitive in the global economy, and over the past 20 years, have been engaged in a process of education reform (Jules, Miller & Armstrong, 2000, p. ix). Of particular significance for the region "… is an increasing demand for postsecondary education, particularly in the areas of science, technology and management. This is critical if the region is to steer its development and be equipped to address the challenges ahead" (Jules, Miller & Armstrong, 2000, p. xi). Given the global contexts in which these education reform efforts are occurring (i.e. the centrality of science and technology in the development and maintenance of national economies; and the emergence of a science and technology based world economy), attention needs to be given to the nature and extent of science education in the Caribbean. The first section of this article therefore focuses on an analysis of science education research in the Caribbean[2], followed by sections which provide inexhaustive examples of science education policy and practice in the region. In these sections, emphasis is given to large scale national efforts occurring in three Caribbean countries, i.e. Barbados, Bermuda and Jamaica. The chapter concludes with a brief discussion, and provides recommendations for future directions in science education for the Caribbean region.

Key words:

Caribbean, science, education

Science education research in the Caribbean

Science education research in the Caribbean, while still relatively unknown and under-appreciated by many professional science educators outside of the region, has been occurring at a steady pace for at least the past 30 years. The work of Fraser-Abder (1988a; 1988b) serves as a comprehensive compendium of documented Caribbean science education research occurring during the period 1970-1987. During the early part of this period, it was clear that the role and purposes of science education in the Caribbean were of concern (e.g. Lambert, 1974; Lancaster & King, 1977; Mark, 1978). During the late 1970s-mid 1990s, several science education faculty at the University of the West Indies rose to prominent positions as internationally recognised Caribbean science education researchers, i.e. Workeley Brathwaite, Pamela Fraser-Abder, June George, Joyce Glasgow and Winston King. During this period, their published work focused on a number of issues pertinent to science education in the region, including *culture and cognitive development* (Fraser-Abder, 1982; 1985a; 1986; King 1978a); *science curriculum development* (Alexander & Glasgow, 1981; Fraser-Abder, 1985b; Fraser-Abder & Douglass, 1986; Glasgow, 1987; King, 1978b; 1978c); *science teacher education* (Brathwaite, 1978; Fraser-Abder, 1979; Fraser-Abder & Shrigley, 1980; Glasgow & Robinson, 1983); *the impact of science on social issues and concerns* (Lancaster & King, 1977; King, 1979; 1982; 1987; Brathwaite, 1985); *assessment* (King & Brathwaite, 1991); *scientific literacy* (Glasgow, 1986); *environmental education* (Glasgow, 1987; 1989; 1993); and *the relationships between Caribbean beliefs and conventional science* (George, 1988; George, 1995; George & Glasgow, 1988; George & Glasgow, 1989).

As noted by Fraser-Abder (1988a), Caribbean education researchers and policymakers in the 1970s and early 1980s justifiably could have been accused of force-fitting the results of educational research found in developed countries into Caribbean school settings (p. 1). During the latter part of the 1980s however, a trend could be seen in the science education research emerging from the region which sought to focus more specifically on the particularities of the Caribbean and the need for context specific research endeavours. George (1988), for example, argued that a failure to develop curriculum materials in which were identified context specific subject matter idiosyncratic to the Caribbean, might result in "students being hindered in their attempts to link school science with everyday experiences" (p. 816). Regarding these concerns, the recently published work of June George and Joyce Glasgow (e.g. George, 1995; 1999; 2001; George & Glasgow, 1999) has been of particular interest and significance.

Building on the basis of previous theoretical and empirical work in mainstream science education which investigated the influence of children's background knowledge and its interaction with formal science instruction (e.g. Driver & Erickson, 1983; Prout, 1985; Driver, Squires, Rushworth & Wood-Robinson, 1994), the thrust of George and Glasgow's collaborative work sought to provide an empirical basis upon which idiosyncratic Caribbean science-related beliefs might be analysed in the context of conventionally accepted scientific concepts and principles. Major science-related beliefs have been classified into the areas of *child rearing practices and injunctions*; *food and nutrition*; *pregnancy, birth and postnatal care*; *temperature changes*; *changes in the physical environment*; and *household practices* (see George & Glasgow, 1988; 1999; George, 2001 for a more detailed discussion of these beliefs and their relationships to concepts in the canonical life and physical sciences). Since the majority of teachers in the Caribbean share a similar cultural background with the children they teach, it is reasonable to assume that they (at least initially) also make sense of conventional science from the same kind of belief bases discussed in George and Glasgow's research (see George & Glasgow, 1999, pp. 13-23). This line of enquiry presents a number of important implications for the manner in which the whole enterprise of science teaching and learning is conducted in the Caribbean. Important implications exist for the formal processes of science teacher education (content and pedagogy), school science curriculum development and subsequent classroom instruction, and the types of assessments which are designed and administered. Although George and Glasgow's published research in this area drew on data from studies conducted in Jamaica and Trinidad & Tobago, respectively, there is broad applicability to the rest of the English-speaking Caribbean. It will be of interest to see how this line of science education research might successfully be applied to other Caribbean islands, e.g. the Dutch-, French- and Spanish-speaking islands whose traditional belief systems show broad similarities (and yet distinct differences, based on their own unique colonial and developmental histories) to the English-speaking islands.

