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Students' preparedness to integrate Information and Communication Technology tools and resources for the learning of Organic Chemistry concepts in the District of Masvingo, Zimbabwe

Crispen Bhukuvhani, Nicholas Zezekwa and Gladys Sunzuma
Bindura University of Science Education, Zimbabwe

ABSTRACT

Information and Communication Technology (ICT) tools form an important component in the teaching-learning process. The research surveyed 100 A' Level students' views on the availability of ICT tools and resources and their preparedness in terms of computer literacy to successfully integrate ICT resources in learning organic chemistry concepts. A self-constructed questionnaire was used to collect data complemented by in-depth interviews and in-situ observations. Data collected was analysed using SPSS Version 15 to find frequencies of commonly held views. The study revealed students had no ready access to computers. Computer usage for learning purposes and other uses was relatively low. Schools had no Computer Aided Instruction (CAI) software. However, the students agreed to a larger extent that integrating ICT in teaching and learning of Chemistry enhances conceptual understanding of Organic Chemistry. The researchers recommend that it must not only be the role of the teacher to encourage for the increased use of ICT tools but all stakeholders (parents, government, industry) to realise fruits from this noble endeavour.

Keywords: *ICT Integration, ICT Tools, Organic Chemistry, Advanced Level*

INTRODUCTION

Bell (1973), Reich (1991), and Toffler (1980) cited in Reigeluth (1995) have identified several massive changes that today's society has undergone, from the agrarian age to the industrial age, and now the information age. These drastic changes have certainly affect today's education systems at various levels (Goktas and Yildrim, 2003). The need to incorporate Information and Communication Technologies (ICT) into education is now inescapable (Goktas and Yildrim, 2003). In this context, integration of ICT into education is a critical issue. ICT has had a critical role in enhancing the quality of education. The role of ICT is to serve education in particular, by helping students to learn and teachers to perform their teaching profession more effectively (Goktas and Yildrim, 2003). It is also important to note that despite the abundance of these technologies, effective use of them is a critical issue.

In Zimbabwe, Advanced Level ('A' Level) is a two-year secondary education course (i.e. fifth and sixth years of secondary school education) equivalent to grades 11-12 in South Africa or AS Level in Britain. Chemistry is believed to be a challenging discipline at 'A' Level by many people. Erduran and Scerri (2003) noted that 'A' Level Chemistry students experience difficulties with many Chemistry sub-disciplines which include among others inorganic chemistry, organic chemistry and physical chemistry. Erduran and Scerri (2003) provide an insight into how an understanding of the structure of chemical knowledge could improve teaching and learning in the subject. Some concepts need to be developed in a linear manner as in organic chemistry, but in inorganic chemistry there may be no clear relationship between the concepts under study. As a result organic chemistry has troubled many teachers and students. Green (2002) in her study analysed the content of chemistry sub-disciplines and revealed that there is a difficulty in methodology and approaches of teaching organic chemistry concepts. Consequently, 'A' Level

examiners' reports, have also reported on poor performance in organic chemistry questions, (e.g. UCLES 1993; UCLES 1994; UCLES 1997; UCLES 1998; UCLES 1999a; UCLES 1999b; UCLES 2000a; UCLES 2000b; UCLES 2001a; UCLES 2001b; UCLES 2004a; UCLES 2004b; ZIMSEC 2005).

This has pointed to a pedagogical issue that has prompted the need for and provides an opportunity to look at the art of teaching and learning of organic chemistry at 'A' Level. It is an indisputable fact that the learning of chemistry is very dependent on the use of student-centred methods, participatory methods and problem solving approaches for both theoretical and practical lessons (Skemp, 1987; Jaji, 1994). Integrating computers into the teaching and learning of organic chemistry can go a long way in solving the above problem, since it is an alternative approach available to the teachers and students in the study of chemistry (Anderson 2002; Gyongyosi 2005).

The Government of Zimbabwe's position on integrating ICTs has been seen through the expanded rural electrification programme and its commitment to equitable access to ICTs-embedded education and facilitating the acquisition of basic, applicable and affordable ICT equipment as well as the landmark launch of the ICT policy framework in 2005 (Muchena, 2005)

This, therefore, makes it worthwhile to explore ways in which computers, if available and readily accessible by both teachers and students, may be used in teaching and learning of organic chemistry.

