Science Education for Sustainable Development – The impact of UNESCO's Global Microscience Experiments Project in the Caribbean

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1. UNESCO's Global microscience Experiments Project

The Global Microscience Programme was launched by UNESCO, the United Nations Educational, Scientific and Cultural Organization and IUPAC, the International Union of Pure and Applied Chemistry in 1996. The Research and Development in Mathematics, Science and Technology Education (RADMASTE) Centre, Witwatersrand University, South Africa developed the methodology, and the kits were produced by Somerset Educational Ltd. The microscience approach was introduced to over 80 countries, many of them in Africa. Each microscience kit is a portable science laboratory in a box[1]. Refer to Figure 1. Microscience kits are available for biology, chemistry physics and primary science. These kits are supported with chemical kits along with teacher and student worksheets – a complete package.

UNESCO sees its microscience experiments project as one of the most direct methods of enabling schools and students scientifically. The project objectives are:

- Promote practical science experimentation using microscience as an advocacy tool among policy makers
- To improve the science curricula by inclusion of hands-on experimentation for better understanding of science using these kits
- To increase the interest in young people in science so as to promote gender equality, scientific literacy and the choice of a scientific career.
- To promote capacity building for science education and enhance development of scientific thinking and experimentation for students.

A study done by the University of Port Harcourt, Nigeria which involved forty (40) senior secondary level students looked at enhanced performance in physics practicals through the microscience experience. This study found that students who used the microscience kits performed better than those that used the conventional laboratory apparatus[2]. Ohunene and Ebele (2014) agrees that 'hands-on' activities must be encouraged as it makes the learning of science more real and practical to the student, encouraging critical thinking and exploration[3]. Engaging students in content and practice fosters the development of science process skills such as observing, communicating, experimenting, predicting, exploring etc.

2. Why Microscience?

[1] AJCE, 2012, 2(1), Special Issue "Small is Beautiful" UNESCO's quarterly journal A World of Science, vol. 9, no. 3, July 2011
[2] Awotua-Efebo et al, "Towards an Enhanced Performance in Physics Practicals: The Microscience Kits Experience. International Journal of Education and Research, Vol. 3 No. 4, April 2015
[3] Ohunene and Ebele."Science Education and Sustainable Development in Nigeria". American Journal of Educational Research 2.8 (2014): 595-599

Microscience has several benefits. The kits are more convenient to store, easy to use and experiments are completed much faster. Microscience kits are easy to manage and transport. They can be used outside of a science laboratory since microscale experiments are much safer, generate a lot less waste and they are portable. They have less impact on the environment with less waste being generated, a lower energy and water dependence. Students can now carry their laboratories with them for outdoor learning activities. The ability to conduct experiments in a shorter time, allows for a wider variety of experiments, therefore, allowing students more opportunities to develop science process skills. Additionally, microscience is ideal for schools with limited science laboratory facilities. Engagement in more hands-on science experiments can therefore elevate students' interest in science and scientific careers. The affordability of microscience allows students to work independently with their own kits. In science laboratories where equipment and materials are limited students are forced to work in groups or take turns in doing experiments.

These features make microscience an excellent tool for Education for Sustainable Development (ESD). It fits well within the context of Sustainable Development Goal 4 to ensure inclusive and equitable quality education and promote lifelong learning. This paper outlines how microscience has increased access and improved the quality of science education in the Caribbean and was repackaged to reorient science education for sustainable development. Several successful partnerships were forged with the private sector, international NGOs, government agencies, science academies and universities.

