CONTINUOUS PROFESSIONAL DEVELOPMENT
(CPD) FOR SCIENCE TEACHERS

OpenSTEM Africa

USING ICT TO SUPPORT LEARNING

Acknowledgements

Ministry of Education

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For information on OpenSTEM Africa see: www.open.ac.uk/ido

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Contents

OpenSTEM Africa: Ghana

The overarching aim of OpenSTEM Africa, Ghana, is to make a contribution to Government of Ghana/Ministry of Education policy to the effective teaching of practical science.

Effected by:

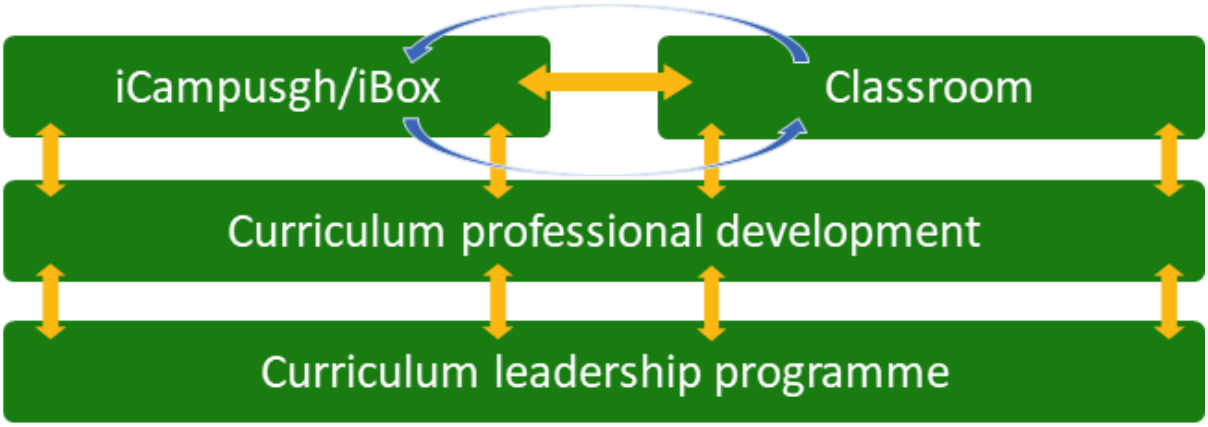
1. **Virtual Lab:** onscreen interactive science instruments using real data and with examples of science lessons, to improve the experiential teaching and learning of science in Senior High Schools, helping develop girls' and boys' practical science study skills, and building on the iCampusgh/iBox model developed by CENDLOS.

Underpinned by:

2. **Continuous Professional Development (CPD) for science teachers:** which develops confidence, skills and strategies to enable improved teaching and learning in the sciences, with a particular focus on ICT-based practical sciences, and which supports them in meeting the aspirations of the SHS elective science curriculum (Physics, Chemistry and Biology).

Embedded in Senior High Schools through:

3. **Curriculum Leadership Programme:** for Heads of Department/Heads of Subject, which enables them to effectively implement short- and long-term strategies to improve teaching and learning in the sciences, with a particular focus on ICT based practical science in their school.



The school-based professional development and leadership programmes will help more teachers use ICT-based science resources more and more effectively, with more learners. The support for school leaders' facilitates the development of a sustainable community of practice in science within the school, led by the Head of Department/Subject Lead and with the support of the Headmaster/Headmistress, in line with National Teaching Council Guidelines.

CPD programme for SHS science teachers

This CPD programme for SHS science teachers is designed by experienced Senior High School science teachers working with Heads of Science and SHS curriculum and Science Resource Centre developers, representing a wide range of Senior High Schools in Ghana. They are working with representatives from the Ministry of Education, CENDLOS, GES, the University of Ghana and from The Open University (UK) on OpenSTEM Africa: Ghana.

