

# ICT-based teaching and learning in Ghana: OpenSTEM Africa

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## Abstract

Reimagining learning spaces involves an increased focus on the opportunities and challenges implicit in ICT-based teaching and learning. OpenSTEM Africa: Ghana, is a collaboration between The Open University (OU) UK, Ghana's Centre for National, Distance and Open Learning (CENDLOS) and the Ghana Education Service (GES), in an initiative guided by the Ministry of Education (MoE) to help improve teaching and learning in the sciences and, given a near doubling of the SHS student population since 2017, to address the pressure on laboratories and science equipment in many Senior High Schools (SHS). The partnership has worked on co-creating PC-based onscreen science applications to develop skills in practical science; on co-designing continuous professional development materials for science teaching and learning, and on co-developing a leadership programme for heads of science to create ICT-focused communities of practice. Covid 19 has presented significant challenges to progress, as schools in Ghana closed in March 2020, only starting to re-open January-March 2021. We planned further face to face co-design and review for our first materials, planned to be loaded onto the 'iBox', a CENDLOS-designed local server intranet in each of 148 low-resourced upper secondary schools.

Arguably the landscape is changing. During school closure the Government of Ghana launched an internet version of the iCampusgh platform used on the iBox, and while this could negatively affect disadvantaged, rural or more remote contexts, it opens up the possibility to engage a higher proportion of Senior High School science teachers and students via laptop, tablet and/or mobile phone as well as PC. It opens up engagement via connectivity outside as well as inside the classroom - via the online teaching and learning formats developed by MoE and schools during school closure, in informal leadership groups, with coaches or mentors, in student study groups, with friends and independently. Implementation is delayed, but the OU and Ghana academics and learning designers have continued to produce and review materials via an OU 'sandbox' website and video conferencing. This paper examines the co-creation and co-designing of the OpenSTEM Africa resources and the extent to which remote working has enhanced new ways of collaboration.

## Introduction

Africa is the one region in the world where the population is estimated to double by 2050 and to quadruple by 2100 (<https://population.un.org/wpp/>) and today over 50% of the population of sub-Saharan Africa is under 20 years of age. With a young and ever-growing population there will be increasing pressure on the 'bricks and mortar' buildings of schools, colleges and universities, including those needed for teacher education (Dladla and Moon 2000). And there will be greater pressure at secondary and tertiary level as expectations grow, via the Sustainable Development Goals, of young people staying on in education.

Across Africa, via the African Union 2063 agenda there is a drive to provide "well educated citizens and a skills revolution underpinned by science, technology and innovation" (<https://au.int/agenda2063/goals>). However, pressure on that agenda is already visible, due to the complex infrastructure needed for the sciences, with current shortages of qualified science teachers and too little provision of laboratories, equipment, chemicals and reagents.

Covid19 has highlighted the difficulties for many across Africa of the accessibility and affordability of computer hardware, software and internet access. Any ICT-based solution needs to meet the detailed needs of enough of its potential users including those in rural areas (Kalisa and Picard 2019). But Africa has already shown the way in sidestepping cumbersome fixed-line phone technology and is beginning to augment its use of PC technology by embracing, at least for professional and social situations the myriad opportunities offered by

tablets and mobile phones - for example with its use of phone-based micro-finance for mobile banking and bill payments (Asongu 2018). Mobile phone usage is expanding in Africa with an estimated 475 million internet users by 2025 <https://www.gsma.com/mobileeconomy/sub-saharan-africa/> and it is clear that the population of Africa is embracing this particular form of technology. While education, at least at school level, remains relatively wedded to the use of PCs, for example with policymakers, educators and parents generally challenging the use of mobile phones in schools for fear they are used solely for social purposes, [Permit SHS students to use Mobile Phones in School \(ghanaeducation.org\)](#), evidence suggests that their use could improve learning outcomes (e.g. Aggor et al 2020, Barfi et al 2021). At tertiary level there seems to be a slightly more relaxed view, for example with students independently accessing materials from the internet, and the use of WhatsApp for submitting tertiary assignments. (e.g. Abiodun et al 2020)

Universal primary education, and since 2015, the focus SDGs on lower secondary education reflects that fact that more children are transitioning to secondary education (World Bank 2018) and accessing science education. The SDG objectives to achieve gender equality and a quality education for all also frame the need, matched in government policies across Africa, to improve opportunities for all young people, especially girls, to study science subjects and take up STI-related careers. Nevertheless, in Ghana there remain concerns at policy level that nationally across Senior High schools (SHS), there is much lower enrolment (11.7% in 2016-17) in elective science subjects than in other specialist options and that fewer students enrol in science subjects at tertiary level (Ministry of Education (MoE) 2018). In Ghana, only 33% of students in tertiary education in 2016 were studying science subjects, well short of the Government of Ghana's 60% target (MoE 2018). With increasing secondary-level student numbers in Ghana, particularly since education at SHS was made free in 2017 and a double-track system introduced in 2018 to cope with the increased numbers, teaching is under-resourced, with shortages of qualified science and maths teachers. Moreover the pressures on school infrastructure have increased, in particular on the already low level of access to science laboratories. There are needs for improvement at Senior High School level articulated in the new MoE *Ghana Education Strategic Plan 2018-30*, including the need to improve the quality of teaching and learning materials for example by improving the student text book ratio from its current national aggregate of 0.5; the need to address the "inadequacy of computers and inadequate integration of ICT in teaching and learning at SHS" (MoE 2018 p.36); the need to improve the quality of teaching, and to improve learning outcomes in STEM subjects, especially for girls. There are still significant barriers in Ghana to women and girls' full participation in science subjects, such as socio-cultural attitudes, lack of female role models, and unsupportive educational environments (Ministry of Gender, Children and Social Protection 2015). Global evidence also suggests that lack of practical scientific equipment in schools and few opportunities for 'hands on' work can negatively impact on girls' achievement in science (UNESCO, 2017). In Ghana there is recognition by government that there is a lack of access to practical activities in the sciences, with an urgent need for well-equipped modern science laboratories (MoE 2018).