Current developments in Caribbean science education research may be exemplified by the work of Kolawole Soyibo (e.g. Esiobu & Soyibo, 1995; Soyibo, 1995; Soyibo & Figueroa, 1998; Soyibo, 1999; Soyibo & Hudson, 2000) and Melody Williams (e.g. Williams, 1997a; 1997b; 2002). Soyibo's research has focused on clarifying the cognitive processes used by Jamaican science students in their science learning, and those exhibited by science teachers in terms of how they formulate appropriate assessment strategies in science. Other work has examined the structure and skill levels of laboratory activities used in science teaching, and the effectiveness of computer assisted instruction in science education. Notably, his work has been published widely outside of the Caribbean, which has provided a high level of international visibility for this line of research being conducted in a Caribbean context. Like Soyibo, Williams' research also has attempted to clarify issues relating to cognitive measures of science teacher knowledge and pedagogical effectiveness (e.g. use of concept mapping techniques) and has focused on the incorporation of technology/multimedia in science teacher preparation. As a matter of speculation, it may prove to be a highly informative and potentially rewarding undertaking for emerging science education research in the region to integrate George and Glasgow's work on Caribbean beliefs with the "cognitive processes" and technology/multimedia based science education research being pioneered by Soyibo and Williams, respectively.

Future directions

As Fraser-Abder (1988a; 1988b) pointed out over a decade ago, what appears to be absent -or at least, not very well developed- in Caribbean science education research efforts are cross-cultural studies involving not only various Caribbean islands, but other developed and developing countries. Most available published studies at the time reported the status of science education in specific Caribbean countries, and broader ranging empirical studies aimed at improving science education in the region as a whole were few. This still appears to be the case. While the examples of Caribbean science education research provided here all make major contributions to our understanding of science teaching and learning in the region, there also needs to be a body of work providing an empirical basis upon which useful cross-cultural comparative analyses and extrapolations may be made. A global assessment of science education/teaching in all the islands would be of interest in terms of possible coordination of efforts and long-range planning for future science education research efforts and resulting educational reforms in the region (see Abder-Fraser, 1988a, p. 15).

Science education policy in the Caribbean

It remains unclear -for the most part- whether the findings or implications of the research described above have had any direct or explicit influence on the development of current science education policies in the region. Lewin (2000a), for example, in his discussion of science education policy in developing countries writes that:

> A lot is known about how students learn science in different communities, what misconceptions they have, and what errors in reasoning and deductions they make. Much of this is not grounded in developing countries, but derived from research undertaken elsewhere. It is an issue for science education policy and

> planning to find ways of supporting research linked to development in different countries, which really does make a difference to the practice of science education. Progress on this has been disappointingly slow (p. 35).

Although the social and economic infrastructures to support productive research-policy relationships in the Caribbean still need to be developed adequately, national policies relating to education and training typically place emphasis on the importance of developing expertise in science and technology (see Lewin, 2000b). Clearly, this presents important implications for science teaching and learning in the Caribbean. In the following sections, brief descriptions of education policy initiatives from two Caribbean countries are presented, i.e. the *Education Sector Enhancement Programme* (EduTech 2000) in Barbados; and Bermuda's development of its national *Science Performance Standards*. The initiatives themselves exemplify two "levels" or "types" of policy formulation as they relate to science education in the respective countries, i.e. a national technology-focused education policy with explicit applications to science teaching and learning (EduTech 2000); and policy specific to the teaching and learning of science in the form of national standards.

The *Education Sector Enhancement Programme* (EduTech 2000). As an education policy initiative, Barbados' *Education Sector Enhancement Programme* (more popularly known as *EduTech 2000*) perhaps stands as one of the most ambitious and comprehensive plans of its kind exemplified by a Caribbean nation. This US$ 213 million programme -financed by the Government of Barbados (45%), the Inter-American Development Bank (40%) and the Caribbean Development Bank (15%)- is a seven year project (beginning in December 1998) whose primary stated goal is to "effect an increase in the number of students contributing to the sustainable social and economic development of Barbados" (Barbados Ministry of Education, Youth Affairs and Culture, 1998; 1999; Cox, 2002). Of particular interest within the context of this article is one of the specific policy objectives of ensuring that "all children leave school with the basic skills and abilities that are required to participate productively in the skill- and information-intensive job market". As implied in the name, EduTech 2000 emphasises the use and application of information technology throughout the Barbadian education system. Specifically, the training of teachers and education officers in the use of information technology in education is one of the four main areas of focus of this programme (Miller, 2000a, p. 30).

Boyce (1999; 2000a; 2000b) provides a cogent and articulate analysis indicating how the use of technology in education bears particular applicability to science teaching and learning. In a vividly portrayed prognostication into the technologically enhanced Barbadian classroom of the future, Boyce (2000b) envisions scenarios such as the following:

> Technical drawing rooms will say goodbye to the T-square and compass and welcome AUTOCAD and industrial large-format printers. Mechanical engineering students with benefit from autotronics facilities, the greasy overalls will be replaced by lily-white lab coats. Science labs will have computers equipped with probes capable of recording physical and physiological data. Students will be able to plan, design and conduct exciting research and share their finding with peers and experts. Business students will create their own on-line businesses, trade stock and manage people in virtual offices (some of whom they may never see).

Boyce's scenarios are not mere flights of technological fantasy or instances of futuristic euphoria. In recent years, the power and versatility of the computer have been significantly enhanced with the increasing sophistication of multimedia systems and telecommunications capabilities. The amount of software available for use by science students is growing almost exponentially and the Internet/WWW increases its accessibility (see Ebenezer & Lau, 1999). In addition, recent advances in video, audio and photographic technologies have extended the process skills and sensory experiences associated with science learning (Chiappetta & Koballa, 2002, p. 199). For the traditional school science subjects of biology, chemistry and physics, many innovative possibilities for science teaching and learning currently exist with "computer based instructional systems". Microcomputer-based laboratories (MBLs), allow for the juxtaposition of traditional laboratory investigations with the use of the microcomputer, software and appropriate peripherals to gather, display and analyse data. Calculator-based laboratory (CBL) probeware can allow for data collection and analysis outside of the school laboratory in "'everyday" situations. Other computer technology may be used to simulate or otherwise "capture" real time or time lapse investigations of natural phenomena difficult to reproduce for classroom instruction (e.g. bacterial reproduction in biology; rust formation [oxidation] in chemistry; radionuclide decay in physics), which may be archived electronically for future use. Science teaching and learning (both at the school level and the science teacher preparation level) also may benefit from the use of technology in "concept mapping" (Williams, 2002) and associated developments in "knowledge representation" of scientific concepts (see Fisher, Wandersee & Moody, 2000). While comprehensive, publicly released assessments of EduTech 2000 policy implementation and concomitant student learning outcomes still appear to be forthcoming, currently available information (Cox, 2002) suggests that the project is achieving a creditable measure of success. The *Education Evaluation Centre* (EEC) at the University of the West Indies (Cave Hill, Barbados campus) has been contracted by the Barbados Ministry of Education, Youth Affairs and Culture to monitor and evaluate the programme throughout its duration and, to date, has already administered baseline tests and questionnaires in selected demonstration and control schools as part of the evaluation process (Cox, 2002).

