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The Use of Digital Content to improve upon the Teaching and Learning of Science in Basic Schools in Ghana

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Abstract

The use of improvised materials and digital content would have the following advantages : students would be able to construct their own items and use them to explain basic electrolysis while the school waits for the materials to be provided. Teachers would be able to prepare for lessons more easily. The digital content would provide some information about improvisation in explaining concepts. It is also a boost for environmental education in the sense that the electrolytes used would have few problems regarding their disposal and students would already be used to the materials. Finally, the cost of education, especially in the rural areas would be kept low as low cost materials would be used when the school could not afford the equipment.

Introduction

One of the most important activities performed by an educational instructor in science is the selection of instructional materials. Therefore it is very important for good communication between teachers and students in a way that meets their needs using a variety of instructional materials which includes charts, models, specimens, printed materials, such as textbooks and manuals, and audio-visual instructional materials like audio tapes, videos, computers and their accessories.

A vital aspect of the teaching and learning of science is the use of improvised materials in place of those materials that are not available, as well as the use of Information, Communication and Technology, ICT, and these together help to bridge the huge gap between the teaching and learning of science and truly assimilating it.

In Ghana, the tertiary institutions and some high schools have some access to the internet, but most of the basic schools are yet to be provided with internet services. In the educational system, since the emphasis is on strengthening basic education including raising the basic level of science achievement, some of the Teacher

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Training Colleges have been designated as Science and Maths colleges, so that qualified teachers who graduate from these colleges can adequately handle these subjects at basic schools. Students also take a course that covers the basic use of a computer. In order to bridge the gap between learning science and actually doing it, the use of improvised materials must go hand in hand with the provision of internet services which will result in the production and use of digital content material by teachers which are very much related to the local curriculum of the country[1] especially at basic schools. In this vain, this paper will take a look at the use of improvised teaching and learning materials by basic school teachers in Ghana and attempt to explore an alternative methodology for the teaching and learning of science.

Country profile of Ghana

Ghana is located on the west side of Africa and around its borders are the neighbouring countries of Cote D'Ivoire, Burkina Faso and Togo (see Fig 1). Its official language is English and it became independent from Great Britain on 6th March 1957. The size of the country is 238,533sq km (about the size of Honshu in Japan). There are two seasons (the rainy season and the dry season). The main tribes are the Akans, Gas, Gonjas, Guans, Adages, Frafra, Walas, Ewe, and the Dagombas. The main religious groups are Christians (63%), Muslims (21%), and other traditional religions (16%). The money denomination is the "cedis". 18 year old Ghanaians are considered to be adults and can vote in elections. Regarding politics, Ghana operates a multiparty democracy with presidential and parliamentary elections every 4 years.

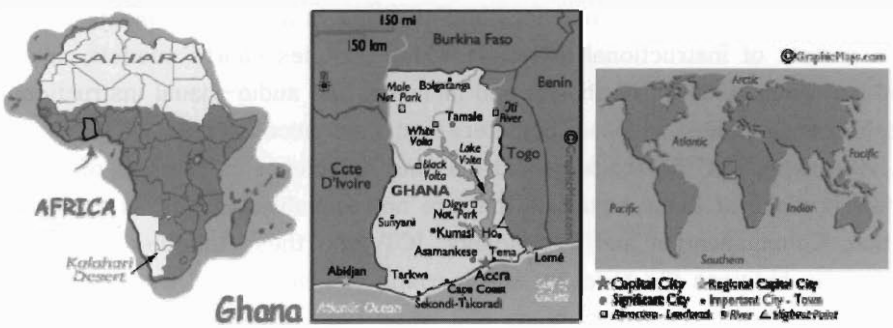


Figure 1 The location of Ghana on African and World maps.

Information, Communication and Technology (ICT) and the Education

There is no doubt that the world has gradually changed with the introduction of computers and other equipment. Information Communication and Technology (ICT) is defined as the set of facilities that facilitate by electronic means the processing, transmission and display of information. In other words, ICT covers any appliance or product that can be used to store, retrieve, manipulate, transmit or receive information electronically. Examples are computers, television sets, telephones, robots etc. One of the most significant of these examples, which is able to transmit large volumes of information and currently has a growing number of users, is the internet. The percentage of internet users for each continent area are shown in the graph below (Fig. 2).