### **CENDLOS, Ghana**

CENDLOS is a Government of Ghana Ministry of Education agency, constituted in 2012 with support from the Commonwealth of Learning to develop alternative approaches to pre-tertiary education in order to increase access to learning and to make learning more relevant for young people. It champions alternative approaches, and in particular technology-based learning. Since 2016, it has been introducing technology-based approaches to SHS teaching and learning through a Ghanaian-developed via a platform known as iCampusgh which is now both web-based and available via a local server called the iBox. The iBox is part of a wide-ranging Government of Ghana Secondary Education Improvement Project (SEIP) to

support what the government describes as 'low-performing' schools in 'underserved districts'. So far iBoxes have been installed in 148 SHS in districts in Ghana and since the pandemic closed SHS in March 2020, a web-based version of iCampusgh has been available nationwide.

## **GES**

Ghana Education Service is the operational arm of the Ministry of Education in Ghana and is responsible for implementing the government policies relevant to all school-age children. It provides oversight of Basic Education, Senior High Education, Technical Education and Special Education, working directly with schools via separate Divisions to improve the quality of education, GES provide teachers and organises CPD for schools via regional and district offices and the work of circuit supervisors.

## **The Open University UK**

The Open University (OU) UK is a distance learning tertiary level institution which during its 50 years of existence has developed technology-based learning in its remit to meet the needs of its students. Across those 50 years it has pioneered distance learning in tertiary-level science subjects in ways which were previously not thought to be possible, e.g. by supplying home-based students with boxes of practical science equipment to carry out their own experiments; by pioneering the use of DVD demonstrations of laboratory experiments, and more recently by developing interactive onscreen science applications for students through its OpenScience Laboratory (OSL) <https://learn5.open.ac.uk/course/view.php?id=2> The OSL allows access to interactive practical science activities to students anywhere in the world at any time that the internet is available, and OSL features investigations based on on-screen instruments, immersive laboratory experiences, manipulation of objects in 3D space, remote access experiments and virtual scenarios using real data.

The OU has also long-standing expertise in approaches to school-level education through the qualifications in education it offers both at undergraduate and postgraduate level aimed at all those working with school-age children and young people. Further, it has a long history of working in teacher education, including its own distance learning PGCE and Masters in Education qualifications. These are augmented by collaboration with teacher education institutions and the co-creation of digital and print-based open-access materials across Africa and Asia, through programmes such as the Teacher Education in sub-Saharan Africa programme (TESSA) <http://www.tessafrica.net> and its sister programme TESS-India [www.tess-india.edu.in](http://www.tess-india.edu.in) as well as its work in developing the use of technology in learning in programmes such as English in Action (EIA) in Bangladesh <http://www.eiabd.com/>

## **OpenSTEM Africa**

OpenSTEM Africa: Ghana is a collaborative partnership between The Centre for National Distance Learning and Open Schooling (CENDLOS), Ghana Education Service (GES), and the Open University UK, (OU UK) under the guidance of the Ministry of Education. It is a collaboration which it is hoped can be reproduced with other collaborations in countries across Africa to address the constraints facing science education. OpenSTEM Africa is conceptualised as a framework for improving science education in Africa, with the aim of supporting the next generation of African scientists, especially women and girls. At the heart of this framework is the co-development of locally appropriate and gender-sensitive teaching and learning materials, framed within a school leadership programme targeted particularly at middle-leaders, that will both lead and support practitioner-led and sustainable improved

science education.

- At upper secondary level it is designed to address the lack of practical science activities via access to an OpenSTEM Africa Virtual Laboratory - OpenSTEM Africa (OSA) applications through which teachers and students can work with curriculum relevant onscreen science experiments interactively and using real experimental data.
- It is designed to develop Open Education Resources (OERs) to support teachers with the appropriate pedagogy to improve the quality of the sciences - particularly of biology, chemistry and physics, including developing their skills in teaching practical science, using the onscreen experiments in their lessons.
- It is designed to address constraints in teachers' knowledge of both the subject and the appropriate pedagogy by co-developing and embedding locally appropriate and freely available in-service professional development Open Educational Resources (OERs). This includes developing teachers' knowledge, skills and confidence to lead on technology-based learning.
- It is particularly designed to support school subject leaders such as heads of science to lead the long-term development of their departmental staff, in order to identify, respond and (with headteacher and wider support) embed improved science education in schools.