Improving teaching and learning in the sciences at SHS level is part of the Government of Ghana's *Education Strategic Plan (2018–30)* to enable increasing numbers of SHS students to specialise in the sciences at tertiary level and then move into STEM careers. Government of Ghana policy points to the importance of in-service training for teachers for acquiring new skills and keeping abreast of new developments. The National Teacher Standards for Ghana (MoE/NTC) set out the importance of teachers continuing to learn as they teach and the importance of the school as the location of that learning. Ghanaian research suggests that continuous professional development (CPD) taking place within the school is more motivating, more coherent, more sustainable and likely to be more effective in the long term This is the "growth approach in which teachers are given the opportunity to try new opinions, gain new perspectives, and extend their professional capabilities in order to understand and find solutions to problems in their individual schools" (Asare et al., 2012).

SHS science teachers, particularly those specialising in the elective sciences are already experts in their field. This programme is to enable them to work directly with their Head of Science, or Heads of Physics/Biology/Chemistry alongside their departmental colleagues to further develop the expertise of the whole department in teaching SHS sciences, with a particular focus on ICT-based teaching and learning and to help build a community of practice among science teachers in the school.

Using ICT to support learning

Introduction

Using ICT to support learning and teaching represents an exciting opportunity for students and teachers alike, although developing skills and confidence in using ICT takes time and can be challenging at first.

As you will know, the Government of Ghana has as a policy objective: "the improved quality of teaching and learning, and STEM at all levels" and in particular the "integration of ICT in teaching and learning at SHS (MoE 2018) so that more use of ICT and the development of ICT skills in learners is something that all SHS teachers are being asked to do."

This is reflected in the National Teachers' Standards for Ghana Guidelines, which highlight:

"At … senior secondary high school level the teacher demonstrates intellectual curiosity: they have a good understanding of developments in their subject through self-study and wider reading: they attend CPD courses that update them on subject skills; they draw on rich and varied sources well beyond the textbook. They have a developed understanding of how to use ICT in their practice… All teachers have good technological pedagogical knowledge, knowing how to incorporate ICT into their practice to support learning."

(NTC, 2017)

Reflection point

The availability of ICT to support learning has moved on since you began teaching.

How do you feel about the teaching standards above? Does it excite you, or make you feel apprehensive? Think about the ICT skills that you have now, that you might not have had a year ago.

How did you acquire these skills?

Gladys, an experienced SHS Chemistry teacher, explains that for her it happened as part of her professional development:

"A few years ago, I could barely go online to search for information. When I started my Masters' programme at KNUST, I had no choice but to buy a laptop and start learning. I had to go online most of the time to either submit my assignments or search for information. Everything was moving so fast in my class that I had to learn quickly."

You have probably developed a significant number of skills in ICT without realising it. For example, you have probably not consulted a manual on how to use Facebook! In this unit, you will have the opportunity to work with your Head of Department/Head of Subject and colleagues to further develop your skills and apply these in the classroom.

By the end of this unit you will:

- understand that integrating ICT into learning and teaching is a pedagogical issue rather than just a technological one
- have thought about the sort of pedagogy needed to be able to successfully integrate ICT into your classroom teaching
- have thought about how ICT can enhance and transform teaching
- collected a number of practical examples which you can develop and adapt for your own teaching
- continued to develop your skills in using ICT in teaching and learning, via the final section of this unit.

A full list of CPD units can be found at:
https://www.open.edu/openlearncreate/Teacher_units

ICT in the curriculum

The term 'ICT' is used in Senior High schools both as a subject for students for study, and as a medium for learning. As an SHS teacher of the elective sciences you will have students in your class who are taking ICT as a subject and will be gaining expertise in understanding applications, programming, desktop publishing and networking. Other students in your class may be much less comfortable with using ICT in learning, though they may be using smartphones or tablets for their social activities outside school.

You may be skilled at incorporating ICT into your teaching or this may be something you are not yet used to doing. Research suggests that SHS teachers in Ghana feel confident about basic computer skills such as word processing, less sure about web-based skills, and unsure about their media related skills (Sarfo et al., 2017). However, this may be explained by the fact that teachers are more used to using the internet for social activities rather than teaching and learning.

With more access to ICT-based materials and processes, and by incorporating the expertise you use in your social use of ICT, you as an SHS science teacher have the opportunity to develop these professional skills and your pedagogy. You may find yourself in the situation in which your students – particularly those taking ICT as an elective subject – are more proficient than you in some applications. They will be an important resource for you!