Figure 1 - Microscience kit

Science Education - the Caribbean Context

In Caribbean countries, science is taught to all students at the primary and lower secondary levels (ages 5-14 years) as part of their formal schooling. At the upper secondary school (grades 10-12) students branch off into different streams, one of which is the pure science stream. Biology, Chemistry, and Physics are taught in the pure science stream. Less than seven percent (7%) (3000-5000 out of 70,000) of students in the Caribbean study the pure sciences at the Caribbean Secondary Education Certificate (CSEC) level[4]. This has triggered low enrolment of students in STEM fields at the tertiary level resulting in a regional deficit of human resources in science, technology, and innovation (STI). The level of interest in the sciences at the secondary level is rooted in what happens at the primary and early childhood levels. The reasons why young people do not develop an interest in science are complex; however, there is firm evidence that indicates a connection between attitudes of science and the way science is taught.[5] Dry facts presented to students for memorising and regurgitation in examinations through the traditional teacher-centered approach has been the main method of teaching in schools.

Science laboratories are poorly resourced due to the limited availability and high cost of science equipment. Remote communities have limited access to basic utilities such as water and electricity preventing some schools from having science laboratories. Little exposure to hands-on learning impedes the development of basic scientific literacy. Students struggle to connect theory with practice, and only perceive science as a set of facts, rarely experiencing science as a method for generating new knowledge.

3. Guyana's Microscience Model

UNESCO introduced its microscience experiments project in Guyana in 2011, fifteen years after its launch. In 2011 only ten percent (10 %) of students enrolled in biology at the CSEC level, eight percent (8%) in chemistry and five percent (5%) in physics. This pilot project was launched to address the major challenge of the emphasis on theoretical science and limited use of experiments. A one-day microscience workshop held on June 29, 2011, organised and funded by UNESCO, initiated this pilot in fifteen secondary schools. This project was coordinated by the Science Unit within the National Centre for Educational Resource Development (NCERD), Guyana.

A microscience steering committee, led by UNESCO's Regional Coordinator and Facilitator for microscience implemented this project. This steering committee included members from the local educational community (the University of Guyana and the Cyril Potter Teachers Training College), NGOs (Conservation International – Guyana), and the Ministry of Education. UNESCO provided biology, chemistry, and physics microscience kits for fifteen pilot secondary schools selected from across the eleven educational districts of Guyana. Teacher and student microscience manuals for biology, chemistry and physics linked to the CSEC syllabi were created from the available list of worksheets.[6] School-based training was conducted in the pilot schools.

3.1 Microscience within the Inquiry Based Science Education (IBSE) Framework

In the Americas, the Inter-American Network of Academies of Science (IANAS) joined several Academies of Science to actively generate Inquiry Based Science Education (IBSE) projects. The Caribbean Academy of Sciences (CAS) promoted IBSE for selected Caribbean countries.

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[4] Tewarie, B. "*Sustainable Development: Thinking it through making it happen*." (Hansib Publishing (Caribbean), Limited,2015), 35

[5] UK Expert Group. "*Science Education Now: A Renewed Pedagogy for the Future of Europe"* *http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf*

[6] Ministry of Education. "*Microscience Manuals*"https://education.gov.gy/web2/index.php/students-resources/secondary-school-resources/microscience-manuals

CAS hosted an IBSE workshop in Guyana in 2008 which initiated an IBSE pilot for ten primary schools. IBSE is promoted in Europe through the Pollen Project. It is grounded in the belief that it is important to ensure that students truly understand what they are learning, not simply memorize content and information' (Pollen, 2009).[7] It uses the scientific method as a teaching methodology to teach science content. This approach is seen as learning about science through science.

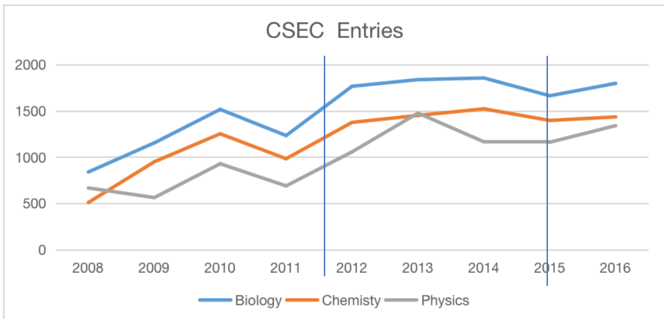
The microscience training workshops used IBSE as the framework for science lessons. Teachers were encouraged to use the microscience kits to generate IBSE lessons for interactive learning. It was timely to merge microscience with IBSE for the selected fifteen pilot schools.