The Open University was awarded four years philanthropic funding to pilot OpenSTEM Africa in Ghana, working with CENDLOS and GES. The overall objective, particularly in light of the current pandemic, is to scale-up the programme to reach a national level. That is not to minimise the setbacks to the project as a result of Covid19. Co-production of materials has been delayed by the pressures of the pandemic both within Ghana and in the UK, and by the difficulties of remote working on the complex creation of innovative resources. Implementation is planned for later 2021 and into 2022.

### **Communities of practice**

Central to developing the use of ICT in teaching and learning is addressing the challenge of embedding change and addressing conceptually the ways in which new practices can be sustained. The notion of a community of practice as a 'social learning system' (Wenger 2000), presents the concept of dynamic and sustainable learning based on competence and experience. Members of the community are bonded through ties of particular professional practice through 'mutuality' (strong relationships/social capital, 'enterprise' (learning energy) and 'repertoire' (self-awareness/reflexivity in development).

Communities of practice are small systems, constituted at local level.

Communities of practice grow out of a convergent interplay of competence and experience that involves mutual engagement. They offer an opportunity to negotiate competence through an experience of direct participation. As a consequence, they remain important social units of learning even in the context of much larger systems. These larger systems are constellations of interrelated communities of practice

(Wenger 2000 p, 229)

This idea of social learning infers both a dynamic process of learning and a community-constituted body of knowledge. It can also infer complex patterns of learning across multiple communities of practice,

For professional occupations, however, the social body of knowledge is not a single community of practice... [T]he 'body of knowledge' of a profession is best understood as a 'landscape of practice' consisting of a complex system of communities of practice and the boundaries between them.

(Wenger-Traynor et al 2014 p, 14)

The concept of boundaries (Wenger 2000) is sometimes seen as a potential concern, giving rise to concerns about exclusivity and 'othering'. But as Wenger points, 'boundary processes' both define the community and conceptualise learning as potentially moving the boundaries of the body of knowledge.

In social learning systems, the value of communities and their boundaries are complementary. Deep expertise depends on a convergence between experience and competence, but innovative learning requires their divergence. In either case, you need strong competences to anchor the process. But these competences also need to interact. The learning and innovation potential of a social learning system lies in its configuration of strong core practices and active boundary processes

(Wenger 2000 p, 234)

The idea of communities of practice in education - often glossed as 'professional learning communities' or PLCs (e.g. Botha 2012, Dogan et al 2016) though e.g. Brodie 2013 sees PLC as a subset of communities of practice, - is gaining increasing purchase globally at policy level as governments wrestle with the funding implications, organisational challenges and sometimes disappointing outcomes of large-scale cascade methods of in-service training/continuous professional development for teachers, tutors and lecturers. Cascade training is increasingly criticised for its dilution of message due to the trickle down effect of the training, its failure to meet the detailed, specific and immediate needs of professional learners and its typical methods of a single large-scale training session outside the context of school, college or university (e.g. Bett 2016). Communities of practice in contrast offer a model of dynamic professional learning, locally controlled, regular and frequent, continuous and self-sustained. Such a notion of a learning system, particularly with its levels of 'engagement' and 'alignment' is particularly apt for discipline-specific departments in secondary schools.

Such a model however, is not without its critics. A dynamic model of learning infers multiple options and directions at every step. This in turn can imply the near impossibility of close scrutiny of either the process of learning and change within the community of practice, or the power to change its direction. Communities of practice offer a level of autonomy and self-direction which can be deeply worrying, for example, to governments accustomed to centralised scrutiny and control and with ultimate responsibility for outcomes. Conceptually as well, a model which is resistant to detailed understanding of its processes retains a sense of ambiguity to those outside the community - a 'black box'. The ambiguity can extend to understanding how such communities are set up, - or even doubt about whether it is possible to create or engender a community of practice.

However we believe that some of this ambiguity is a mistaken understanding of the importance of leadership within the community. Chauraya and Brodie (2017 p, 223) for example refer to "groups of teachers who come together to engage in regular, systematic and sustained cycles of inquiry-based learning", suggesting that some form of peer structure is sufficient. Wenger (2000 p,231) on the other hand refers to the fact that "communities of practice depend on internal leadership, and enabling the leaders to play their role is a way to help the community develop."