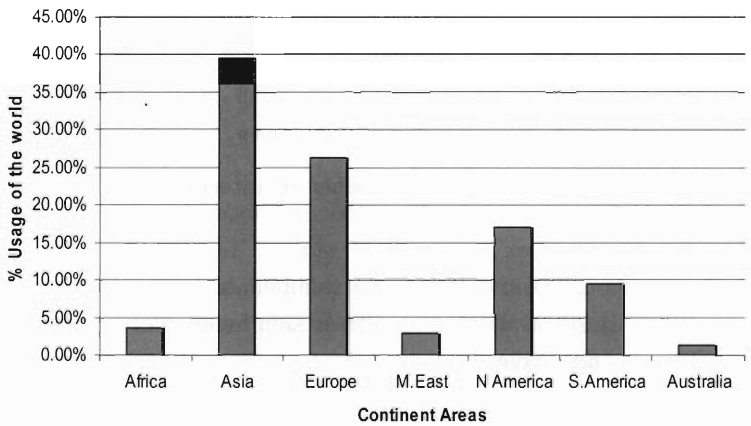


Figure 2 The percentage of internet users in each continent of the world.[1]

Asia has the highest percentage of users and this figure is 11 times larger than Africa, which has a user percentage of 3.5%. Europe has the second highest percentage of users behind Asia.

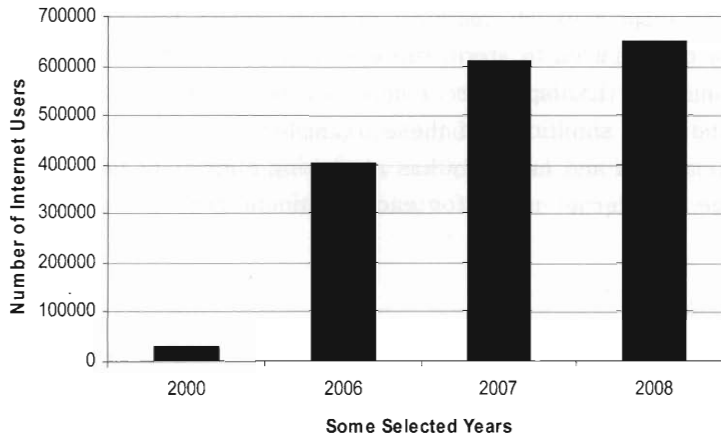


Figure 3 The increase in the number of internet users over some selected years in Ghana.[2]

Between the years 2000 and 2006, the number of internet users has risen 13 times and from 2006 to 2007, there was also a significant increase in the number of internet users (Fig. 3 and Table 1).

Table 1 Internet users with regard to population growth in Ghana.

Year	Population	Internet Users	Users of the population (%)
2000	18,881,600	30,000	0.2
2006	21,801,662	401,300	1.8
2007	22,931,299	609,000	2.7
2008	23,382,848	650,000	2.8

Even though the table above gives an indication that there has been a significant increase in the number of internet users with an increase in the population, this might not necessarily indicate an increase in the number of personal computers per household in a developing country like Ghana. Studies[4] have shown that the ICT sector can be used as a job creation opportunity for the youth. Again, ICT can be used as a skill for enhancing the chances of getting a job. It has also been reported that the youth face a form of discrimination in the open labour market since employers always go for experienced and skilled people who often have worked doing that kind of job for a number of years. The challenge in addressing youth unemployment

was to engage them in some form of skills training to improve their chances of getting a job. In recent times schools are taking up the role of educating students in ICT. With access to ICT, professional development and support, teachers who have used technology to learn will be more able to help students in the use of ICT. It has been noted that another challenge that e-learning can be used to address is the use of e-learning to deliver training to an already active workforce instead of mobilizing them for face-to-face learning which always proves to be costly. Furthermore, there are many more people requiring training than experts to deliver that training, and instead of attempting to place these experts at so many places to deliver the training, e-learning can be used. Using e-learning for training provides another methodology but does not totally replace the traditional form of delivering training. In some developing countries, there is restricted admission into traditional universities due to a lack of additional facilities and there is also non-availability of tertiary institutions to students from nearby villages, so these students have to travel long distances to attend tertiary institutions. In order to increase the accessibility to tertiary education in developing countries, "Open university" has been proposed. The "Open university" is said to use a mixture of technology ranging from face to face, print, audio, video and web-based to deliver lectures to students living in different areas. When the educational sector adopts new and emerging technologies for schools and classrooms (including e-learning) it will offer good opportunities for developing countries to introduce new teaching tools to be used together with the old ones. E-learning allows for efficient transfer of knowledge anywhere and anytime regardless of the subject matter. The transfer of knowledge by electronic means also provides an opportunity for some countries to produce their own training content and make them available for use. Using digital content to teach some concepts in science has been recommended as another way to teach and learn science. However there are a number of challenges to the use of the internet and, for that matter, e-learning. It is reported that there is a lack of, or very low, internet connectivity in some developing countries. Furthermore, people who do not have access to the internet and personal computers would have to go to other places and pay for the internet use at a high cost.

