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### **NIGERIAN TEACHERS' PERCEPTION OF BARRIERS TO TECHNOLOGY INTEGRATION INTO THE CHEMISTRY INSTRUCTIONS**

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#### **Abstract**

*This paper documents chemistry teachers' perceptions of barriers to technology integration into the chemistry lessons. Underlying the study was a conceptual underpinning which focused on the concept of ICT integration, competencies of integration and chemistry curriculum. 13 participants were recruited for the study. Their participation in this research is voluntary. Semi-structured, open-ended interviews were employed as the means for collecting decontextualized statements about barriers to technology integration. The pool of statements obtained was subjected to phenomenographic analysis. A limited number of qualitatively different perceptions of*

*barriers to technology integration were identified as: lack of teacher training, lack of technical support, limited time for teacher planning, computer placement in remote locations making access difficult, budget constraints and basic resistance to change by many teachers. The discussion and implications sections of the paper explore the issues on barriers to ICT integration chemistry instructions in greater depth by pointing out the multifaceted relationship among the barriers as well as recommending ways of overcoming the identified barriers.*

**Key words:** Chemistry curriculum, technology integration, pedagogical competencies, technological competencies, teacher perceptions.

### **Introduction**

In many parts of the world, a large number of educational institutions have exclusively commenced introducing Information and Communication Technology (ICT) into the teaching of chemistry (Association of African Universities, 2002; Onasanya, Shehu, Ogunlade & Adefuye, 2011; Greaves, 2012). Today, the federal and state ministries of education in developing countries have invested huge amount of money to procure technology tools such as computers, CDs, DVDs, application software, digital media applications and devices, e-books and electronic references, handheld computers and the Web for improving the quality of science instructions in schools (Association of African Universities, 2002; Chitiyo, 2006; Wilson, 2010).

Modern technology offers many means of improving teaching and learning in the classroom (Lefebvre, Deaudelin, and Loiselle, 2006). New technology (e.g., computer, e-books, Web) also has the potential of increasing student motivation (Osborne and Collins, 2000 Hall & Hord, 2001; Bunch & Broughton, 2002; O'Hanlon, 2009) and class attendance (Shelly, Cashman, Gunter and Gunter 2006), facilitate clearer thinking, and develop interpretation skills with data (Newton and Roger, 2003). Students can conduct Web-based literature search, publish their work, meet students with similar interests across the

globe, and participate in shared learning experiences with classrooms worldwide (Becker, 1999).

For technology to enhance teaching and learning of chemistry, it must be integrated into chemistry curriculum. Technically and pedagogical sound chemistry teachers are the keys to successful ICT integration. The best strategy for ICT integration is to put the technology into the hands of the trained teachers, make it easily accessible, and let them decide on how to use it in their classrooms at the point of instruction. Robey (1992) noted that a teacher's vision of the use of technology to improve his/her existing classroom practices will eventually determine the extent and effectiveness of ICT integration in the classroom.

Research in the area of ICT integration into science classroom is focused on documenting teachers' level of awareness and extent of ICT usage (Adekomi, 2006; Onasanya, Shehu, Ogunlade, and Adefuye, 2011). It should be noted that relatively little research has been done on teacher perceptions of barriers to the successful integration of ICT into chemistry education. Barriers of ICT utilization in chemistry teaching can be perceived differently by teachers because of differences in their experiences, content knowledge, pedagogical content knowledge, and interests. Better understanding of pedagogical challenges in implementing chemistry curriculum can be achieved if chemistry educators understand teacher's perceptions of barriers in ICT usage. Teachers' perceptions of barriers to ICT integration in schools, however, influence design of the curriculum, implementation of curriculum, and development of useful educational technology projects. Thus, teachers' perceptions of barriers to the successful integration of ICT in teaching chemistry are central to creating a successful teaching and learning environment in chemistry classrooms. The study presented in this paper reports chemistry teachers' perceptions of barriers to the uptake of ICT in their chemistry classrooms. Several studies (Klinger, 2006; Shafika, 2006; Olakulein, 2007; Goktas, Yildirim & Yildirim, 2009) on teachers usage of ICT for instruction revealed that while teachers may know technology best practices, the potential of technology best practices,

the potential of technology in stimulating students' learning and making school studies relevant to real-life contexts, they do not put technology into maximum use for instructional purposes. It is obvious that hundreds of interrelated factors may be responsible for this observation. In light of the above-mentioned observation, this present study is conducted with the aim of expanding knowledge regarding the uptake of ICT for chemistry instruction. Hence, the conduct of this study is directed by a central research question which is formulated as: what barriers were encountered by teachers during ICT integration into chemistry instruction?