Reflection point

Could you talk to your Head of Department about using more ICT in your teaching? Could you use the ICT lab for any of your lessons? Ask your HoD!

Think about the students that you teach. Who do you know in your classes who enjoys using ICT? If you were able to use the ICT lab for a science lesson, which students could you use to support others who are less confident?

If the ICT lab is too busy to be able to use with your class, is it possible for you to bring your own laptop or your tablet into school to use in teaching a lesson?

Who are the teachers in your school who are very confident in using ICT? Who could you ask for help? Think about this now, so when you have an idea for using technology, you know who to ask.

As Ako explains:

"I teach an SHS3 chemistry class. Sometimes I need to type instructions for practical lessons, I normally ask some of the students to help with the typing."

As Azindoo, an SHS Physics teacher suggests:

> *"I have a large class and sometimes is difficult showing a demonstration from the laptop. So what I do is, I put them in groups and get a leader for each group. They then come in groups to watch the demonstration. This is time consuming but very effective to get students fully engaged in the learning process. This helps the teacher to do less talking in lesson presentation."*

ICT as a pedagogical issue

The effective use of ICT in the classroom is a **pedagogical issue** (rather than just a technological one), and to be successful teachers need to adopt active approaches to learning and teaching and to reflect on their attitudes to learners and learning. If you need to learn how to use a particular technology – such as a spreadsheet for collating experimental results – it will be easier if you are clear about what you want to use it for.

Activity 1: Am I able to actively engage learners in my lessons?

Think about the lessons you have taught this week. Discuss these questions with your Head of Department/Head of Subject or reflect on them by yourself. Answer as honestly as you can.

- Are students engaged and motivated to learn?
- Are classroom relationships based on mutual respect?
- Does the learning challenge students and build on existing knowledge?
- Are students given the chance to talk about their ideas to support their learning?
- Are the teaching and learning activities as relevant as they could be to your students' lives?
- Do the activities promote a range of skills including critical thinking and creativity?
- Does the assessment test a range of skills and give credit for more than recall of knowledge?

Based on your answers to the questions:

1. list the things that you would like to do more of in your teaching – and still be teaching the syllabus
2. list the things that you need to try to do less of – and which wouldn't affect the coverage of the curriculum.

These points highlight aspects of your teaching to discuss further with your Head of Department in a coaching session.

It is easier to think of ways to integrate ICT into your teaching if you are used to actively engaging students.

Activity 2

Plan an activity to do as part of a lesson next week in which students are actively engaged. Use the textbook for ideas if you have one available. If possible, discuss your ideas with a colleague or your Head of Department.

You could organise students into pairs or groups to solve a problem or discuss an issue; you could set a research task and ask students to be creative about how they present their work; or you could ask students to discuss a set of open-ended questions in groups.

Use the examples to give you some ideas. They do not have to involve ICT at this stage, but the first step in the successful integration of ICT is using active pedagogies.

Classroom example 1

Mrs Dabre was starting Section 3 Unit 1 of the SHS 2 Chemistry curriculum on rates of reaction. She gathered her students around the front and dropped a piece of chalk into some vinegar in a glass. It started to fizz.

She asked them to discuss with the person next to them how to make it fizz faster and how to make it fizz slower? After a few minutes she collected their ideas on to the board.

She then asked them how we measure speed. They suggested km/hr, but Kofi, one of the students, remembered that in Physics they use m/s. Mrs Dabre then gave them a few minutes to discuss how they could measure the speed of this reaction. The idea of timing how long it took for the chalk to disappear quickly came up. With a bit of prompting they also suggested catching the gas and seeing how long it took to catch a test tube full over water or putting the glass on a balance and watch the mass fall.

When they went back to their places, she wrote two questions on the board:

- What are the factors which affect the speed of a reaction?
- How can we measure the speed of a reaction?

She told them to use results of their brainstorming (which were on the board) and the text book to help them.

Did you notice…

- She presented a practical problem at the start of the lesson
- The students had chance to discuss their ideas. All were involved in discussions, not just those who immediately knew the answers

They made their own notes – which involved more thinking than if they were copying – but the process was scaffolded by the brainstorm notes on the board and the text-book.