Studies have revealed that[5] among the other ICT protocols like the radio, which has a large audience, moderate cost of production and delivery giving it a lower cost per learner. Radio offers a moderate cost for distance programmes for adults in health and agriculture, but with modern trends the radio is not able to provide the visual part of the information being transferred. Students in basic schools are usually between the ages of 6 and 15 years, and their use of the internet needs to be strictly monitored, therefore the simpler use of ICT will be the digital content produced by educational authorities and recorded on CDs or CD ROMS.

The digital content consists of topics from their syllabus and short videos of

how to perform very simple experiments and demonstrations. If the students are able to observe the digital content and discuss it with their peers, the teacher will not have to spend so much time on that particular concept. The use of the digital content provides the learners with the opportunity to learn at their own pace, which is especially useful for slow learners so they can learn ahead of time so that the class does not have to wait for them during class lessons. Again the challenge is the non-availability of the digital content.

Information was obtained from teachers teaching in basic schools over an area in the central region of Ghana. Some documents with very vital information were also obtained from some schools. Due to distance and time constraints, it cannot be said with certainty that the findings were the exact reflection of what was pertaining in lots of basic schools with reference to the use of ICT in the teaching and learning of science. Thus the findings cannot be used to make generalizations.

A survey was done earlier on Ghana's participation in *TIMSS 2003*[9] and it was noted that the certification of teachers, their teaching experience as well as their background, among a lot of other factors, had an effect on the level of achievement of the students in science which has shown some differences to other selected country's scores in 2003 and 2007. The average score of Ghana in science as compared to other selected countries has increased from 255 to 303 (Fig.4).

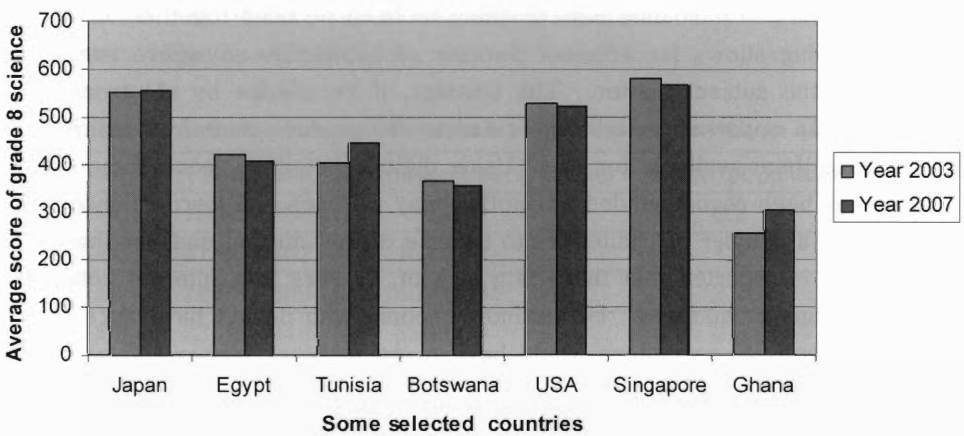


Figure 4 Performances in science for some selected countries in TIMSS 2003 and 2007.

Figure 4 shows a summary of some countries science results. A low percentage of Ghanaian basic school students were taught by teachers with university degrees. The majority of the teachers at the basic level at that time had Teachers' Certificate 'A', a post secondary teacher training certificate, which is not a degree. The science teachers had an average teaching experience of about 8 years. Also the

majority of mathematics and science teachers at grade 8 were males with only about a tenth being females. Some teachers were also reported to have placed more emphasis on relating the knowledge acquired by students in their daily lives instead of placing more emphasis on the conduction of scientific investigations. The JSS2 students were therefore taught by teachers, many of who were below 30 years of age, which was in contrast to the situation in most of the countries which had a high achievement in science. Also, two thirds of the countries which had a high achievement in science and mathematics had 8^{th} grade and 4^{th} grade teachers with at least a university degree or an equivalent. The science teaching force around the world was reported to have an average of 16 years of teaching experience.

One of the most important activities performed by an educational instructor is the selection of instructional materials or improvised ones to enhance student learning. Students come to school with different learning styles, unique backgrounds and experiences and varying levels of interest. Therefore it is very important for good communication between teachers and students in a way that meets their needs. Instructional materials include charts, models, specimens, printed materials, such as textbooks and manuals. The audiovisual instructional materials include audio tapes, videos, the use of computers and the internet in instruction which have been classified as part of ICT.