Development of Bermuda Science Performance Standards**.** Beginning in 1997, Bermuda, in response to international global developments in education, undertook a sweeping reform of its entire public education system. In a radical overhaul of its primary (elementary) and secondary education system, primary schools were reduced from seven year to six year schools; three year middle schools were created from the final year of primary school and the first two years of the secondary school (analogous to the conversion from "junior high schools" to "middle schools" in the U.S.); a new senior school (high school) was built; and the four year senior school began with a full complement of students. Concerted efforts were made to support these significant changes, including the phasing in of a new set of national curricula for the government (i.e. public) schools. Phase 1 introduced the *Bermuda Middle School Curriculum* (1997), followed by the *Bermuda Senior School Curriculum* (1999) in Phase 2 and the *Bermuda Primary School Curriculum* (2001) in Phase 3. In terms of science teaching and learning, the curriculum documents, mandated for use in the public schools, consist of *Bermuda Science Education Goals, Scope and Sequence* and instructional modules that were designed using national science education standards from the United States, Britain and Canada. At time of writing, the Bermuda Education System is in the final phase of systemic change. In 2001, a draft version of the *Bermuda Science Performance Standards* (BSPS) was released by the Bermuda Ministry of Education and distributed to science educators and other stakeholders for review and critique. The BSPS are intended to provide a framework supporting the year-by-year science curriculum spanning preschool to senior school. The curriculum (content standards) provides details of *what* students should know and be able to do at a particular stage in their academic and social development. The curriculum is aligned with the BSPS to indicate *how* students may effectively demonstrate their mastery and understanding of scientific concepts and skills (Blades, 2002; Bermuda Science Performance Standards, 2001). Although almost all other Caribbean countries have science curricula designed to "fit" their own circumstances and educational priorities, the case of Bermuda deserves special note. The BSPS document is distinctive in that it is the first major national work of its kind developed in the Caribbean which provides specific performance descriptions, sample activities and also examples of student work which clearly delineate desired levels of competence and achievement in science[2]. As such, the BSPS may be regarded as an instrument designed to very specifically assess understanding of a variety of important science concepts and skills.

The BSPS are categorised into five strands, i.e. *physical science* (SC1); *life science* (SC2); *earth and space science* (SC3); *the history and nature of science* (SC4); and *the nature of scientific inquiry* (SC5). Each strand also is subcategorised into "Learning Phases", with each phase corresponding to developmental benchmark/grade levels. For the four phases, Learning Phase A (the first) corresponds to the preschool-Primary 3 grades (kindergarten and lower elementary grades in the U.S.) while Learning Phase D (the last) corresponds to the Senior 1-Senior 4 grades (high school grades 9-12 in the U.S.). Based on classical Piagetian developmental theory, the phases represent approximate cognitive levels for children and the performance standards are communicated as a hierarchy of knowledge as students progress from one phase to the next (Bermuda Science Performance Standards, 2001, p.1). Commendably, while the BSPS and its accompanying science curricula were based on science education standards developed in other countries, explicit mention is made in the Foreword of the *Bermuda Senior School Science Curriculum* (2000) document that the curriculum is "Bermudianised" (p. iii), i.e. tailored to the specific social, cultural and physical contexts within which instruction will occur. In common with Barbados' EduTech 2000 programme, the BSPS also incorporates a strong focus on technology and competence in its use by science students. Currently, a technology infusion initiative (in collaboration with the Curry School of Education at the University of Virginia) is in process including training in the use of peripheral devices (probeware, robotic telescopes, digital microscopes etc.), identification of Internet/WWW resources, introductory web development skills and the use of CD-ROM programmes to enhance instructional modules taught at the Senior 1 and Senior 2 levels (Blades, 2002). Interestingly, even though the technology infusion initiative involves instruction for science teachers in the use of technology, no teacher preparation institutions currently exist in Bermuda. Formal preparation in the use of the technology to enhance science instruction ideally occurs in the teacher preparation programme, and in other countries, is subsumed under pedagogical standards of "what science teachers should know and be able to do" (see the National Research Council's [1996] *National Science Education Standards*, for example). Given Bermuda's recent development of Science Performance Standards for students, perhaps it is now an opportune time to consider the development of an analogous set of Performance Standards for science teachers and the simultaneous development of an effective science teacher preparation programme to ensure the continuance of high quality science teaching and learning in the Bermuda Education System.

Future directions

Issues relating to science, technology and science education will weigh heavily in future education policy directions in the Caribbean. In their *Caribbean Education Strategy Report*, Jules, Miller and Armstrong (2000) discuss a regional developmental objective of "an internationally competitive labor force and more effective and equitable education systems". As a proposed indicator indicating progress toward the realisation of this objective, the authors suggest that by the year 2020, the Caribbean region should be able to demonstrate "*a 30% increase in persons with qualifications in science and technology at the postsecondary level*" (p. xviii; author's italics). As another indicator, they also suggest that "by 2005, a *Virtual Caribbean Institute for Educational Research and Planning* will be in operation" (p. xix). As they point out, the year 2005 is significant since it is at this juncture when the North America Free Trade Area (NAFTA) will take effect in the region, and new trade agreements with the European Union will be phased in. This event will have significant implications for the future economic progress of Caribbean countries, affecting a wide range of regional concerns (all involving some level of scientific and technological literacy) such as agriculture, tourism, textile industries, the use/abuse of available natural resources, communications, and entrepreneurism, to name a few.