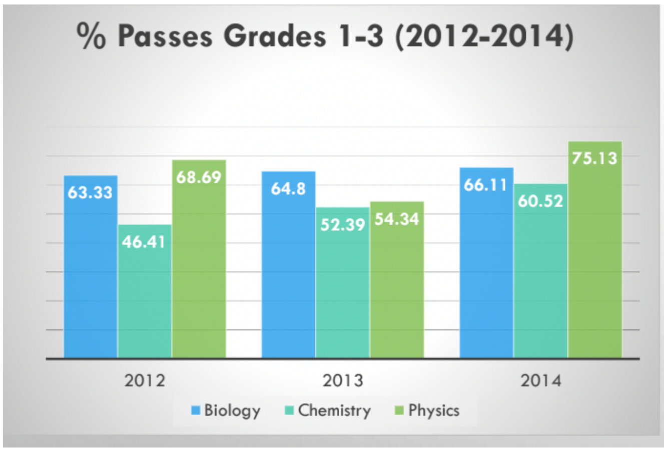
3.2 Immediate Impact - Increased Student Entries and Examination Performance

Among the selected pilot schools were those without science laboratories that could not enroll students for CSEC biology, chemistry and physics. The School Based Assessment (SBA) component of these subjects account for 20 % of the subject grade and require that students conduct experiments and submit laboratory reports. With the provision of the microscience kits these schools immediately enrolled students for the CSEC sciences.

This successful pilot led to the expansion of the microscience project during the period to ninety (90) additional schools from 2012-2014. Funding was jointly provided by UNESCO and the Ministry of Education for the provision of kits with supporting training for the expansion. During this expansion phase, student entries at the CSEC level in biology, chemistry and physics increased by 5.1%, 10.6% and 10.3% respectively. The performance of students in the CSEC examinations between 2012 to 2014 in biology, chemistry and physics increased by 4.39 %, 30.40 % and 9.38% respectively. Table 1 shows student enrollment from 2008 to 2016. This trend confirms what Awotua-Efebo and colleagues reported. Refer to Figures 2.

[7] Jasmin D., *"Pollen Spreads Inquiry-Based Science Education throughout Europe",* *https://webstorage.cienciaviva.pt/public/pt.cienciaviva.io/recursos/files/media23255_21057009415c0f.pdf*





Figures 2 – Increased entries (above) and improved student performance (below)

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
Biology	839	1153	1514	1232	1763	1835	1853	1661	1795
Chemistry	510	949	1251	982	1374	1449	1520	1395	1433
Physics	667	563	928	689	1056	1474	1165	1160	1339

Table 1: CSEC Student Entries - 2008-2016[8]

An analysis of the Ministry of Education's Strategic Plan for the period 2008-2013 showed that CSEC enrolment in the sciences more than doubled. The percentage increases in biology, chemistry and physics were 2.12%, 2.17% and 2.21%.

4. Reorienting Science Education for Sustainable Development

To build societies that are informed about how the world functions in all its dimensions and how these dimensions interrelate will require all citizens to possess basic scientific literacy. Scientific literacy enables students not only to understand the natural world, but also provides them with the tools to understand the impact of human activity and, engage and adapt to the changes they will face in their lifetimes.[9] Science education is critical for promoting sustainable development and improving the capacity of the people to address their

[8] Examinations Division, Guyana, "*CSEC Data Analysis Report*", (Ministry of Education)
[9] UNESCO,*"Current Challenges in Basic Science Education"*, http://unesdoc.unesco.org/images/0019/001914/191425e.pdf

environment and development issues. UNESCO also shares the idea that students need to learn about science through science for science.