For education, ICT can be defined as the computing and communication facilities and features that support teaching and learning. The basic ICT equipment that can be found in almost all homes are the radio, television etc, but some people use these items mostly for purposes other than educational purposes. As traditional classroom practices no longer provide prospective teachers with all the necessary skills for teaching students to survive economically in today's work place, distance education by means of radio and television for basic and secondary schools was introduced. It is a project called "Presidential Special Initiative on Distance Learning" and is sponsored by the Government of Ghana through the Ministry of Education in which subjects like Mathematics, English and Science etc, are broadcast on television. But it is reported that a lack of interactivity, the inability of electronic equipment to receive signals and timings of radio and television programmes among other issues were cited as reasons for the low usage of television and radio for educational purposes.

The television stations that broadcast educational subjects can allow some form of interaction by inviting the viewers who are watching the program to call in to ask questions and ask for clarification about the points they do not understand. However these programs are aired in the morning when the students are at school and in the afternoons when the students are attending extra classes or attending to household chores. Since the programs are just 30 minutes, the educational authorities can fix the timetable so that students can watch it and discuss concepts among

themselves, but there is the likelihood that topics covered on the television might not be the same topic that is being taught by the teacher in the classroom. There are still some remote areas in Ghana which have very poor reception for television programmes.

The national radio and television station broadcasts subjects like mathematics, English, Science etc for basic and secondary schools. This is called "The Presidential Special Initiative on Distance Learning" and it is sponsored by the Government of Ghana through the Ministry of Education.

According to the cone of learning experience students will be able to remember 50% of what they learned using the audio-visual material, which tends to be midway between abstract and concrete, and when they discuss it with their peers the retentive memory concerning the concept learned increases to 70%. This is where audio-visual materials, like the television, the video cassette recorder (VCR), the computer and its accessories, which are part of Information Communication and Technology, ICT, can be used to show digital content with the use of improvised materials to both teachers and students (Fig. 5 and 6). 650,000, representing 2.8% of the estimated population are internet users[3]. Some of the higher institutions have ICT followed by the secondary level. Most basic schools have no ICT, but it is expected that they will be provided with some basic ICT in the future.

The education policy[4] for ICT in Ghana has the following as part of its objectives :

- To provide guidelines for integrating ICT tools in all levels of education
- To provide a means of standardising ICT resources for all schools
- To facilitate the training of teachers and students in ICT
- To promote ICT as a learning tool in the school curriculum at all levels
- To ensure that all students have ICT literacy skills before completing each level of education.

Figure 5 Demonstration of motion on TV

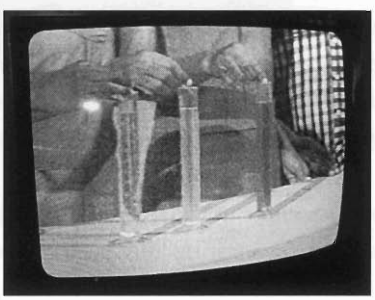


Figure 6 Demonstration of viscosity on TV

Some current projects in 2007 were the Global Teenager Project and Nepad E-schools (New Partnership for Africa's Development) which aimed to expose children to ICT use in education. Some efforts at raising student achievement in science include:

(a) Student assessment in science has been monitored within the framework of the Trends in International Mathematics and Science Study (TIMSS) organized by the. International Association for the Evaluation of Educational Achievement (IEA), for students in both 2003 and 2007. The average score in grade eight science increased from 255 in 2003 to 303 in 2007.

(b) 15 of the 38 Teacher Training colleges have been designated as science and maths colleges.

(c) Science, Technology and Mathematics Education (STME) Clinic, instituted in 1987 aims to help increase the number of girls who opt to study science at higher levels in educational institutions.

(d) Science, Technology and Mathematics project (STM), a technical cooperation project between the Governments of Ghana and Japan (2000 - 2005) aimed to help improve the capacity of basic school teachers in the teaching and learning of science and mathematics.

In March of 2008, when 2nd year teacher trainees in one of the training colleges in Ghana were asked to choose from a number of topics, what they would like digital content to be prepared for, 20 of them who represented 66% of the teacher trainees decided on "Types of forces" (Fig. 7).