How could she include ICT? Mrs Dabre could have the students use a computer spreadsheet in plotting graphs whilst they measure the speed of the reaction. She could have asked them to collate all the students' views in a Word document or create a PowerPoint slide with a graphic of the key information.

Classroom example 2

Mrs Mensah was teaching photosynthesis (SHS 3, Biology Section 1, Unit 4).

She started the lesson with a simple question: where do plants get their food? This was covered in the integrated science curriculum, and she needed to be confident students remembered about photosynthesis, before she could move on. Last year she had asked a series of closed questions. Several students answered correctly, but she later realised that many in the class did not actually remember. The class had not done well in the school- based assessment on this. This time, she showed them a video of photosynthesis. Then she divided them into groups to discuss what they had watched. She made sure the groups each had students of different attainment levels and asked each group to draw a plant in the middle of the paper and annotate it to show how they made their food.

While they were working, she moved round the room asking questions and noting which students seemed to need more help.

After 15 minutes, the students stuck their own poster on the wall each group looked at all the others. They then had 5 minutes to make changes to their own. Each group then came forward to make a short presentation about their poster.

Did you notice...

- By mixing the attainment levels in the groups, peer support could take place
- Mrs Mensah would have been left with a good idea about who was struggling

Through the activity, they revised what they had covered in integrated science in an engaging and inclusive way.

How could she include ICT? Mrs Mensah could ask the class to look up photosynthesis on the internet after school and bring two or three facts about it to the next class.

What technology are teachers using?

Activity 3: What technology do you use?

Make a list of the technology that you use in your daily life and what you use it for.

- How do you use technology in your professional life? Make this a topic of conversation with colleagues who teach your science subject or across the whole science department in your school.
- Could you make more use of the technology available to you?
- If so, in what way?

As Akwasi, an SHS Biology teacher comments:

"I use my personal laptop and my personal mobile phone. Sometimes I use the TV from the department. Professionally, I use ICT to research topics and appropriate activities that go with them. I will use ICT for lesson preparation (e.g. I will get resource materials online), during lesson presentation (to demonstrate concepts and facts) and to conclude lesson.

ICT increases the flexibility of lesson delivery and gives me as the teacher a variety of pedagogies."

How can technology support teaching and learning?

In order to be confident that money on technology is being well spent, it is important that educational practices change for the better. Changing educational practices through the use of ICT, can change teacher behaviour, teaching context and student behaviour. All of these have the potential to lead to improved learning outcomes.

The impact of using ICT can be evaluated in terms of whether it offers:

- support (the digital devices achieve the same learning as other resources)
- extension (the digital devices achieve the same learning but in different ways)
- transformation (the digital devices support learning that could not be achieved in other ways).

For the government, when investing in technology for education, the objective would be that digital devices are not only used to replace current pedagogical approaches but that teachers will employ digital devices to transform learning.

Activity 4: Using ICT to transform learning

Think of a science topic that you will be teaching next week.

Imagine that you and your students could have access to any technology that you wished.

1. How could you use the technology to support how you would normally teach this topic?
2. How could you use technology to achieve the same learning but in different ways?
3. How could you use technology to provide learning opportunities that would otherwise not be available?

As a subject or departmental group and under the guidance and support of your Head of Department, collect all your ideas for points 1–3 on to a flip-chart and keep it as a resource to support future planning or to inform the individual coaching sessions you will be having with your Head of Department.

Practical science

The practical science applications such as the virtual microscope being introduced by OpenSTEM Africa are designed to help you to teach your students practical science in the absence of other reliable equipment.

With each instrument there is an example lesson plan, demonstrating how it might be used to support science learning.

The instruments could be used to:

- introduce a topic
- deliver the main content of a lesson
- consolidate key concepts and ideas
- teach practical skills
- help students solve problems you have posed
- encourage critical thinking
- relate science to everyday life.

Working with your Head of Department, take a look at the virtual microscope and the lesson plan. Consider:

- what practical skills the students will learn
- how the application is being used
- alternative ways in which the application could be used.

As more instruments become available, work with your Head of Department and colleagues to develop more example lesson plans.

The pedagogy of using ICT

Activities 5 and 6 will help you to think about the effective use of technology and how to make it transformational.