Particularly in the context of education in Africa, formal leadership roles remain critically important to successful change. In our view the - at times - overemphasis on teacher agency ignores the 'enabling' role of school structures, with the positional leadership of both senior leader and middle leaders critical to designing, supporting and embedding change at school-

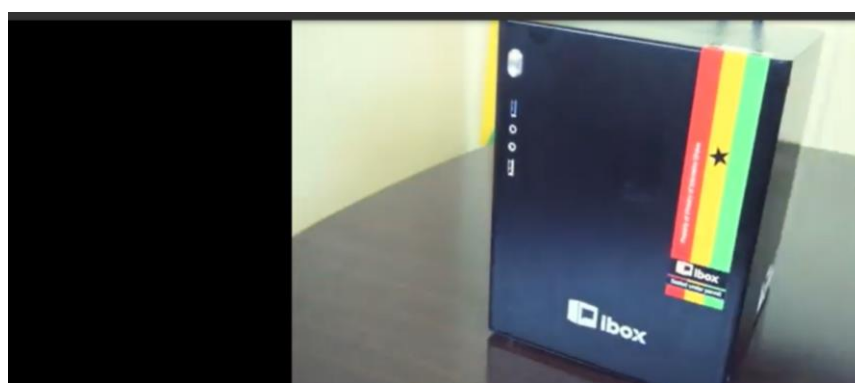
level (e.g. Hoy and Sweetland 2001). In the particular context of OpenSTEM Africa and upper secondary schools, with their structures of separate ‘worlds’ of discipline-specific departments, we believe that teacher agency can only function in dynamic and sustainable ways within a framing of practitioner positional leadership - e.g. the leadership of heads of department or heads of subject such as in SHS in Ghana. Heads of department/heads of subject hold a key position as middle leaders and expert practitioners. Headteachers are of course also integral to this structure and offer more generalised and senior level support (e.g. Asuga et al 2016)

### **iCampusgh and the iBox**

The platform iCampusgh was initially designed by CENDLOS in 2016 to be used as an intranet on the iBox, a Ghanaian-developed local server fixed into ICT labs in schools and with content provided as part of a wide scale ICT development programme with funding provided by [The World Bank](#). The content on iCampusgh/the iBox was initially planned to provide ICT-based learning and teaching in the less well-resourced Senior High Schools (Cullen, Mallet and Murphy 2019).



**Figure 1.** An iBox *in situ* in a Senior High School in Accra, Ghana.



iBOX iCAMPUSGH

**Figure 2.** The most recent version of the iBox



The iCampusgh/iBox initiative continues in development (see this introductory video on the development of the iBox <https://youtu.be/XNyjxcKeh0> ). The iBoxes have been set up in 148 public SHSs across Ghana and one iBox has a 'reach' at any time of 100m and an unlimited number of users, and so potentially available across for many lessons concurrently across the school. Use in 148 schools give the iBoxes altogether a potential reach of approximately 150,000-200,000 students and teachers. However in response to the Covid-19 school closures, CENDLOS/GES accelerated the development of the internet-based iCampusgh portal <https://icampusgh.com/contact.html> which was officially launched by the Ministry of Education (MoE) in Ghana on 30 March 2020 (Taddese 2020) with a potential reach of all 1.2 million SHS students and 30,000 teachers across Ghana, though limited to the proportion who can connect to the internet from home. According to [The World Bank Implementation Status and Results Report](#), in the first few weeks after the programme was launched, an average of 60,000 to 75,000 students were logging onto iCampusgh.

### Challenges pre-Covid19

When the OpenSTEM Africa project began in Ghana, CENDLOS and GES had already developed, uploaded and disseminated curriculum content for the 'core' SHS curriculum. However the premise that these two agencies were bringing to our new partnership was the challenge that there had been the limited take up of the iBox materials. In other words in schools where there is an iBox with materials available to support learning and teaching, then students and teachers were not using them to the extent which was envisaged. This was identified in an informal report by the World Bank, which noted,

The iBoxes deliver pre-prepared video lessons, student exercises and content assessment to SHS students and teachers. However, the independent verification indicates that the technology is not being adequately used by students and teachers in many schools that still lack the infrastructure (computer labs) to access the content. The current policy prohibiting cell phones and/or tablets further prevents students from accessing the iCampus on their personal devices. (World Bank 2017 p,3)

Within our OpenSTEM Africa partnership we were agreed that there were several potential reasons for this low take-up in schools - including those stated by the World Bank above - and which are particularly pertinent to teaching and learning in the SHS elective sciences of biology, chemistry and physics:

- A need to for easier/more extended access to an ICT lab.
- Government/school/parental concerns over the use of mobile phones to access ICT-based teaching and learning.
- Students needing to develop skills and confidence in accessing technology-based learning.
- Science teachers needing to develop skills and confidence in accessing technology-based learning.
- Science teachers/science subject leaders/heads of department needing long-term school-based professional development to widen their range of support for science pedagogies.
- Some development of the iBox materials needed to make them more interactive, more attractive and more relevant to students and teachers, especially girls.

Teachers in schools with iBoxes already installed had identified as a cause of concern situations where the ICT lab is wholly scheduled for use for ICT lessons and so there

are challenges in making it available for teaching other subjects. Despite the fact the 'reach' of the iBox means ICT-based teaching and learning could be set up in the ordinary classrooms in a school, the possibility of classes in school but outside the ICT lab using iCampusgh materials is restricted to classes where teachers can set up a laptop with speakers and all ICT-based learning and teaching is directed from the front of the classroom. As well, the parallel challenge of the lack of confidence among teachers and students in their ICT skills and the need to develop familiarity with the technology used for teaching and learning (GEEAP 2020) is set against the pressures on secondary school teachers to prepare students for the SHS school leaving/tertiary education entrance examinations, (currently the West Africa Senior School Certificate Examinations WASSCE) and so a reluctance to spend time on the development of new skills.