Consideration of the *EduTech 2000* and *Science Performance Standards* policy initiatives described above suggests several exciting possibilities for the productive overlap of science education research and policy in the Caribbean. For example, efforts occurring in the teacher education component of Barbados' *Education Sector Enhancement Programme* and Bermuda's *Science Performance Standards* provide the potential for mutually beneficial collaborative work. To speculate further, possible integration of these efforts –perhaps under the aegis of regionally endorsed science standards- might provide the beginnings of the infrastructure which is needed for sustainable growth in science and technology education across the entire Caribbean region.

Science education practice in the Caribbean

Science education practice (i.e. those pedagogical actions which are actually performed in a formal or informal instructional setting by an individual science teacher or teachers, and which may be shown to have demonstrable positive effects on students' learning and understanding of science) is more difficult to document and discuss within the context of this article since many useful examples of science education practice will be at the individual school level across a range of Caribbean countries. For the purposes of this article, examples of science education practice in two Caribbean countries (Jamaica and Bermuda, respectively) will be highlighted. These examples indicate documented, relatively large scale efforts which may serve as useful models for adoption and modification by other Caribbean countries.

Science Matters in Life Everyday (SMILE). Jules, Miller & Armstrong (2000), in discussing their Caribbean Education Strategy up until the year 2020 note that "the region as a whole lags far behind in science and technology and a more concerted effort is needed to bridge that gulf" (p. 27; author's italics). The Science Learning Centre in Jamaica is cited as an example of a "useful Caribbean initiative" which addresses the teaching and learning of science at the early childhood stage of development. In 1990, the Insurance Company of the West Indies Group Foundation (ICWI), in collaboration with the University of the West Indies (Mona campus) established a Science Learning Centre to promote the interactive learning of science. The mission statement of the organisation is "to act as demonstration centre to provide learning opportunities which will impact on the reform of science education at the early childhood and primary school level and in the wider community" (ICWI, 1999; ICWI, 2000a; ICWI, 2000b). As a demonstration resource and through its various community based activities (e.g. science clubs, workshops, school visits, provision of audio-visual aids and publications), it has had an impact on more than

200,000 students and 4,000 teachers (Jules, Miller & Armstrong, 2000, p. 28). The focus on early childhood science education began in 1997, and with the assistance of the Japanese Government Grass Roots Assistance Program and UNICEF, the Science Matters in Life Everyday (SMILE) early childhood programme was initiated in 1998. As indicated in the name of the programme, SMILE focuses on science in everyday life and has been developed for young children 4-6 years of age and their teachers. A range of science concepts and topics are taught by way of interactive activities and include: water; air; colours; shapes, sizes and textures; temperature; states of matter; sounds; grouping, classifying and estimating; and environmental awareness (ICWI, 2000). The programme produces low cost, hands on science activities for pre-school children, trains early childhood educators in the use of interactive materials and methodologies, and disseminates information on appropriate science and early childhood educational teaching and learning materials. The Center has a database of more than 300 indigenous activity materials as well as culturally appropriate international materials, science education videos, activity kits and guides and manuals. It is anticipated that an early introduction to the exciting world of science through low cost materials and training of teachers would stimulate continued interest in both the teaching and learning of science (Jules, Miller & Armstrong, 2000, p. 28).

Bermuda Schools' Science Enrichment Program**.** In collaboration with the Bermuda Ministry of Education, the Bermuda Biological Station for Research (BBSR) has developed the *Bermuda Schools' Science Enrichment Program* (see BBSR, 2002). In accordance with its mission statement (i.e. "*to conduct research and science education of the highest quality from the special perspective of a mid-ocean island and to provide well-equipped facilities and responsive staff support to visiting scientists, faculty and students from around the world*"), the program provide hands-on science experiences for Bermuda's school children and free professional development resources for Bermuda's science teachers. Through an assortment of widely funded initiatives, the Bermuda Schools' Science Enrichment Program encourages young Bermudians in the primary and middle grades to develop an interest in science, and encourages older students (high school and undergraduate levels) to enter the scientific field through experiences in authentic scientific research. The program plays a pivotal role in Bermuda's national science education reform efforts, and emphasises the value of "science in the community". As part of the year round enrichment program, hundreds of students are taken to nature reserves, marine science laboratories and science classrooms at these facilities. One facility sponsors a plankton tow to interested class groups. Many professional scientists donate their time as part of program to visit schools and speak with students. During these experiences, students begin to gain a better appreciation of the "real life" nature of science, how scientists work and recognise that science is indeed a human endeavour (Blades, 2002).

Bermuda is fortunate to have many other local facilities and community resources which are utilised to enhance the teaching and learning of science. At the preschool/primary and middle school levels for example, integrated projects by preschools and primary school students have been shown at the annual Bermuda Agricultural Exhibition and at school sites, and local organisations collaborate with the Bermuda Ministry of Education to support the Bermuda Government School curriculum with guided field trips, classes, teacher workshops, curriculum theme ‘boxes” or packets for loan (Blades, 2002).