'The purpose of science in the context of sustainability is to understand and clarify the dynamics of what is required to prevent 'the human system' – individual and collective, physical, social, economic, cultural and psychological – from destroying the environment on which it depends.[10] The human – nature relationship is important for sustainability. To foster a strong human-nature relationship, students need to develop basic scientific literacy at an early age.

The opportunity to present microscience as a tool for Education for Sustainable Development (ESD) emerged in 2015 through the development of Guyana's ESD policy. The potential use of microscience kits in Climate Change Education for Sustainable Development (CCESD) and the UNESCO Sandwatch programme was recognized through the policy development process. The Sandwatch programme was implemented as a flagship programme for CCESD. Sandwatch is an example of Education for Sustainable Development in action and is used to monitor beach and coastal environments. It mirrors the scientific method through its approach - Monitoring, Analysing, Sharing and Taking Action (MAST).[11] It is an excellent example of the use of nature as a science laboratory, and a model of IBSE. The integration of microscience, Sandwatch and CCESD was infused in the design of workshops and presented as a model for reorienting science education for sustainable development. Additionally, the use of smaller amounts of chemicals, lower dependence on water and energy, reduced waste generation and the affordable cost of the microscience materials (kits and manuals) for the provision of a good quality of science education presented within the IBSE framework connected content within the relevant context of sustainable development. Microscience therefore lowers the carbon footprint of science education - transforming "education as sustainable development".

Connecting science content within the development-relevance context links microscience to the UNESCO Education for Sustainable Development pillars of learning - learning to know, learning to do, learning to be, learning to transform oneself and one's society and learning to live together. Figure 3 shows a model lesson on water. What it is made of (electrolysis of water), how it is cycled and how this natural cycle is affected by climate change.

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[10] Maiteny and Parker, "*Module 5 Study Guide – Science and Culture in Education for Sustainability"*(London South Bank University Faculty of Arts and Human Sciences),15