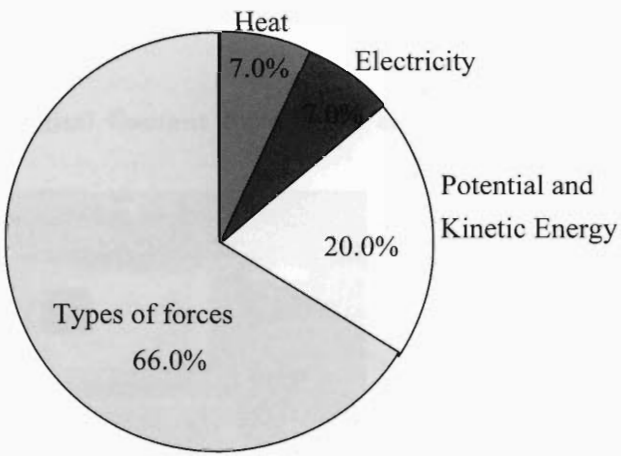


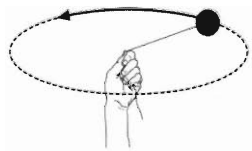
Figure 7 The topics that teacher trainees wanted digital content to be prepared for.

From the question below, Ghana's score was 22, well below the international average of 60 (Table 2). According to the intermediate international benchmark of science achievement, students are expected to be able to communicate basic scien-

Table 2 The performance of Ghana on a question item as compared to some selected countries.

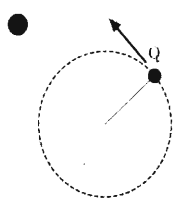
TIMSS2003 Intermediate International Benchmark, 475
Content Area : Physics
Example Item 5
Topic : Forces and motion

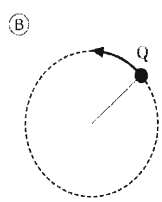
The diagram on the left shows a ball on the end of a string being whirled in a circle. The diagram on the right shows the whirling ball as viewed from above.

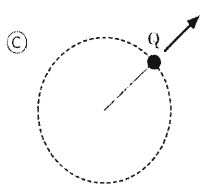


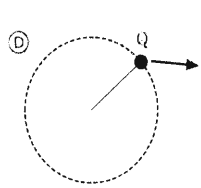
(View from above)

After several whirls, the string is released when the ball is at Q. Which of these diagrams shows the direction in which the ball will fly the instant the string is released?









Country	Overall % correct
Ghana	**22**
Korea, rep. of	87
Singapore	79
Japan	77
USA	76
England	74
Morocco	33
South Africa	22
International Mean	**60**

tific knowledge and they also should be acquainted with some aspects of energy, force and motion among other things, but the graph further below shows the mean performance of Ghana in Physics as compared to some other countries (Fig. 8).

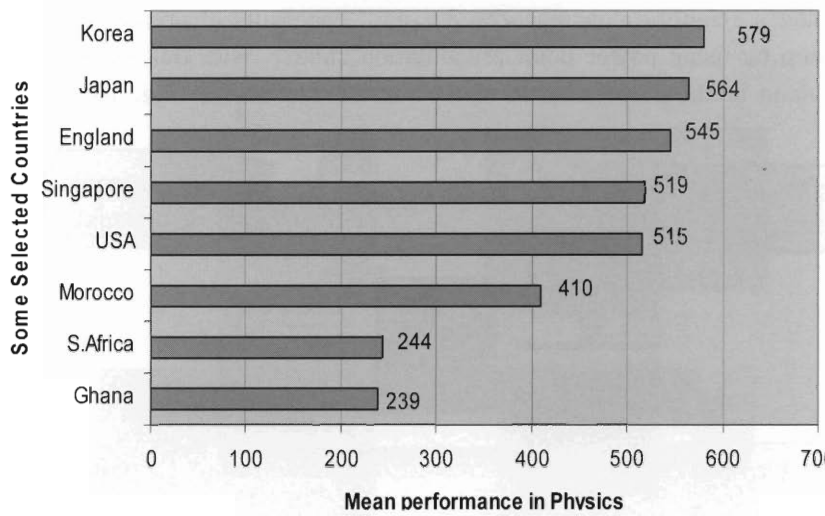


Figure 8 Mean performance in Physics as compared to some selected Countries in *TIMSS -2003.*

The results showed that the Junior High school, second year students in Ghana who answered the questions had little conceptual understanding of some scientific principles and therefore had difficulty in solving problems requiring the application of these principles.

An example of Digital Content Production and Use

Figure 9 Digital content production and editing system.