Future directions

The programmes described above both demonstrate the philosophy that the teaching and learning of science does not happen only within the four walls of a classroom. As has been well documented by researchers interested in informal science education, the stimulation of children's curiosity and interest in science and technological matters occurs to an appreciable extent in informal (or nonformal) learning environments (see, for example, Druger, 1988; Boyd, 1990; Semper, 1990; Falk & Dierking, 1992; Rennie & McClafferty, 1995). As both programmes indicate, science teaching and learning is best accomplished through concrete, hands-on, "everyday" experiences to which students can relate, and which typically play some role in their daily activities. Both the *Science Matters in Life Everyday* programme in Jamaica and the *Bermuda Schools' Science Enrichment Program* show significant potential for leadership in developing this aspect of science education practice in the Caribbean region. Of particular importance is the attention to well designed science education practice targeted toward the primary or elementary grades. Typically interest (and hence academic achievement) in science declines for a substantial proportion of students during the upper elementary/lower middle school grades (see, for example, Neathery, 1997), and especially so for females. Such efforts will be of primary importance in the foreseeable future to the extent of scientific literacy among the wider Caribbean citizenry.

Discussion and concluding comments

The ongoing development of science education research, policy and practice in the Caribbean will continue to receive a great deal of attention in the years ahead. As the region prepares itself to be even more competitive in the science and technology-oriented world of the 21st century, the quality and extent of science education in each country may well serve as one of the most important indicators of the region's progress as a whole.

As discussed above, published science education research emerging from the region has generated a great deal of information regarding science teaching and learning in a Caribbean context. However, better articulation and integration of science education research needs to be established across the region, with cross-case analyses and comparative studies performed in different Caribbean countries. Central to these endeavours will be the establishment (or re-establishment) of an appropriate vehicle for the dissemination of research findings, i.e. a dedicated publication outlet for the presentation of pedagogical implications, curricular innovations, etc. which are subject to review and critique by other science education researchers both within and external to the region. If the financial expense associated with printing and maintaining a traditional paper journal is prohibitive, perhaps a peer-reviewed electronic journal format ought to be considered (see Sweeney, 2001a; 2000). Also important for the development of science education research in the region will be the forging of closer links with national policy recommendations, which perhaps will require the undertaking of carefully designed experimental or quasi-experimental educational studies for replication and application to formal classroom teaching and learning.

In terms of science education policy in the region, the examples provided above indicate a range of noteworthy initiatives currently being undertaken in the respective countries. The initiatives hold much promise for the individual countries themselves, but more importantly, also hold promise for what may be learned by other countries in the region for possible adoption or adaptation to their own particular educational circumstances.

Universal accessibility to science education (or efforts toward such), coupled with an emphasis on public awareness of and involvement in science education are features of documented, nationally visible science education practice in the Caribbean. More examples like the *Science Learning Centre* and the *SMILE* programme in Jamaica, and Bermuda's *Schools Science Enrichment Program* are needed throughout the region in a concerted attempt to improve the scientific literacy of *all* sectors of the Caribbean population. A focus on informal science education at the early childhood and primary grade levels ought to accomplish much in terms of nurturing the scientific habits of mind and development of the technological skills needed for full adult participation in contributing to the sustainable social and economic development of the Caribbean.

Any discussion of science education research, policy and practice in the Caribbean would be incomplete without attention being given to the supporting mechanisms for the professional preparation of science teachers. High quality, effective science teacher education in the region is a major area of concern. Well prepared science teachers are *essential* to the successful attainment in the region of the much vaunted goals of developing critical thinking skills in students who are lifelong learners, proficient in the use of technology, and who are able to function productively in the "Information Age". In common with other developing countries (and also developed countries), the recruitment, retention, and facilitation of continuous professional growth of science teachers are concerns which must be adequately addressed by Caribbean countries (see Ware, 1992a; 1992b). As noted by Hall & Marrett (1996), Delannoy (2000), Miller (2000b) and Jennings (2001), the incorporation of technology into the formal process of teacher education generally (and science teacher education in particular) is rapidly becoming a central feature of teacher preparation in the region. For the development of science teacher preparation programmes in particular, the advances in distance education technology and use of sophisticated instructional software pioneered by the University of the West Indies may prove to be advantageous in recruiting and preparing much needed science teachers across the Caribbean (see, for example Hall & Marrett, 1996; Delannoy, 2000; Miller, 2000b; 2001; UWI/Commonwealth of Learning, 2001). Several resources may be utilised for enhancing the professional preparation of science teachers in the Caribbean. Since effective science teachers must exemplify mastery of their subject area specialties in addition to a thorough knowledge of learning theories and effective pedagogical practices, university faculty in the sciences (biology, chemistry, physics, etc.) also should play an integral role in the formal process of science teacher preparation, at both the elementary and secondary levels. Ongoing professional development for science teachers (preservice and inservice), and the maintenance of close links with university faculty mentors also may result in science teachers becoming more reflective, deliberate and intentional concerning their professional practice and its connections to student learning outcomes (Sweeney, 2001b; Sweeney & Tobin, 2000; Sweeney, Bula & Cornett, 2001).

The Caribbean is poised to transform the rhetorical advocacy of "scientific literacy for all" into a reality. When this is no longer spoken about in rhetorical terms (and when the initiatives described in this chapter are no longer initiatives, but instead are well established science education research activities, policies and practices across the Caribbean), the region will then be closer to achieving its considerable leadership potential, and well equipped to play its role in shaping the world of the 21st century.

Notes

[1]The most inclusive definition describes the region (both in geographic and cultural terms), as that bounded to the north by Bermuda and the Bahamas; to the west by Belize located on the Central American mainland; to the East by that arch of islands extending to Barbados; and to the South by Guyana and Suriname on the South American mainland and the islands of Aruba, Curaçao and Bonaire (Miller, 2000a, p. 7). The Caribbean Region therefore represents a diversity of cultures, traditions, languages and ethnicities. For the purposes of this chapter, I have largely co-opted Jules & Panneflek's (2000) definition of the Caribbean (as used in their report) to include *Anguilla, Antigua & Barbuda, Aruba, The Bahamas, Barbados, Belize, Bermuda, The British Virgin Islands, The Cayman Islands, Dominica, Grenada, Guyana, Haiti, Jamaica, St. Kitts & Nevis, St. Lucia, Montserrat, The Netherlands Antilles, Trinidad & Tobago* and *The Turks & Caicos Islands*.