CONTEXT OF THE STUDY

Computers are now available in many schools in Zimbabwe. Computers for African Schools (CFAS) have sent approximately 2200 computers to Zimbabwe for installation and use as educational tools (CFAS 2005). Zimbabwe also receives donations of refurbished computers from Computer Aid International, a non-profit organisation (CompAid 2006). Zimbabwe has also witnessed a countrywide donation of computers from the Presidential Computerization Programme (Muchena 2005). A total of 350 computers were donated to schools in Masvingo Province from the Presidential computerisation programme (MOESC 2006). The Ministry of Education Sport and Culture in partnership with World Links on the other hand donated a total of 400 computers to schools in Masvingo Province (MoESC 2006). It can be also noted that some responsible authorities for some mission and private schools buy computers for their schools.

Most schools with computers offer computing as a subject at Advanced Level. According to Cawthera (2005) the computer use in Zimbabwe is only a fraction, on average it is about 20-30% of what it should be. In another study the Harvard University Guide (HUG) was used to establish the e-readiness in Zimbabwe. The HUG is an internationally recognised model, especially for developing countries for e-readiness surveys. The HUG model uses a four-stage scale (1= low state of readiness and 4= ideal state of readiness). According to the HUG model, Zimbabwe is not uniformly ready and overall country score is 1.4 out of the possible 4.0 (Muchena 2005). This was attributed to lack of availability, cost and quality of ICT services and equipment and lack of networked learning which addresses how well the education system integrates ICTs into its process to improve learning among other reasons for the low rating (Muchena 2005).

Ottevanger, Leliveld, and Clegg (2003) in an ongoing Science, Mathematics and ICT (SMICT) study observed that in Zimbabwe calculators, ICT equipment such as computers, videodisks, and other electronic media are not yet being used much in schools for concept development. Emphasis is still on the specific media literacy skill acquisition. It seems ICT is rarely used as part of teaching and learning materials, not even in private schools where resources are

comparatively abundant. Teachers regularly use ICT for lesson preparations, mostly word processing but hardly in actual teaching. It is therefore no longer a question of availability but that of effective use (RGU, 2005). However, as Goldenstein (2002) noted, ICT must be integrated into the curriculum if it is to have any purpose in schools.

THEORETICAL FRAMEWORK

Potential Effects of Computer Use in Teaching and Learning of Chemistry

Perhaps, the single best-supported finding in research literature is that computer use in the teaching of chemistry produces achievement results superior to those obtained with traditional or conventional methods of teaching. According to Anderson (2002), computer aided learning (CAL) packages have the capability to transform the way pupils understand and learn. Anderson (2002) also noted that the richness and variety of the visual presentation of knowledge through these media, in contrast to the somewhat one-dimensional world of the textbook will open horizons for pupils of all abilities, but particularly for those who find verbally presented data more difficult to comprehend. The use of computers can greatly improve achievement (Cotton 1991; Funkhouser 1993; Naidoo 1997; Brambaugh and Rock 2001; Ku et al 2005).

CAI enhances learning rate, Cotton (1991) found out that CAI users sometimes learn as much as 40% faster than their counterparts. Cotton (1991) also found supporting evidence to the effect that CAI users retain their learning better; and that CAI leads to more positive attitudes than conventional instruction. Other benefits include high student attendance, motivation and collaboration among students.

Funkhouser (1993) found that students who used commercially available problem solving software scored significantly higher on tests than groups of students who did not use the software. It also improved their problem solving capabilities. Guhlin (1996) in Knuth and Rodriguez (2000) echoed the same sentiment saying that teachers can use technology for discovery learning and developing students' higher-order thinking skills.

Visual representations by a computer enhance teaching/learning of chemistry concepts. There is much research evidence on the positive effects of computer use. According to Yushau et al (2003) with computers students can visualize concepts, which are difficult to comprehend without computers. This stems from the fact that computers provide easier and clearer illustrations than those a teacher would make. In a study on the influence of visualization, exploring patterns and drawing generalizations, Yushau et al (2003) reported that students indicated visual representations on a computer screen as more beneficial to their understanding as compared to diagrams in books. In addition, Shaw (2006) noted that visual image goes beyond spoken and written words.

According to Romiszowski (1981) the inclusion of computers in teaching and learning is threefold; first, one can programme a computer to execute a particular instructional strategy faithfully. One can simulate more or less perfectly certain learner-tutor interactions and study them in much greater detail than is possible in real-life situation. Second, the data collection, storage and analysis capabilities of the computer make it an ideal base for research. Third, many cyberneticians would assert that the complexity of the teaching-learning process is such that only with the help of the data processing capabilities of a computer can we hope to improve the teaching/learning process from its primitive state of development (Romiszowski 1981).