We brought to those challenges the 3 strands of OpenSTEM Africa, Ghana:

- 1. The OpenSTEM Africa Virtual Lab:** onscreen interactive science applications built using real data, building on the OU's OpenScience Laboratory  
<https://learn5.open.ac.uk/course/view.php?id=2>

Underpinned by:

- 2. Continuous Professional Development (CPD) units for science teachers:** to develop confidence, skills and strategies to support improved teaching and learning in the sciences, focusing on ICT-based practical science,

Embedded in Senior High Schools through:

- 3. Curriculum Leadership programme for heads of department/heads of subject,** to support them in creating communities of practice to improve teaching and learning in the sciences, with a particular focus on ICT based practical science in their school

All the materials being co-designed and co-created for OpenSTEM Africa Ghana, are embedded in the SHS science curricula with Virtual Laboratory applications which provide experiments which are directly relevant to the objectives of SHS Biology, Chemistry and Physics. Similarly the CPD units for SHS science teachers are rooted in the MoE objectives for SHS (MoE 2018) and integrally linked to the teacher competencies and progression set out in the National Teachers' Standards for Ghana (NTC 2017). Both the CPD units and the leadership programme are informed by a Ghanaian literature on educational leadership and teacher development. (e.g. Asare et al (2012), Sarfo et al (2017))

### **Progress pre-Covid 19**

Our partnership has a strong focus on the co-design and the co-creation of materials and resources and on developing programmes led by our Ghanaian experts. Pre-pandemic during 2019, several face-to-face workshops were held in Ghana with SHS science teachers to start the co-creation and storyboarding of materials (Figure 3).

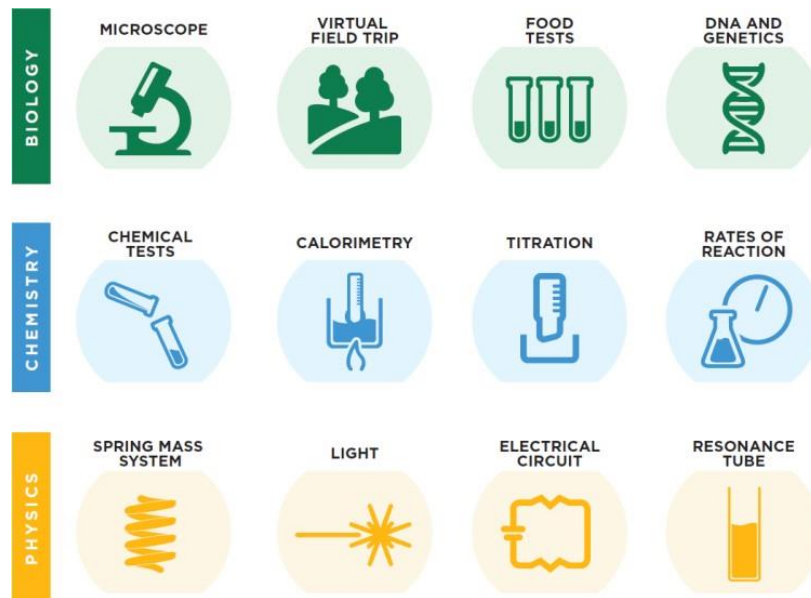
The applications and materials we have developed are designed as digital OERs. The OU's current move to a 'mobile first' design for all its applications (i.e. for its own modules and qualifications) could be of especial interest to all teachers and school leaders in Ghana as we further develop the programme, as the phone is the technology of choice, and smart phones are widely used even in the less well-resourced regions of Ghana.





**Figure 3.** Co-design workshops with the Senior High School expert teacher group in Accra, Ghana, July and October 2019

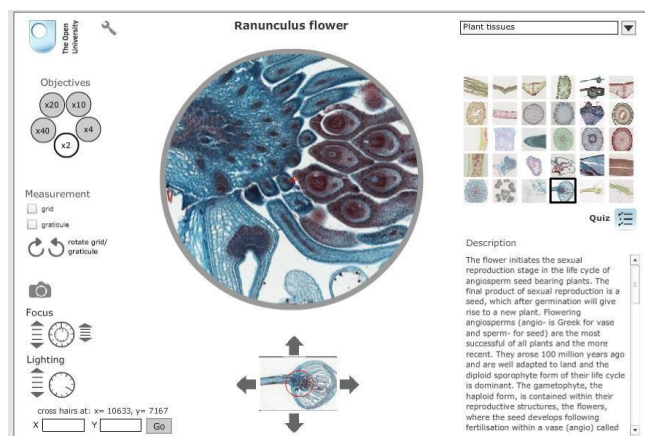
For our co-creation of onscreen interactive applications, the workshops held in Ghana identified 12 potential applications that could support, replace or provide new opportunities for experiential practical science (Figure 4).