[2]I have tried to be comprehensive in my review, discussion and analysis of contemporary science education research, policy and practice in the Caribbean; however, with limited space for discussion, any inadvertent errors of omission or oversight are my sole responsibility.

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References

Alexander, G. & Glasgow, J. (1981). UNICEF regional primary school project: Report on teacher training and curriculum development activities, 1978-1980. *Caribbean Journal of Education, 8*(1), 75-101.

Barbados Ministry of Education, Youth Affairs and Culture. (1998). *EduTech 2000: An education policy framework for Barbados*. Bridgetown, Barbados: Author.

Barbados Ministry of Education, Youth Affairs and Culture. (1999). *EduTech 2000*. Bridgetown, Barbados: Author. Available online: http://www.edutech2000.gov.bb/edutech_2000.htm

Bermuda Biological Station for Research. (2002). *Bermuda Schools' Science Enrichment Program*. Available online: http://www.bbsr.edu/Education/Science_Enrichment/science_enrichment.html

Bermuda Science Performance Standards. (2001). Bermuda Ministry of Education, Hamilton, Bermuda.

Bermuda Senior School Science Curriculum. (2000). Bermuda Ministry of Education, Hamilton, Bermuda.

Blades, K. J. (2002). *Personal communication* (January, 2002). Science Curriculum Officer, Bermuda Ministry of Education, Hamilton, Bermuda.

Boyce, S. L. (1999). *Impact of technology on the teaching-learning process in the Caribbean: Experiences from Barbados and Jamaica*. Paper presented at The Caribbean and Technology-Enhanced Learning conference (sponsored by the Commonwealth of Learning), St. Michael, Barbados, November 24-27, 1999.

Boyce, S. L. (2000a). Impact of technology on the teaching-learning process in the Caribbean: Experiences from Barbados and Jamaica. *Technology in Education Online Journal, 1*(1). Available online: http://www.ccsedu.com/tcent/papers/paper01.htm

Boyce, S. L. (2000b). The classroom of the future: Imperatives for Barbados. *Technology in Education Online Journal, 1*(1). Available online:

http://www.ccsedu.com/tcent/papers/paper02.htm

Boyd, W. L. (1990). Museums as centers of learning. *Teachers College Record*, 94, 761-770.

Brathwaite, W. E. (1978). *In-service strategies for improving teacher abilities in science education*. In Proceedings of the Regional Primary Science Conference, pp. 156-160. University of the West Indies, Cave Hill, Barbados: Caribbean Regional Science Project.

Brathwaite, W. E. (1985). Social relevance in science education: Problems and strategies in a Third World island economy. In G. B. Harrison's (Ed.), *World trends in science and technology education*, pp. 82-87. London, UK: Trent Polytechnic.

Chiappetta, E. L. & Koballa, Jr., T. R. (2002). *Science instruction in the middle and secondary schools* (5th edition). Upper Saddle River, NJ: Prentice-Hall.

Cox, S. (2002). *Brief on the GOB/IDB/CDB Education Sector Enhancement Programme* (personal communication, March 2002). Ministry of Education, Youth Affairs and Culture, Bridgetown, Barbados.

Delannoy, F. (2000). Teacher training or lifelong professional development? Worldwide trends and challenges. *TechKnowLogia*, *2*(6), 10-13. Available online: http://ipdweb.np.edu.sg/lt/feb01/pdf/teck_teachertraining.pdf

Driver, R. & Erickson, G. (1983). Theories-in-action: Some theoretical and empirical issues in the study of students' conceptual frameworks in science. *Studies in Science Education*, *10*, 37-60.

Driver, R., Squires, A., Rushworth, P. & Wood-Robinson, V. (1994). *Making sense of secondary science: Research into children's ideas*. London: Routledge.

Druger, M. (Ed.) (1988). *Science for the fun of it : A guide to informal science education*. Washington, DC: National Science Teachers Association.

Ebenezer, J. V. & Lau, E. (1999). *Science on the Internet: A resource for K-12 teachers*. Upper Saddle River, NJ: Prentice-Hall.

Esiobu, G. O. & Soyibo, K. (1995). Effects of concept and vee mappings under three learning modes on students' cognitive achievement in ecology and genetics. *Journal of Research in Science Teaching*, *32*(9), 971-995.

Falk, J. H. & Dierking, L. D. (1992). *The museum experience*. Washington, DC: Whalesback Books.

Fisher, K. M., Wandersee, J. H. & Moody, D. E. (2000). *Mapping biology knowledge*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Fraser-Abder, P. (1979). The teaching of elementary science. *Journal of Education in Science for Trinidad and Tobago*, *7*, 8-11.

Fraser-Abder, P. (1982). The effect of science teaching on the Trinidadian fifth grade child's concept of Piagetian physical causality. *Caribbean Journal of Education*, *9*, 167-187.

Fraser-Abder,P. (1985a). The status and implications of the cognitive developmental levels of elementary students in Trinidad and Tobago. *Journal of Education in Science for Trinidad and Tobago*, *12*, 1-6.

Fraser-Abder, P. (1985b). The development of primary science education in Trinidad and Tobago. *Caribbean Curriculum*, *1*, 55-67.

Fraser-Abder, P. (1986). Sub-cultural differences in cognitive development among elementary students in Trinidad and Tobago. *Caribbean Journal of Education*, *13*(1-2), 27-41.

Fraser-Abder, P. (1988a). *Summary of science education research in the Caribbean, 1970-1987*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Lake of the Ozarks, MO, April 10-13, 1988.