Activity 5: Examples of using iCampusgh and the iBox

Teachers in Ghana are using the iBox and iCampusgh, which have been developed by CENDLOS, in a number of ways:

1. **Catch up** – students who have missed lessons are able to access the material at home or in the ICT lab and go through what they have missed.
2. Using the **video** lesson interactively – the teacher plays the video lesson to the class but stops the video periodically to ask questions or to set up a short discussion between the students about one of the issues raised.
3. **Flipping** – students work though the lesson on iCampusgh at home in advance of the classroom lesson. The teacher then organises a series of activities in groups or pairs designed to probe students' understanding. Through careful questioning, peer-support groups can be established and the teacher can focus on those who need the most help.
4. **Note-taking** – the teacher displays the notes and students work in pairs or groups to convert the notes into alternative formats such as poster, a mind- map or a concept map. While they work the teacher walks around asking questions and checking individuals' understanding.
5. **Teacher absence** – the teacher knows that they will be absent on a particular day so arranges for the class to access the lab and work through a designated lesson.

Classify each of the above as:

1. supporting learning as usual
2. extending learning
3. transforming learning.

Activity 6: Analyse the two examples of teachers using ICT

Work with your Head of Department to work out what advice you would give to Mr Adu and to identify questions you want to ask of Mrs Accquah.

Mr Adu uses PowerPoint

Mr Adu's school has just bought a digital projector and all teachers are being encouraged to use it in their classes if they have a laptop to connect to it. Mr Adu is not very happy about this; he is not very experienced with using technology, but he decides that he will make a PowerPoint presentation for his next Physics lesson. He is teaching temperature and its measurement (Physics SHS 1, Section 3, Unit 1). He makes some notes on the different types of thermometer and how they work on some PowerPoint slides. In the classroom he puts on the PowerPoint and then tells his students to copy the notes into their notebooks in silence. It's quite difficult for the students at the back to see the slide but Mr Adu is a very strict teacher and they are nervous about telling him so they say nothing. While the students are copying the slides, the teacher sits at his desk looking at his laptop. He realises that he has made two mistakes on slide 1. He has spelt 'resistance' wrong (resistence) and he has forgotten to add the 'pyrometer' to the list of types of thermometers, although there is a slide on it later. He quickly moves onto the next slide although most of the students have not finished slide 1. But there's another mistake on slide 2: he has labelled the axis wrong on the graph to show the linear relationship between the height of the liquid and the temperature. He quickly switches off the laptop and tells the students to open their books and copy the notes from the book.

Mrs Accquah uses a projector

Mrs Accquah works in a rural school where there are insufficient textbooks, and today her colleague is using the ones that she needs. However Mrs Accquah has managed to borrow a projector. She has a different approach to technology to her colleague and wants to use it to get her students talking to each other. She chooses pictures that she has found online, telling the life-cycle of a cockroach and a butterfly. She shows her students the pictures by connecting her phone to the projector using an adapter and cable. Mrs Accquah puts her students in groups of 4 and explains that the pictures have been mixed up so they're in the wrong order. In their groups they have to reorganise the pictures and then write down the life cycle. As the students are working, Mrs Accquah moves around the classroom helping different groups of students with any problems she can see that they are having. She asks them to write down the structural changes that occur in each species. She is surprised to see that one of the quickest students is a very quiet boy who doesn't often take part in class activities. When all the groups have finished, she asks his group to put the pictures into the right sequence. When the class has agreed this is correct, she brings different students to the board to check that all the students understand and can summarise the structural changes as each organism develops.

Classroom examples of using ICT

Activity 7: Using ICT in class

Read and discuss the examples below. They were all supplied by participants in a free online course in March 2019 and developed further by SHS teachers in Ghana.

Decide on the top three suggestions and explain why you like them. Explain what the technology is enabling you to do that conventional methods would not.

"I set up a spreadsheet on my laptop to capture experimental results. Students came and entered their results. I displayed the table using a projector and we worked together to calculate averages and draw graphs."

Using ICT can help make teaching and learning more interactive. For example, using a laptop computer and a projector to show students an educational video. Rather than simply asking students to copy facts from the chalkboard, when they watch the video they hear and see and can thereby construct their own understanding and knowledge, as opposed to just being given it.