**Figure 4.** Onscreen interactive applications to support the teaching of the elective sciences.

Some of these planned applications are amenable to multiple uses over the three years of SHS study. For example, in biology, a digital microscope can be used to study single-celled organisms in Year 1, the structure of plants in Year 2 and complex mammalian tissues in Year 3 - in fact the digital microscope can potentially be used for more than 50 separate experiments within the SHS curriculum. The digital microscope not only recapitulates all the

practical elements of a physical microscope (Figure 4), such as coarse/fine focussing, illumination control, magnification objectives, measuring graticule and stage manipulation, but because it is fully interactive, students are able to navigate to areas of interest and access explanatory text. The fact that both students and teachers can regularly revisit key virtual instruments such as a digital microscope, will help to build both confidence and familiarity in the use of onscreen tools to enhance the learning and teaching of practical science.



**Figure 5.** A screenshot showing the interface used to access the digital content of the OpenUniversity Open Science Laboratory digital microscope.

OpenSTEM Africa, Ghana was launched in late 2019



**Figure 6.** Launch of OpenSTEM Africa: Ghana, Ministry of Education, October 2019

## **Covid19: school and university closures and home working**

During 2020 and 2021 GES, CENDLOS, The Open University and the SHS science teacher expert group have continued to work together, remotely, to design and create and critically evaluate iterations of the first set of materials. This was extremely challenging in both Ghana and the UK due to the restrictions caused by the pandemic. In the UK, the OU campus closed in March 2020 and as of September 2021 is only now beginning to re-open. All departments closed on campus, including the OU laboratories and technical and production departments such as Learning and Design, with teams having to work remotely from home. In Ghana during the school closures, though teachers continued with some classes for some of the period March 2020-March 2021 (e.g. SHS3 WASSCE examination classes) in general SHS learning and teaching has been remote and teachers have been engaging with their students via multiple methods from home. Though it might be argued that students and teachers would have more access to iCampusgh due to its launch as an internet platform, they need to have their own PCs, laptops, tablets or smartphone, an internet connection available to them at home and be able to afford the cost of extended hours of household connectivity.

As UNICEF (2020) reported, only 22% of households overall across Ghana have access to the internet at home and only 15% have access to a computer. Nevertheless, SHS students are likelier to have connectivity than the average Ghanaian household, and within a total national population of approximately 30 million, both the number of mobile phone subscribers (16.7 million) and the numbers of mobile internet users (10.7 million) reported in 2019 (GSMA 2020) suggests greater potential connectivity. Further, during the closures caused by the Covid19 pandemic, several internet providers in Ghana (e.g. MSN) for some of the time zero-rated educational websites to provide free access to users.

In addition, the fact that the iCampusgh SHS 'core' curriculum lesson content is focused directly at the students arguably helped to mitigate difficulties in students maintaining full contact with their teachers, for example due to distance (many SHS are boarding schools so a significant distance from the student's home), or teacher shortages due to illness or caring responsibilities.

## **Progress during Covid19**

Despite these challenges OpenSTEM Africa continued to develop their collaborative work during this period. We worked remotely, talked via email, via discussion on platforms like Zoom and Teams. As the first set of materials were produced, then starting in August 2020, they were progressively loaded onto a UK-based OU OpenLearn Create site [OLCreate: OpenSTEM Africa: Ghana OpenSTEM Africa: Ghana](#). What followed then (September 2021-April 2022) was a period of critical evaluation from our Ghana-based colleagues, followed by amendments and re-editing which is just completing in September 2021.

4 units of the heads of science programme and 10 units of teacher CPD materials have now been co-developed, and as seen with the 'landing pages' below, 9 Virtual Laboratory applications - each linked to multiple experiments - have either been created ready to be uploaded to iCampusgh in October 2021 or are in their final stages of development and testing to be uploaded in early 2022. And in conjunction with the development of the Virtual Laboratory, we are now developing interactive exemplar lessons to support SHS science teachers in leading their practical teaching of the use of specific applications and experiments, and in directly supporting students to try out and practise experiments for specific SHS curriculum purposes.