Fraser-Abder, P. (1988b). *Sourcebook of science education research in the*

Caribbean. Washington, DC: UNESCO.

Fraser-Abder, P. & Douglass, R. (1986). A curriculum journey: Science - A Process Approach for Trinidad and Tobago (SAPATT). In Pamela Fraser-Abder's (Ed.), *Science education research in Latin America and the Caribbean* (conference proceedings), pp. 100-114. St. Augustine, Trinidad: Faculty of Education, University of the West Indies.

Fraser-Abder, P. & Shrigley, R. L. (1980). A status study on the science attitudes of elementary school teachers in Trinidad and Tobago. *Science Education*, *64*, 637-644.

George, J. (1988). The role of native technology in science education in developing countries: A Caribbean perspective. *School Science Review*, *69*(249), 815-820.

George, J. (1995). Health education challenges in a rural context: A case study. *Studies in Science Education*, *25*, 239-262.

George, J. (1999). Worldview analysis of knowledge in a rural village: Implications for science education. *Science Education*, *83*(1), 77-95.

George, J. (2001). *Culture and science education: A look from the developing world*. Accessed online at: http://www.actionbioscience.org/education/george.html

George, J. & Glasgow, J. (1999). *The boundaries between Caribbean beliefs and practices and conventional science: Implications for science education in the Caribbean*. Monograph series No. 10 (Series Editor: Lynda Quamina-Aiyejina), Education for All (EFA) in the Caribbean: Assessment 2000. Kingston, Jamaica: UNESCO.

George, J. & Glasgow, J. (1988). Street science and conventional science in the West Indies. *Studies in Science Education*, *15*, 109-118.

George, J. & Glasgow, J. (1989). Some cultural implications of teaching towards common syllabi in science: A case study from the Caribbean. *School Science Review*, *71*(254), 115-123.

Glasgow, J. (1986). Factors affecting scientific literacy in Jamaican grade nine students. In Pamela Fraser-Abder's (Ed.), *Science education research in Latin America and the Caribbean* (conference proceedings), pp. 234-252. St. Augustine, Trinidad: Faculty of Education, University of the West Indies.

Glasgow, J. & Robinson, P. (1983). *Environmental education: Modules for pre-service training of teachers and supervisors for primary schools*. Paris, France: UNESCO.

Glasgow, J. (1987). Science syllabi with environmental emphasis in the Caribbean. *Caribbean Curriculum*, *2(1)*, 1-15.

Glasgow, J. (1989). Environmental education: Global concern, Caribbean focus. *Caribbean Journal of Education*, *16*, 1 & 2, 1-12.

Glasgow, J. (1993). Teachers and environmental education: A Caribbean approach. In Walter Leal Filho's (Ed.), *Environmental Education in the Commonwealth*, pp. 64-94. Vancouver, Canada: Commonwealth of Learning.

Grant, E. S., France, R. B. & Hsu, S. (2000). Towards an Internet-based education model for Caribbean countries. *Journal of Educational Media*, *25*(1), 21-30. Available online (earlier version): http://www.col.org/tel99/acrobat/grant.pdf

Hall, W. M. & Marrett, C. (1996). Quality teacher education via distance mode: A Caribbean experience. *Journal of Education for Teaching*, *22*(1), 85-94.

Insurance Companies of the West Indies Group Foundation. (1999). *Science Matters in Life Everyday: A guide for teachers, parents and caregivers* (Volume I, April 1999). Kingston, Jamaica: Insurance Companies of the West Indies Group Foundation Science Learning Centre.

Insurance Companies of the West Indies Group Foundation. (2000a). *Science Matters in Life Everyday: A guide for teachers, parents and caregivers* (Volume II, March 2000). Kingston, Jamaica: Insurance Companies of the West Indies Group Foundation Science Learning

Centre.

Insurance Companies of the West Indies Group Foundation. (2000b). *Programmes: Early childhood hands-on science*, "Science Matters in Life Everyday" (SMILE). Available online: http://www.jsdnp.org.jm/icwi_slc/progr.htm

Isaacs, P. A. (1980). Piaget's theory and the Caribbean. *Caribbean Journal of Education*, *7*(2), 110-130.

Jennings, Z. (2001). Teacher education in selected countries in the Commonwealth Caribbean: The ideal of policy versus the reality of practice. *Comparative Education*, *37*(1), 107-134.

Jules, D., Miller, E. & Armstrong, L. A. (2000). *Caribbean Education Strategy Report*. St. Lucia: The World Bank.

Jules, V. & Panneflek, A. (2000). *Education For All in the Caribbean: Assessment 2000* (Subregional synthesis report, Volume I, Summary). Kingston, Jamaica: UNESCO. Available online: http://www.unesco.org/ext/field/carneid/synthesis-1.pdf

King, W. K. (1978a). *The interpretation of Piagetian developmental psychology in terms of primary science: The need for research*. In Proceedings of the Regional Primary Science Conference, pp. 84-94. University of the West Indies, Cave Hill, Barbados: Caribbean Regional Science Project.

King, W. K. (1978b). The development of an integrated science programme for the Caribbean. *Bulletin of Eastern Caribbean Affairs*, *4* (March/April), 1-14; (May/June), 23-30.

King, W. K. (1978c). Why teach integrated science? *West Indian Science and Technology*, *3*, 15-17.

King, W. K. (1979). Science and society: Implications for science education. *Caribbean Journal of Science Education*, *1*, 4-7.

King, W. K. (1982). Caribbean science education: A decade in review. *Hong Kong Science Teachers Journal*, *10*(2), 166-177.

King, W. K. (1987). Social and cultural responsibilities of science in the school curriculum: Objectives and teaching methods. *Caribbean Curriculum*, *2*(1), 16-33.