Biggs (1999) argues that understanding is not transmitted by direct instruction but is enabled by the student's approaches to learning. In his view, learning is a process in which students interact

with the world. As they learn their ideas change and they see the world in a different light. Acquiring information will not change visual representations. They need to think about and structure the information to undergo conceptual change (Hewson et al 1998).

All these benefits of integrating ICTs in education have made the Nziramasanga Education Commission (1999) recommend the introduction and mainstreaming computer-based teaching and learning in the pedagogy of schools in Zimbabwe (Muchena 2005).

In the organic chemistry introductory topics, computer software can be used to help students in learning the nomenclature and general formulae of organic compounds for the learning outcome 10.1(a). Computer graphics can also be used to illustrate the shape of molecules for learning outcomes 10.1(c) and (d). Three-dimensional molecular models can be used to illustrate the concept of chirality and optical isomerism for 10.1(g) (CIE 2007; ZIMSEC 2007).

This research sought to answer the major research question: How are 'A' Level students using computers in learning of organic chemistry concepts? The following sub-questions guided the study:

1. Are there computers and ICT resources available and accessible for learning purposes?
2. How do students use ICT tools in their learning?
3. Are there sufficient CAI programs that can be used for learning of organic chemistry?
4. Do the students have the computer expertise to effectively integrate ICT in learning organic chemistry?

RESEARCH METHODOLOGY

The researchers used a descriptive survey design. The district has ten 'A' Level schools and of these five offer chemistry. Simple random sampling technique was used to select the students' sample from the five schools. The students who participated in the study were those who were present for the chemistry lessons the days the researchers visited and administered the questionnaires at their schools.

One hundred (91.74%) out of a possible 109 upper sixth form chemistry students were randomly sampled for the survey of these, 74% were male and 26% were female. These were the appropriate group since they had already covered the organic chemistry component in their studies. The modal age of advanced level students was 18 years (55%). Most of the respondents were from mission schools since in the sample three schools included for the study were mission schools, one private school and one urban boarding school.

The researchers gave full details of the intention of the research to the participants first. The participants had informed consent and their responses were handled with strict confidentiality. Their participation was voluntary and those who agreed had also a chance to withdraw from the study.

The questionnaire was used as the main instrument for the study. The questionnaire had both closed and open-ended questions. The questionnaire items solicited from students for the availability and use of computers, use of a variety of ICT resources, computer literacy and proficiency, frequency of computer usage and availability and use of CAL/CAI software. Questionnaire items were pilot tested to 'A' Level students in Bindura district to remove

ambiguities on the items thereby increasing the reliability and validity of the instrument. In-depth interviews with some of the students and teachers as well as site observations were also used complementarily to validate questionnaire responses through triangulation. Anonymity of the participants was preserved by use of pseudo names while schools were coded A, B ... to E.

Data collected was analysed using SPSS Version 15 to find frequencies of students' commonly held views as whether and how students are using ICT resources in their learning of organic chemistry concepts. The responses for each question were presented in percentages to easily judge the students' extent of ICT use in their learning. The extent of ICT integration was interpreted from responses as: < 50% = Low, ≥ 50 % but < 75 % = High and ≥ 75 % = Very High.

RESEARCH FINDINGS

Availability of Computers and Their Main Use in Schools

It is evident that in all schools which participated in this survey, computers were available; these also include computers in computer laboratories and those used for administration purposes. There is no school with less than ten computers. All schools had number of computers ranging from 10 to 20 on average. Physical observations by the researchers also confirmed that all the sampled schools had computers.

Most students indicated that the available computers are mainly for use in the classrooms (65%) followed by use in administration (16%). Personal use and professional development are very low with 13.3% and 6%. The classroom usage is mainly in the teaching and learning of computer studies as a subject. Interviews conducted confirmed that all these schools have included computer studies in their curriculum and is offered as a separate examinable subject.

> "*At our school, some of us do Computing as one of their subjects at 'A' Level" (Tinashe, School B)*

Accessibility of Computers and ICT Equipment

The computers are not readily accessible as reflected by percentage frequencies shown in Fig. 1 though it has been seen that this may be an intervention to enhance the understanding of organic chemistry concepts. Seventy-one percent of students indicated that computer aided learning programs are very helpful. Most of the respondents indicated that simulations help much in understanding the concepts such as reaction mechanisms and structure of compounds. They also mentioned that if available, computer-based chemistry software motivates them as they are interactive and can be used anytime if need be.