### **Conceptual framework**

#### **ICT integration**

ICT is basically a technological tool that is used for accessing, gathering, manipulating and presenting or communicating information. As viewed by World Bank (2006), ICT includes the full range of computers hardware, computer software and telecommunication facilities. Digital cameras, computer games, CDs, DVDs, cell telephones, telecommunication satellites, and fibre-optics are also components of ICT. It should be noted that ICT is not particularly reserved for education; it is not a panacea for solving all educational problems either but it is "certainly a useful tool that enables us to link various learning communities together in different ways" (Taylor, 2006, p.4).

Integration has a sense of completeness or wholeness (Earle 2002). ICT and other crucial educational components such as content and pedagogy are moulded into one entity. As a result, the quality of the lesson would somehow be diminished if the ICT ingredients were taken away from the ICT-integrated lesson (Williams, 2003).

ICT integration in this paper is defined as the combination of all technology parts, such as hardware and software, together with each subject-related area of curriculum to enhance learning. Furthermore, ICT integration is using any ICT (including information resources on

the web, multimedia programmes in CD-ROMS, learning objects, or other tools) to help meet the curriculum standards and learning outcomes of each lesson, unit, or activity.

Extensive formal training and practical experiences are imperative for successful integration of ICT at all levels of education.

### **Chemistry curriculum and information and communication technology (ICT)**

Literature on curriculum studies revealed that the term 'curriculum' can be used in a number of different ways. But for the purpose of this paper, curriculum is considered as the knowledge, skills and performance standards students are expected to acquire in particular educational levels or through sequences or clusters based on subject matter units of instruction, such as Language, Arts, Mathematics, Science, English and others.

In Nigeria, the senior secondary school chemistry curriculum has been designed in line with 6-3-3-4 educational system. Each unit in the SSS chemistry syllabus is organized under: topic, performance objectives, content, activity and notes. In some educational jurisdictions, the new curriculum is monitored by the inspectors from state Ministry of Education (MOE) and Teaching Service Commission (TESCOM), to ensure proper implementation in the classroom. Among other things, the chemistry curriculum seeks to achieve the following educational aims:

1. Acquiring of chemistry knowledge (understanding of the major chemistry concepts).
2. Using scientific methods (applying scientific ideas, skills and strategies in enquiry).
3. Developing reasoning and thinking skills and fostering certain desirable attitude.
4. Providing access to careers in chemistry and technology.
5. Developing science knowledge for active citizenship (to help citizens make informed and responsible judgements).

As conceived by Ivowi (2004), curriculum implementation involves quite a number of activities culminating in translating curriculum documents into classroom practice. For chemistry curriculum to be implemented properly, teachers must not only understand the curriculum but also be pedagogical and technologically empowered to personalize the curriculum in such a way as to meet the instructional needs of their students (Newton and Rogers, 2001). It is recognized by chemistry educators that computers and other technologies can provide unique, effective, and powerful opportunities for implementing chemistry curriculum and hence help alleviate some of the problems encountered by students in learning chemistry contents.

Several researches (Osborne and Collins, 2000; Newton and Rogers, 2003; Al-Alwani, 2005; Murphy, 2006, Li, 2007) have shown that using technology in the classroom motivates students, encourages them to become problem solvers, and creates new avenues to explore information. Teachers also have found that using computers or computer-related technologies can capture and hold students' attention. Interactive technologies, such as software applications, digital media, reference guides, tutorials animations, simulations, and the Web, are especially engaged as they allow students to determine the flow of information, review concepts, practise skills, do in-depth research, and more.

Technologies that provide interactivity, learner control, and students' engagement are a natural choice for improving instruction (Shelly, Cashman, Gunter and Gunter, 2006). When used properly, technology is extremely beneficial in the learning process.