[11]UNESCO, "*Sandwatch"* https://www.unesco.org/en/sids/sandwatch

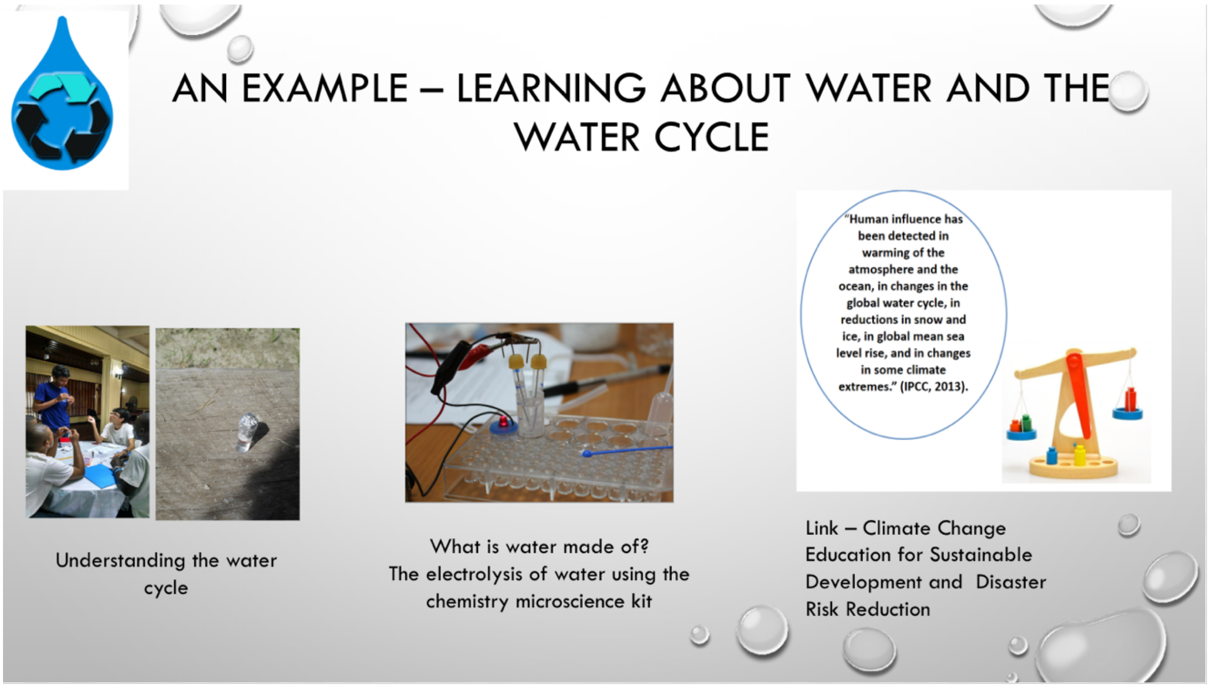

Figure 3 - Understanding water[12]

5. Regional Expansion

Guyana's microscience pilot and expansion was two-fold. Through this expansion, capacity building for science teachers increased and the microscience package (kits, chemicals and manuals) were provided for all participating schools. The immediate impacts were seen through increased access to science education and better student performances at the CSEC examination. Motivated by this achievement, UNESCO designed and funded a sub-regional project to share Guyana's implementation model with other Caribbean countries. This project commenced in 2015 immediately following Guyana's expansion phase. The capacity building component of the project included the hosting of one regional workshop and three workshops for Belize, St. Lucia and St. Kitts and Nevis were implemented. A total of 127 science educators were trained. Microscience kits were provided by UNESCO for each pilot country[13]. The use of the microscience kits during the three-day regional workshop merged with the Inquiry Science Education Learning (IBSE) and linked with the CXC requirements for School Based Assessments (SBA) was especially useful for the other participating countries to see the relevance of the adaptation of this programme for their respective countries. The design of the workshops to have participants identify the challenges facing science education in their respective countries and schools.

UNESCO provided additional support for the following five countries through its participation project to pilot microsience - Belize[14], Jamaica, St. Lucia, St. Kitts and Nevis and Trinidad. Capacity development was done using Guyana's model - an ESD model reorienting science education for sustainable development.

6. Partnerships

[12] *Microscience Workshop Lesson*, 2018
[13] Guyana to Lead UNESCO Sub-regional Science Project, *Kaieteur News*, January 28, 2015, https://www.kaieteurnewsonline.com/2015/01/28/guyana-to-lead-unesco-sub-regional-science-project/

[14] Science in a Kit, *Amandala*, October 2, 2015, http://amandala.com.bz/news/science-kit/

Several successful partnerships were forged with the introduction and expansion of microscience in the Caribbean.

- **Science Academies**
  The Caribbean Science Foundation and the Caribbean Academy of Sciences secured funding to build capacity through primary STEM teacher workshops and provided microscience kits as part of the STEM workshops for Antigua, Barbados, Dominica, Jamaica, St. Vincent and the Grenadines and St. Kitts and Nevis.[15]

- **Private Sector**
  Sagicor Life Inc. presented microscience prize packages to Caribbean schools that participated in its Sagicor Visionaries STEM competitions. Digicel Foundation Jamaica built science laboratories and provided microscience kits and training for selected schools and teachers training colleges.

- **Peace Corps Guyana**
  Peace Corps response volunteers were trained as master trainers and provided school-based training and on-site implementation for primary and secondary schools located in remote communities in Guyana. Microscience kits are used in after school wildlife club activities and outdoor environmental activities.

7. Microscience – Present Context

Microscience has the flexibility to allow interactive science learning from anywhere and can work for remote, hybrid or face to face learning. The COVID -19 pandemic led to emerging educational approaches and microscience fits well in situations where students cannot access schools or science laboratories. The importance of the basic sciences is highlighted this year – designated as the International Year of the Basic Sciences for Sustainable Development – IYBSSD2022.

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