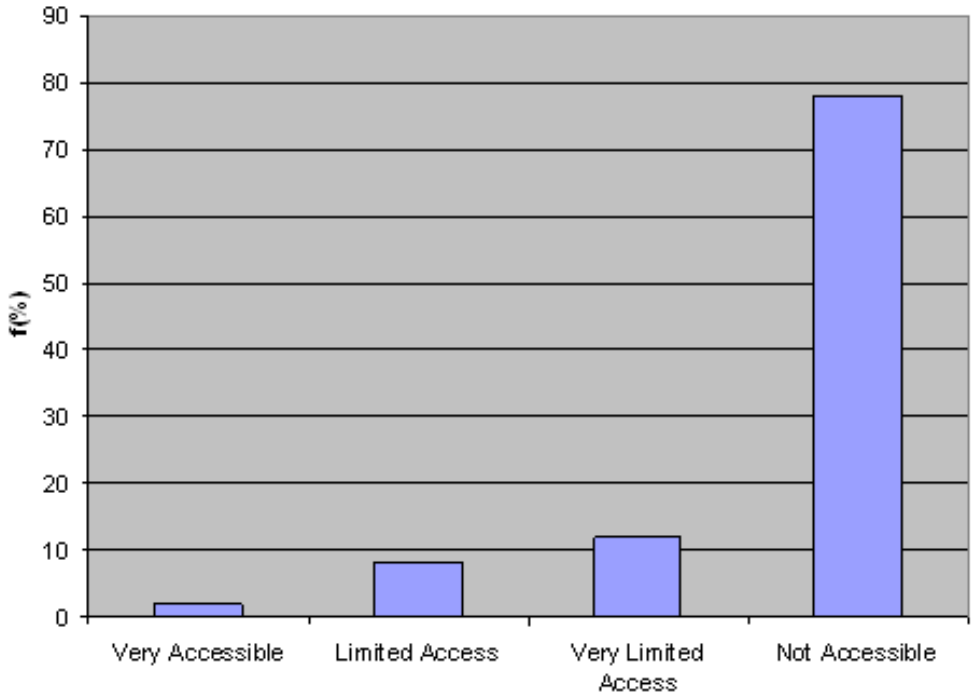

Fig. 1: Accessibility of computers for learning by students

Computing studies teachers and students are the one who have more access to and use of the computers available in the schools. This was echoed in an interview with another student *Sam, School A*:

> *"Only students who are doing computer studies and their teachers use the computer labs and though Internet is available it is only restricted to the administration"*

These comments tend to point to the message that there is lack of access for ICT resources e.g. computers for learning purposes.

Availability of CAI Software

Almost all students (91%) noted that there is no computer instructional software available at these schools. Very few could name some CAI software in Chemistry e.g. LiveChem, Chemistry Set, Organic Chemistry Help and The Virtual Chemistry Laboratory. These had either heard of them or read about them or used these at Internet Cafes. In all schools surveyed there was an indication that the necessary and needed software are very expensive that they can not afford.

> *"There are machines out there not being used by the departments because they can't afford the software that they need to run. We are talking about CD-ROM based stuff...There is so much, it is wonderful. But we can't afford it.... (Science Teacher, School E).*

Some teachers also indicated that ICT spending has to take second place when there are more important priorities such as buying textbooks:

> *"We know for a fact that there is nothing that we can do to develop our IT capacity in the school because we can barely keep pace with buying replacement textbooks." (Teacher, School C)*

Though there are no such computer software for Chemistry in schools and that most of the students are not even aware of their existence they do strongly believe that they are very helpful in enhancing the understanding of organic chemistry concepts as most of these offer simulations/modelling of organic reaction mechanisms and modelling three-dimension structures of organic compounds and isomerism among other responses they gave for the open ended part of the questions 13 and 15 on the questionnaire for students and teachers respectively.

Students' ICT Resources Usage and Computer Literacy and Expertise

The students rated themselves on computer literacy and proficiency as follows: 32% very literate, 46% moderately literate and 22% illiterate. Their use of varied ICT resources is as in Table 1 below.