## **Methodology**

### **Design of the study**

This paper is based on a piece of qualitative research, and it is concerned with individuals' perceptions of barriers to ICT integration into the teaching and learning of chemistry. Hence, a phenomenographic research approach was employed. The underlying

assumption to this approach employed is that “there are many ways of interpreting the same experience and that the meaning of the experience to each person is what constitutes reality” (Ary, Jacobs, Razavieh, Sorensen, 2006, p. 461). For this reason, the concept of participant perspective is a central one for researchers using this approach (Mertler, and Charles, 2008, p. 196). Phenomenographic research approaches were designed at the University of Gothenburg in Sweden in the early 1970s to investigate the qualitatively different ways that phenomenon in the world can be perceived, conceptualized or understood (Gall, Gall, & Borg, 2007). As considered by Fraenkel & Wallen (2006), this research approach is one of the most difficult types of qualitative research to conduct since the researcher must get the participants to accurately relive the experience in their minds, along with their associated reactions and perceptions.

### **Participants**

The participants were 13 teachers teaching chemistry in Senior Secondary Schools located in Ogbomosho North and South Local Government Areas of Oyo State. They had received formal training for the teaching of the subject from different faculties of education in Nigerian Universities. Their chemistry teaching experience range from 9 to 25 years (mean = 14.7 years)

They were recruited through flyers (containing information about the study) that were displayed on the school notice boards. Their participation in the study is voluntary.

### **Instrument for data collection**

Based on the single research question, a series of guiding questions labelled as Guiding Questions Barriers to ICT integration (GQBICTI) serves as the instrument used for data collection during the semi-structured interview. These guiding questions were designed, piloted and refined by the investigator before use. Both close-ended and open-ended questions constituted the GQBICTI. This data collection strategy was employed because of two reasons: first, to provide

structure to data collected through the use of close-ended questions which require yes or no responses from participants; second, to give teachers a greater degree of freedom in expressing their perceptions on barriers encountered by them during ICT integration into chemistry instruction.

### **Teacher interviews**

One-on-one interviews with chemistry teachers were utilized for data collection. Each participant was individually interviewed in a separate room that was set aside in the chemistry laboratory. The interviewee was engaged in talking while the researcher listened keenly to identify further questions that emanated in the conversation. To minimize problems with validity and reliability associated with data collection strategy, the investigator strictly adhere to the roles expected of an interviewer during the conduct of interview. These expected roles are specified by Howitt and Cramer (2005, p. 266) as:

1. The interviewer is actively building as best s/he can an understanding of what s/he are being told.
2. The interviewer formulates questions and probes in a way which clarifies and extends the detail of the account being provided by the participant.
3. The interviewer is cognizant of other interviews which s/he has conducted with other participants. Issues may have emerged in those which appear missing in the current interview. Why is that? How does the participant respond when specifically asked about these issues?
4. The objective of the interviewer's activity is to expand the detail and to interrogate the information as it is being collected.

5. The interviewer should be good “listener” rather than taking detailed notes. A high quality tape recording or video recording of the interview is the main record.

Each interview lasted approximately 45 to 50 minutes. The questions asked during the interview sessions were meant to uncover information about barriers to integration of ICT into teaching and learning of chemistry. The interviews were tape recorded and later transcribed.

### **Coding and analysis of interviewed data**

Teachers' responses to the semi-structured interview about barriers to ICT integration into chemistry instruction were coded and analysed by two independent coders using coding categories. In arriving at phenomenographic categories (i.e., teacher-level and school-level barriers) used in the qualitative coding scheme, previous studies (Pelgrum 2001; Becta, 2003; Al-Alwani, 2005; Gomes, 2005; Li, 2007 O' Hanlon, 2009; Ross & Lowther, 2009' Wilson, 2010) focusing on barriers to uptake of ICT by teachers were examined. The criteria for assigning the transcripts of individual participants into phenomenographic categories and subcategories were fine-tuned on the basis of the pilot data.