The digital content production and editing system looks like a special computer which comes together with a microphone, and a camera which uses software called "Content Author Presto" (by a Sony broad- band solution company) (Fig. 9). The digital content to be prepared starts with the preparation of the materials to be used in explaining a scientific concept or concepts. The material preparation is recorded step by step by using power point presentation slides. With this system, the explanation is done at the same time as the materials are shown (Fig. 10).

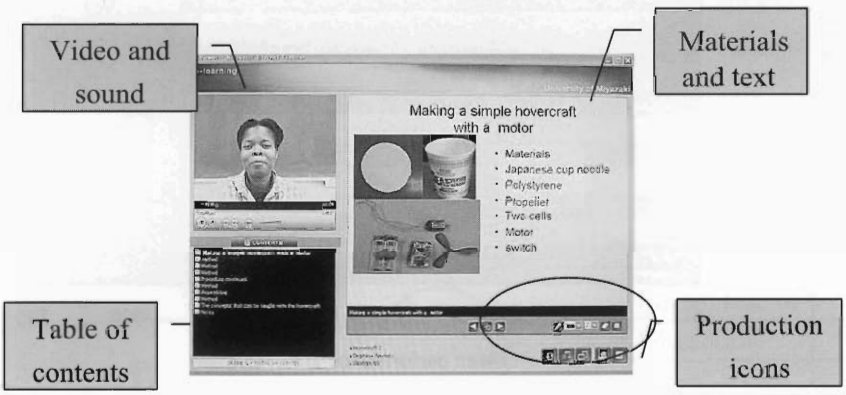


Figure 10 Computer monitor showing the content production and editing system.

The monitor of this system shows the pictures of the person giving the explanation and the materials that are being referred to. Also, certain marks can also be used to point to particular areas. This special computer is not in all the schools, but in order to make the digital content, all the stake holders in Education would have to purchase it together with all the necessary software. After the digital content is produced, it is either uploaded onto the internet or recorded on CDs for use by both teachers and students either in the classroom, the home or the training colleges (Fig. 11).

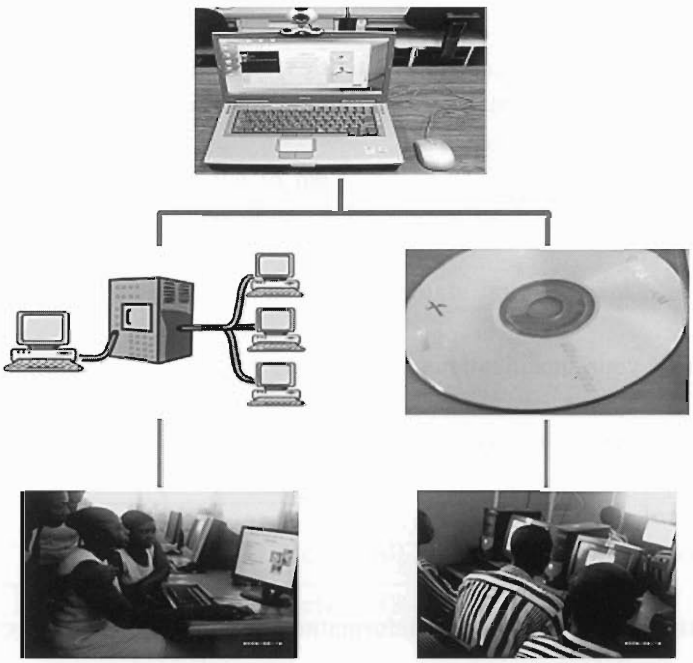


Figure 11 Uses of the digital content.

Implications for teaching

The preparation of the digital content recorded on CDs will enable the teacher to have alternatives when it comes to finding materials to use or construct to explain some of the concepts in science. Again, since simple chemicals like Hydrochloric acid, Sodium Hydroxide etc are very expensive to obtain, and if they are to be used in repeated simple demonstrations, short videos of simple procedures can be produced to show to the students as the school authorities attempt to obtain the chemicals. With the digital content students who have access to a computer or any other appliance that can play the digital content, can learn anywhere, anytime and at their own pace even in the absence of an internet connection. Most importantly they can revise topics before coming to class.

Views on digital content and other materials

In 2008, 20 Ghanaian basic school teachers where asked to fill in questionnaires regarding their background, teaching activities and digital content use. The questionnaires were collected and collated and the information sent by email to Japan. The results are shown in Table 5-12.