King, W. K. & Brathwaite, W. E. (1991). School-based assessment in science: A Caribbean perspective. *School Science Review*, *72*(261), 127-31.

Lancaster, C. & King, W. (Eds.). (1977). *Science education for progress: A Caribbean perspective*. London, UK: International Council of Associations for Science Education.

Lambert, E. N. (1974). New directions in science education in the 70s. *Journal of Education in Science for Trinidad and Tobago*, *2*, 26-38.

Lewin. K. M. (2000a). *Mapping science education policy in developing countries*. Washington, DC: World Bank. Available online: http://www1.worldbank.org/education/scied/documents/Lewin-Mapping.pdf

Lewin, K. M. (2000b). *Linking science education to labour markets: Issues and strategies*. Washington, DC: World Bank. Available online: http://www1.worldbank.org/education/scied/documents/Lewin-Labor.pdf

Mark, P. (1978). Science education and development in the Caribbean: Desired directions. *West Indian Science and Technology*, *3*, 11-13.

Miller, E. (2000a). *Education For All in the Caribbean in the 1990s: Retrospect and prospect*. Kingston, Jamaica: UNESCO. Available online: http://www.unesco.org/ext/field/carneid/monograph.pdf

Miller, E. (2000b). *Models in distance teaching in teacher education in Jamaica*. Paper presented at the Distance Education in Small States international conference hosted by the University of the West Indies Distance Education Centre (UWIDEC), Ocho Rios, Jamaica, 27–28 July 2000. Available online: http://www.col.org/resources/publications/SmallStates00/

Miller, E. (2001). A Western Caribbean profile: Innovating with ICT on a shoe-string. *TechKnowLogia*, *3*(2), 70-74.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

Neathery, M. F. (1997). Elementary and secondary students' perceptions toward science: Correlations with gender, ethnicity, ability, grade, and science achievement. *Electronic Journal of Science Education*, *2*(1). Available online: http://unr.edu/homepage/jcannon/ejse/neathery.html

Osin, L. (1998). *Computers in education in developing countries: Why and how?* Education and Technology Series, Vol. 3, No. 1. Washington, DC: World Bank.

Prout, A. (1985). Science, health and everyday knowledge: A case study of the common cold. *European Journal of Science Education*, *4*(7), 399-406.

Rennie, L. J. & McClafferty, T. (1995). Using visits to interactive science and technology centers, museums, aquaria and zoos to promote learning in science. *Journal of Science Teacher Education*, 6 (4), 175-185.

Richardson, V. (1996). The case for formal research and practical inquiry in teacher education. In Frank B. Murray's (Ed.), *The teacher educator's handbook: Building a knowledge base for the preparation of teachers* (pp. 715-737). San Francisco, CA: Jossey-Bass Publishers.

Semper, R. J. (1990, November). Science museums as environments for learning. *Physics Today*, 2-8.

Soyibo, K. (1999). Gender differences in Caribbean students' performance on a test of errors in biological labelling. *Research in Science and Technological Education*, *17*(1), 75-82

Soyibo, K. (1995). Using concept maps to analyze textbook presentations of respiration. *American Biology Teacher*, *57*(6), 344-351.

Soyibo, K. & Figueroa, M. (1998). ROSE and NonROSE students' perceptions of five psychosocial dimensions of their science practical activities. *Research in Science Education*, *28*(3), 377-385.

Soyibo, K. & Hudson, A. (2000). Effects of computer-assisted instruction (CAI) on 11th graders' attitudes to biology and CAI and understanding of reproduction in plants and animals. *Research in Science and Technological Education*, *18*(2), 191-199.

Sweeney, A. E. (2000). Tenure and promotion: Should you publish in electronic journals? *Journal of Electronic Publishing*. Available online: http://www.press.umich.edu/jep/06-02/sweeney.html

Sweeney, A. E. (2001a). E-scholarship and educational publishing in the 21st century: Implications for the academic community. *Educational Media International*, *38*(1), 25-38.

Sweeney, A. E. (2001b). Incorporating multicultural and Science-Technology-Society issues into science teacher education courses: Successes, challenges and possibilities. *Journal of Science Teacher Education*, *12*(1), 1-28.

Sweeney, A. E., Bula, O. A. & Cornett, J. W. (2001). The role of personal practice theories in the professional development of a beginning high school chemistry teacher. *Journal of Research in Science Teaching*, *38*(4), 408-441.

Sweeney, A. E & Tobin, K. G. (Eds.). (2000). *Language, discourse and learning in science: Improving professional practice through action research*. Tallahassee, FL: Eisenhower Consortium for Mathematics and Science Education at SERVE.

University of the West Indies/The Commonwealth of Learning. (2001). *Distance education in small states*. International conference hosted by the University of the West Indies Distance Education Centre (UWIDEC), Ocho Rios, Jamaica, 27–28 July 2000. Available online: http://www.col.org/resources/publications/SmallStates00/

Ware, S. (1992a). *The education of secondary science teachers in developing countries*. Washington, DC: World Bank.

Ware, S. (1992b). *Secondary school science in developing countries: Status and issues*. Washington, DC: World Bank.

Williams, M. A. (1997a). Integrating concept mapping into science curriculum and instructional practice: Teacher experiences, observations, and recommendations for future projects. *Journal of Interactive Learning Research*, *8*(3/4), 457-485.

Williams, M. A. (1997b). *A formative evaluation of self-instructional modules comprising information on methodology and procedural specifications for the Jamaican Reform Of Secondary Education (ROSE) science curriculum*. Unpublished Master's thesis at the Faculty of Educational Science and Technology, University of Twente, Enschede, The Netherlands.

Williams, M. A. (2002). *Science education research and practice in Jamaica*. Personal communication (February, 2002), Faculty of Educational Science and Technology, University of Twente, Enschede, The Netherlands.