## OpenSTEM Africa Virtual Laboratory

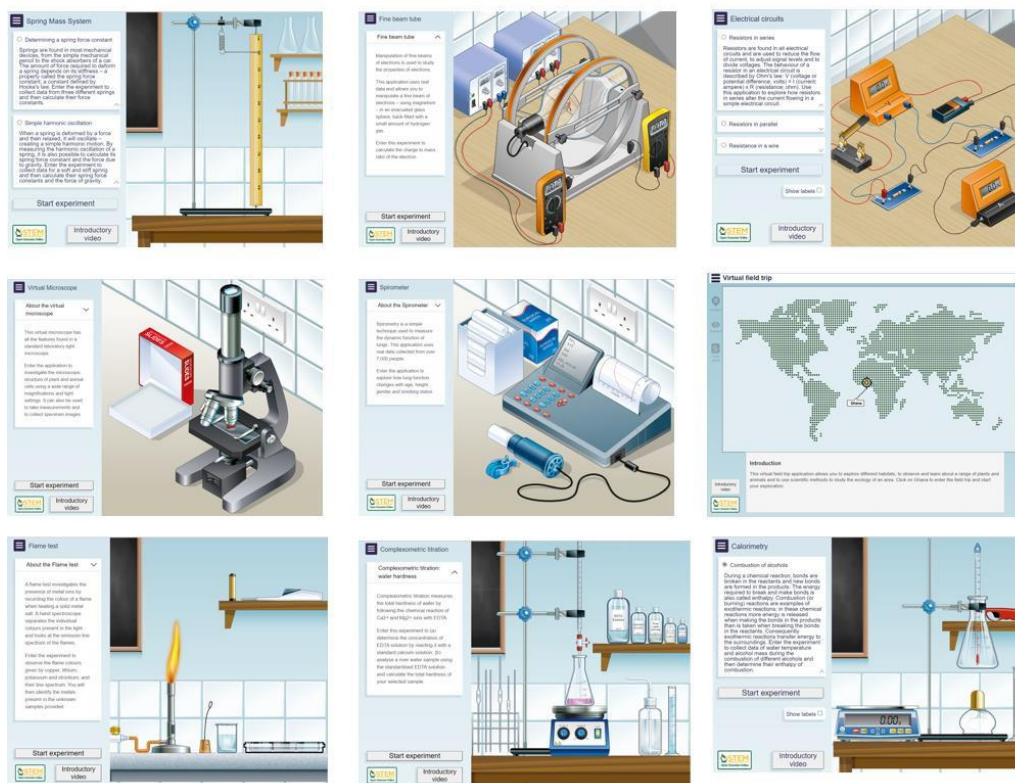


Figure 7. The OpenSTEM Africa virtual laboratory - home pages of the applications

## CPD units for SHS science teachers

CONTINUOUS PROFESSIONAL DEVELOPMENT (CPD) FOR SCIENCE TEACHERS

**openSTEM Africa**

**COLLABORATIVE LEARNING**

CONTINUOUS PROFESSIONAL DEVELOPMENT (CPD) FOR SCIENCE TEACHERS

**openSTEM Africa**

**LINKING SCIENCE TO EVERYDAY LIFE**

### Other units/short courses

3. Using ICT to support learning
4. Planning effective lessons
5. Involving all
6. Effective questioning
7. Organising practical work
8. Approaches to note taking
9. Formative assessment
10. Feedback and feedforward to improve learning

Figure 8. 10 CPD units to support SHS teaching and learning of the elective sciences

## Leadership programme for SHS heads of science



**Figure 9.** 4 units to support SHS HoD in developing and embedding science teaching and learning in their department

The CPD units and the leadership programmes are able to be used both online and offline - i.e. as digital materials which are also printable as pdfs. Throughout the development of these materials we continue to work with CENDLOS to minimise the size of files and the bandwidth needed to run the applications. This work continues.

### The changed landscape for OpenSTEM Africa in Ghana - looking forward

As SHS began to open again in Ghana in 2021, CENDLOS reports that the iBox content is being promoted to students to help with the catch-up of the learning which they have missed during school closure, and that some informal use of tablets and smart phones within the school grounds, for example before and after school hours, is helping students to make greater use of this content. GES and our SHS expert teacher group suggest that while there continue to be significant challenges with remote teaching and learning, SHS teachers and students in Ghana have been encouraged into a greater embracing of technology. [Impact Of COVID-19 On Education: Ghana In Perspective \(modernghana.com\)](https://www.modernghana.com). Expectations were set up as individual school level and there has been reported significant an exciting use of new technologies such as Zoom, Whats App and Google classroom. (e.g. [Aburi Girls SHS To Represent Ghana At Global Robotics Competition \(www.africa.com\)](https://www.africa.com)). But challenges persist. We are still living with the pandemic which is Covid19. In the UK, the OU is still operating largely off-campus, with only gradual and emerging plans for a shift back to campus. In Ghana there is huge and necessary focus on catch-up as SHS have re-opened, with the SHS school year currently (and planned for 2022) running January-December and WASSCE examinations delayed for the second year running. There are pressures on all educational institutions simply to keep running.

We are now at the point - both in the UK and in Ghana - of considering what we want to keep and take forward of the types of innovation that we have worked with during the pandemic. Specifically for OpenSTEM Africa, then the move to an internet-based version of iCampusgh opens up the possibility or providing our technology-based SHS science materials to 1.2 million SHS teachers and students. And with all the challenges of technology, then to move to greater use of technology - including its innovative use in teaching and learning - is the direction of travel.

## References

African Union Agenda 2063 <https://au.int/en/agenda2063/overview>

African Union Commission (2014) "On the Wings of Innovation", the Science, Technology and Innovation Strategy for Africa (STISA-2024). Ethiopia, Addis Ababa  
[https://au.int/sites/default/files/newsevents/workingdocuments/33178-wd-stisa-english\\_-\\_final.pdf](https://au.int/sites/default/files/newsevents/workingdocuments/33178-wd-stisa-english_-_final.pdf)

Aggor, C.S. . Tchao, E.T., Keelson, E. and Diawuo, K. (2020) ' Mobile Phone Usage Among Senior High and Technical School Students in Ghana and Its Impact on Academic Outcomes – A Case Study' in Auer, M.E. and Tsiatsos, T. (Eds) *The Challenges of the Digital Transformation in Education*. Cham, Switzerland, Springer

Asare, E.O. Mereku, D.K., Anamuah-Mensah J. and Oduro G.K.T (2012) *In-service teacher education study in sub-Saharan Africa: the case of Ghana*, Accra, GES.