The teacher can then follow up the educational video by use of questioning, group discussion or a written task/creative task based on what the students learnt from the video.

"ICT helps make teaching and learning more interactive because it can involve students more directly in an encompassing education. The use of pictures and sounds, the golden opportunity of searching the internet, the initiative to make students work in pairs or group questioning after what they saw are effective tasks, more involving than the chalkboard or the teacher talking."

Using tablets can make teaching and learning more interactive by showing videos or pictures in group discussion with students. This will give them opportunity to share ideas, discuss or investigate ideas.

"A video camera on a phone could be used to for debating sessions to make constructive comments on them."

"I have access to and mostly use projector to teach. I use it show images, videos and models to illustrate points. I also create a platform for further discussion on Facebook or WhatsApp."

"I also find the use of Mobile phones by the students to be very useful when I give them assignments. They go to the internet to look for information on the topics provides that will later be discussed in class."

For example, during a class on literature we test the knowledge of various set books; therefore, I can look for a recorded video of a set book and give the students to watch after reading the set book itself. Then we discuss the film and how it portrays the book.

"ICT makes learning more interactive: for instance students watch an animation, a discussion about an issue, or a film, and then discuss the scientific ideas covered."

Using ICT will make learning of concepts more real. It will reduce or eliminate misconceptions that students form when listening to explanations and descriptions. For example, in particle theory, the teacher can show a short video of an animation which represents the particles that make up matter. Topics which rely on understanding things that cannot be seen can come alive in this way.

"ICT makes teaching and learning more interactive when there is multimedia content that is related to the topic or subject area. Learners can actively engage in discovering knowledge and developing new skills. For instance learners can be coached into developing an inquisitive mindset.
We have a computer lab, a projector and desktops that have in built speakers. This provides opportunities for student teachers to develop their own multimedia content to aid in their training."

"I set my students the task of preparing a news report on the issue of malaria. They had to explain how the disease spreads, how it is treated and how it can be prevented. The best responses got the science right and included interviews with (pretend) victims and medical workers. They recorded their reports on a mobile phone and I shared them using a projector."

Accessing technology in your school

Drawing on the ideas in this unit and under the guidance of your Head of Science help to make a departmental audit of the technology that you have in your school and that your department could use. For example, you may have a projector but have to book it well in advance; you may have a laptop or tablet that you can take into a classroom, or you may have access to a computer lab.

How do you access the internet? Try and find ways of working with your Head of Department and departmental colleagues to share resources that you have downloaded so that you can save on the cost of data bundles.

Activity 8: Accessing technology

Look back at your responses to Activity 3 in this unit. Now make a table of the technology that you have access to. For each one, highlight the issues – but more importantly the opportunities.

Device	Opportunities	Issues	Solutions/ideas
Phone	Access to the internet Social media Camera, video and voice.	Cost of bundles.	Work with HoD/colleagues to share Record student presentations, photograph student work.
Projector			
Laptop			
Tablet			
Computer lab			

Activity 9: Developing ideas

Working with your Head of Department or a colleague, select a topic in your specialist science subject you are teaching next week. Use the table you made in Activity 8 to develop one of the ideas in activity 7 into a detailed lesson plan. Try to focus on technology you have access to – or are likely to have access to in the future. If you have worked with a colleague, share your plan with your HoD. Agree with your HoD that they will sit in on the lesson to look positively at the ways in which you have used ICT. Think of ways in which you could organise the class to make the most of what you have.

After the lesson meet with your HoD or your colleague to reflect on what technologies you used and/or what you could have used. Think of more ways to ensure that your suggestions 'extend' and 'transform' learning.

Summary

Using technology effectively to support learning is a about pedagogical improvement, though confidence in the use of technology is important. Used creatively ICT provides opportunities for critical reflection on material related to the lessons.

Reflection point

Reflect on some of the things that you have learnt and some of the things that you would like to get better at. You should raise these with your Head of Department who will be able to help you to think more deeply about your lessons and how they may be further improved step by step.

A full list of the OpenSTEM Africa CPD units can be found at:
https://www.open.edu/openlearncreate/Teacher_units

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