1 Sex : Male ( ) Female ( )

2 Age : ..... Marital status : .....

3 Please write your qualifications.....

4 Number of years in service.....

5 Which school do you teach at?
(a) Public school (b) Private school

6 Mention the resources you get information from to prepare for science lessons.
.....

7 Please comment on the duration of the science period. Tick one.
( ) Enough ( ) Not Enough

8 Which in-service training have you undertaken to enhance the teaching and learning of science in the basic schools. Please tick any of the following:
( ) The production of digital content
( ) Science Technology and Mathematics (STM project)

9 From where do you obtain materials for science lessons that are not readily available in the environment? Please tick 1 of the following.
( ) From the school authorities.
( ) Construct them if possible.
( ) Explain science concepts verbally to students

10 Please state 5 items that you would like to be provided with, so that you can use them to teach certain concepts in basic science.....
.....

11 Do you use any digital content materials to teach science?
Yes ( ) No ( )

12 Do you have an internet connection in your school?
Yes ( ) No ( )

13 If the answer is "No" to no. 7, where do you access the internet from?
(a) From a Café
(b) From another school close to me
(c) State any other.....

Table 5 Age distribution of teachers in Ghana

Age range	No. of teachers
20 - 30years	6 teachers (30%)
30 - 40years	10 teachers (50%)
40 - 50years	4 teachers (20%)

Table 6 Marital status of teachers who completed the questionnaire

	Married	Single
Male	8 teachers (40%)	5 teachers (25%)
Female	4 teachers (20%)	3 teachers (15%)

Table 7 Qualification of the teachers

Qualification	Male	Female
1 Master's Degree	5%	--
2 First Degree	55%	20%
3 Diploma in Basic Educ.	5%	10%
4 Teacher's Certificate A	--	5%

Table 8 Type of basic school they taught in.

Type of school	% of teachers
(a) Public school	80%
(b) Private school	20%

Table 9 Basic items used in the preparation of science lessons.

Main items used to prepare a science lesson	Responses
(a) Syllabus and books	95%
(b) Syllabus, books and the internet.	5%

Table 10 Duration of science periods

Duration of science lessons	Responses
(a) Enough	40%
(b) Not Enough	60%

Table 11 In-service training attended by the teachers in the sample size.

Access to in-service training	Responses
(a) Training regarding the teaching materials	50%
(b) Digital content production and use.	0%

Table 12 Accessibility of the teaching materials in the schools.

What is done when materials are not available	Responses
(a) Construct them.	50%
(b) Explain concepts verbally	40%
(c) Wait for materials from the authorities	10%

Table 13 Types of materials easily found in the environment and those that are needed.

Consumables	Non consumables	Recyclables
Alum*	Stop clock/ watches*	Card boxes*
Candles*	Flashlight*	Cans*
Dry cells*	Stones*	Plastics*
Common salt*	Test tube holders(pegs)*	Bottles*
Flashlight bulbs*	Insulated copper wire*	Zinc metal from dry cells*
Chemicals**	Charts**	
Reagents**	Models**	
	Measuring instruments**	
	Laboratory glassware**	

* Items easily obtained from the environment
** Items needed

Future study

In the future, the researcher would like to locate more simple household items that can be used as electrolytes, which will produce a higher current and voltage without producing any environmental hazard. So far the voltage has been limited to smaller voltages. Also, the researcher would like to make an investigation into the production of Chromium (III) and Chromium (VI) with regards to using stainless steel for electrolysis to produce high voltage.

Countries which take part in TIMSS science assessments, organised by IEA, can form links in an effort to enhance the teaching and learning of science at the basic level.

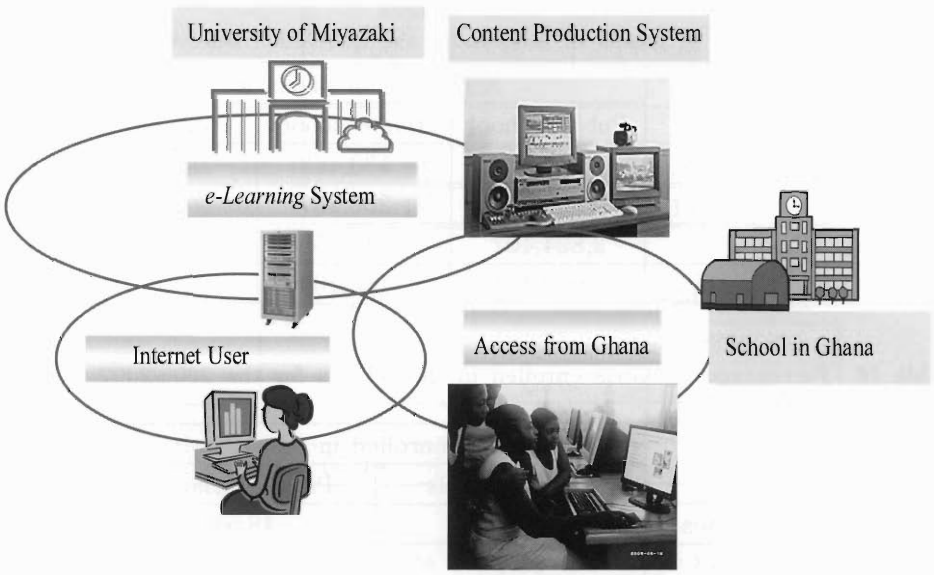


Figure 12 University of Miyazaki Post-graduate Educational Research e-learning system.