Asongu, S. A. (2018) Conditional Determinants of Mobile Phones Penetration and Mobile Banking in Sub-Saharan Africa *Journal of the Knowledge Economy* 9:81–135

Asuga, G.N. Scevak, J. and Eacott, S (2016) Educational leadership, management and administration in Africa: an analysis of contemporary literature, *School Leadership & Management*, 36:4, 381-400

Barfi, K. A., Bervell, B. and Arkorful, V. (2021) Integration of social media for smart pedagogy: initial perceptions of senior high school students in Ghana *Education and information technologies*, 26 (3), 3033-3055

Bett, H. K. (2016) The cascade model of teachers' continuing professional development in Kenya: A time for change? *Cogent Education*, 3:1 1-9

Botha, E. M. (2012). Turning the tide: creating Professional Learning Communities (PLC) to improve teaching practice and learning in South African public schools. *Africa Education Review*, 9(2), 395-411.

Brodie, K. (2013). The power of professional learning communities. *Education as change*, 17(1), 5- 18.

Cullen, J., Mallet, J. and Murphy, K. (2019). *The Opportunities and Challenges for Developing ICT-Based Science Learning and Teaching in Ghana*. Pan-Commonwealth Forum7  
[http://oasis.col.org/bitstream/handle/11599/3276/PCF9\\_Papers\\_paper\\_232.pdf?sequenc%20e=1&isAllowed=y](http://oasis.col.org/bitstream/handle/11599/3276/PCF9_Papers_paper_232.pdf?sequenc%20e=1&isAllowed=y)

Dladla, N. and Moon, R. (2002) *Challenging the assumptions about teacher education and training in Sub-Saharan Africa: a new role for open learning and ICT* Pan-Commonwealth Forum on Open Learning, Durban, South Africa July 29th – 2nd August 2002

Dogan, S., Pringle, R., & Mesa, J. (2016). The impacts of professional learning communities on science teachers' knowledge, practice and student learning: A review. *Professional development in education*, 42(4), 569-588.

Global Education Evidence Advisory Panel (GEEAP) (2020) *Cost-effective approaches to improve Global Learning* World Bank/FCDO



<https://documents.worldbank.org/en/publication/documents-reports/documentdetail/719211603835247448/pdf>

GSMA (2020) Mobile for Development <https://www.gsma.com/mobilefordevelopment/blog/the-state-of-mobile-in-ghanas-tech-ecosystem/>

Hoy, W. K. & Sweetland, S. R. (2001). Designing better schools; The meaning and measure of enabling school structures. *Educational Administrative Quarterly*, 37, 296-321.

Kaliisa, R. and Picard, M. (2019) Mobile learning policy and practice in Africa: Towards inclusive and equitable access to higher education *Australasian Journal of Educational Technology* 35(6) 1-14

Ministry of Education (2018) *Education Strategic Plan 2018-2030* Accra, Ministry of Education

Ministry of Gender, Children and Social Protection (2015) *National Gender Policy: Mainstreaming Gender Equality and Women's Empowerment into Ghana's Development Efforts* Accra, Ministry of Gender, Children and Social Protection

NTC (2017) National Teachers' Standards for Ghana Guidelines MoE/NTC.

Sarfo F. K., Amankwah F. and Konin, D (2017) Computer Self-Efficacy Among Senior High School Teachers in Ghana and the Functionality of Demographic Variables on their Computer Self-efficacy *The Turkish Online Journal of Educational Technology*, 16 (1) pp19-31.

Soares, F. and Galisson, K. (2021) Toward a Deeper Understanding: Testing a Multidimensional Framework of Professional Learning Communities in Sub-Saharan African Schools *Comparative Education Review* 65 (1) 76-103

Taddese, A. (2020). EdTech in Ghana: A Rapid Scan. (EdTech Hub Country Scan). DOI: 10.5281/zenodo.3830951.

UNICEF (2020) Covid-19: Socio-economic impact in Ghana: impact on Ghana's Education. Briefing note No 3 <https://www.unicef.org/ghana/media/3071/file/COVID-19:%20Socio-Economic%20Impact%20in%20Ghana.pdf>

UNESCO (2017) *Cracking the code: girls' and women's education in science, technology, engineering and mathematics (STEM)* Paris, UNESCO

Wenger, E. (2000) Communities of Practice and Social Learning Systems *Organization* 7(2) 225–246

Wenger-Trayner, E., Fenton O'Creevy, M., Hutchinson, S., Kubiak, C. and Wenger-Trayner, B. (2014) *Learning in Landscapes of Practice : Boundaries, Identity, and Knowledgeability in Practice-Based Learning* Routledge

The World Bank (2017) Aide Memoire: Ghana Education Mission Ghana Secondary Education Improvement Project (P145741-Cr. 5452) Proposed SEIP Additional Financing (P163628) March 27-April 4, 2017  
<http://documents.worldbank.org/curated/en/188461498146373134/text/ITM00267-P145741-06-22-2017-1498146370641.txt>

World Bank (2018) School enrollment secondary data  
<https://data.worldbank.org/indicator/SE.SEC.ENRR>