Table 1: Students' use of ICT resources

ICT Resource	**Frequency (%)**
World Wide Web (WWW)	11
On-line resources	4
Externally produced software	12
Internally produced software	10
CD-ROM	38
Desktop Publishing	24
Word Processing	52
Spreadsheets	39

The findings have shown that word processing is the frequently used resource. There is less or no use at all of educational software packages. There is also little usage of CD-ROM based software and other generic software such as spreadsheets and desktop publishing.

From Fig. 2, seventy-four percent of the students have never used computer based learning materials, 12% used it termly and only 7% each for those who used ICT resources in learning weekly and daily respectively. This shows that the usage of ICT in learning is very low in schools in both frequency and variety. The use of ICT is generally restricted to word processing (53.3%). The use of specific educational software packages and use of a range of generic software such as spreadsheets, DTP and other forms of ICT such as Internet and WWW, on-line resources and CD-ROM are used relatively little.

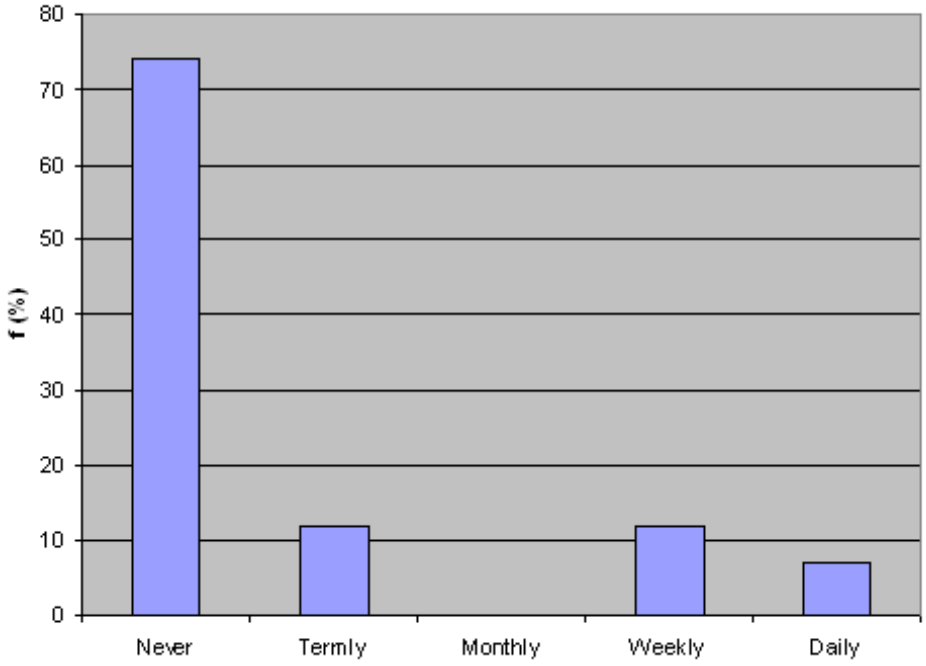

Fig 2: Frequency of ICT use in teaching and learning of Organic Chemistry

CONCLUSIONS AND RECOMMENDATIONS

The research findings reveal that computers are available in schools though they might not be adequate. It has been however, noted from the study that the students had no ready access to computer-based technologies at their schools. The major problem noted was that the computers were more or less a preserve for students who are doing computer science as a subject, with limited access to other subjects such as chemistry. Instead of using CAI and other educational packages, research findings show that word processing is the most used resource. Computer usage by students for learning purposes and other uses was very low, as well as their relatively low computer expertise was noted. Schools had no Computer Aided Instruction (CAI) software though the chemistry syllabus encourages their usage especially for organic chemistry. However, the students agreed to a larger extent that use of ICT resources in teaching and learning of Chemistry enhances conceptual understanding of organic chemistry.

To fully utilise the advantages brought in by the integration of ICT in education and specifically for enhancement of conceptual understanding in organic chemistry there is need to improve on accessibility of ICT resources, because increased computer experience as noted by Akkoyunlu (1996) cited by Assan (2003) diminishes computer anxiety. Computer technology use can be attributed to familiarity and knowledge (Assan 2003). Therefore, apart from availing the hardware there is need to avail CAI software in schools and increased use (accessibility) as attitudes toward computing can be significantly be improved with training and frequent use of ICT resources in learning. Computer-based technologies should be part of the classroom activities. For students to appreciate the benefits of ICT in their learning, teachers should design, develop, publish and present curriculum products using technology resources that demonstrate and communicate curriculum concepts to students inside and outside the classroom.

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