The figure above shows the e-learning system introduced at the Faculty of Education and Culture, University of Miyazaki (Fig. 12). When the digital content is produced, it is uploaded onto the internet, where both students and professors can access the page and view the digital content, providing they have an internet connection and the appropriate password. The researcher, while in Ghana, would like to conduct some research into how this e-learning system, which is accessible from Ghana with a password, could be used with regards to the production of digital content.

Appendix :
Data on Basic Education in Ghana

Table 14 Number of schools for the 2006/2007 academic year at the basic level[1]

Type of Schools	Number of schools		
	Public school	Private school	Total no. of schools
Nurseries	975	2,661	3,636
Kindergartens	10,008	3,742	13,750
Primary schools	12,880	3,530	16,410
Junior High schools	7,122	1,932	9,054

Table 15 Enrolment of pupils in schools for the 2006/2007 academic year

School	Enrolment of pupils in schools		
	Public school	Private school	Total no. of pupils
Nurseries + crèches	51,112	133,462	184,574
Kindergartens	896,522	208,257	1,104,779
Primary schools	2,824,407	541,355	3,365,762
Junior High schools	952,151	180,167	1,132,318

Table 16 Percentages of Girls enrolled in the schools for the 2006/2007 academic year

Schools	% of Girls enrolled in the schools	
	Public schools	Private schools
Nurseries + crèches	50.5%	49.5%
Kindergartens	50.0%	49.6%
Primary schools	48.4%	49.3%
Junior High schools	46.1%	49.2%

Table 17 Number of teachers in the basic schools for the 2006/2007 academic year

Schools	Number of teachers (2006/2007 academic year)		
	Public school	Private school	Total no. of teachers
Nurseries	1,507	5,149	6,656
Kindergartens	27,059	7,081	34,140
Primary schools	84,324	20,933	105,257
Junior High schools	54,210	12,795	67,005

Table 18 Percentages of Trained Teachers in the schools for the 2006/2007 academic year

Schools	% of Trained Teachers (2006/2007) academic year	
	Public schools	Private schools
Nurseries + crèches	29.2%	11.0%
Kindergartens	35.7%	12.2%
Primary Schools	62.1%	16.4%
Junior High Schools	77.2%	26.9%

Table 19 Pupil-teacher ratio in the schools for the 2006/2007 academic year

Schools	Pupil-Teacher ratio (2006/2007)	
	Public schools	Private schools
Nurseries	34 : 1	26 : 1
Kindergartens	33 : 1	29 : 1
Primary Schools	34 : 1	26 : 1
Junior High Schools	18 : 1	14 : 1

Table 20 Completion rate of pupils for the 2006/2007 academic year

Schools	Completion rate of students (2006/2007)		
	Boys	Girls	Total
Primary schools	76.0%	76.9%	80.4%
Junior High schools	67.4%	57.9%	62.8%

Table 21 Basic Education Certificate Examination results in Junior High exams in third year.

2008 Basic Education Certificate Examination results		
Total number of candidates	Number of those who passed.	% of those who passed
338,292	210,282	62.16%

Table 22 Population and number of internet users[2]

Year	Population	Internet Users	% Internet users in the population
2008	23,382,848	650,000	2.8%

Table 23 Some projects in ICT being undertaken in Ghana in 2007[4]

Project : Innovative Best Teacher Award-awards for teachers who excel in using ICT in education Organization : Ghana Education Service Funding Sources : Government of Ghana (Ministry of Education)
Project : Global Teenager Project-using the internet and especially email as a catalyst to structure exchanges between school teachers. Organization : Rescue Mission Ghana Funding Sources : School Net South Africa & International Institute for Communication and Development (IICD)
Project : Nepad E-schools (New Partnership for Africa's Development) -supporting six schools in six regions with ICT infrastructure Organization : Ministry of Education Funding Sources : HP, Microsoft, Cisco and Oracle

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