The data pieces within each category were then analyzed for subcategories and illustrative key quotes from respondents. A voice sheet for each category was then prepared, each of which was subdivided by the subcategories into which illustrative quotes were entered. Following application of the qualitative coding scheme to the transcripts of individual teacher, frequency counts for each subcategory under the two main categories of barriers were generated. The inter-rater reliability was determined to be 86% for the category of school-level barriers and 92 % for the category of teacher-level barriers using simple agreement analysis. The disagreements between the two coders were resolved through discussion. The high level of

inter-rater reliability obtained was viewed by the investigator as the indicator of the adequacy of the coding scheme.

### **Findings and discussion**

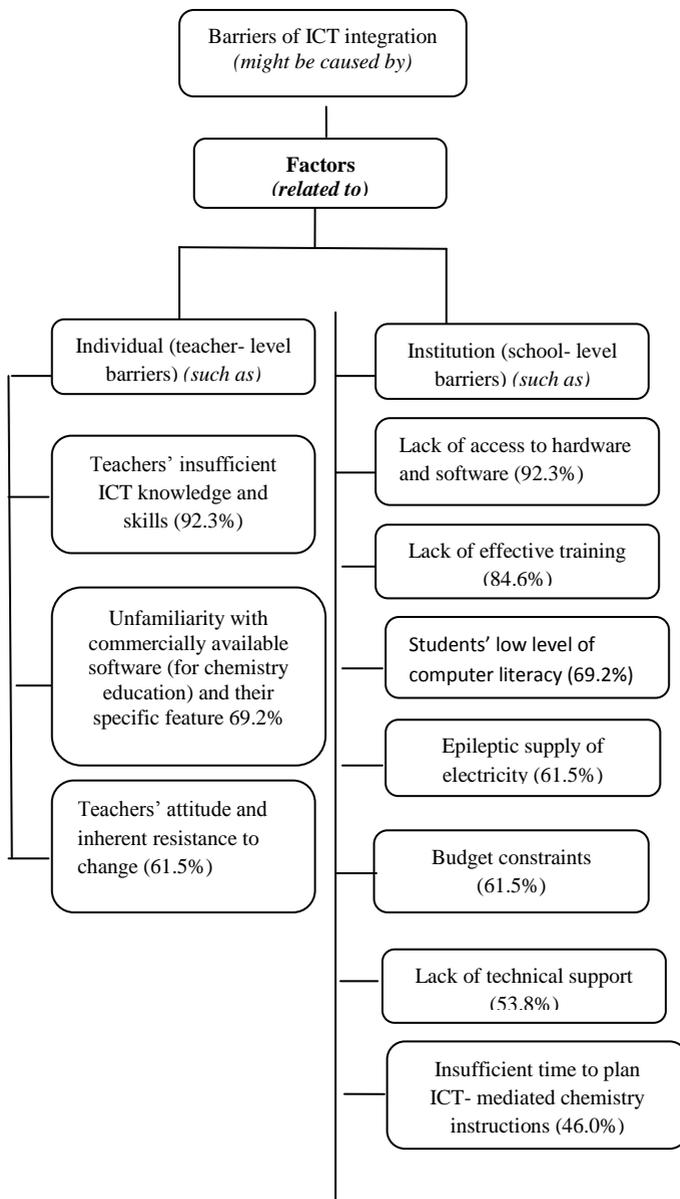
Two themes were derived from oral statements made by the participants during the interview (Figure1). The two themes were teacher – level barriers and school level barriers. The sub-themes which were connected to teacher-level barriers include: teacher's insufficient ICT knowledge and skills (92.3%), unfamiliarity with available software for chemistry education (69.2%), and basis resistance to change by chemistry teachers (61.5%). On the other hand, the sub-themes link with the school-level barriers were lack of access to hardware and software (92.3%), lack of effective training (84.6%), students' low level of digital literacy (69.2%), lack of technical supports (53.8%), budget constraints (61.5%), epileptic supply of electricity (61.5%), and insufficient time to plan ICT-mediated chemistry instructions (46.0%).

### **Teacher-level barriers**

**Teachers' insufficient ICT knowledge and skills:** A significant number of teachers (92.3%) perceived that many teachers possessed little or no knowledge and skills for optimally implementing chemistry curriculum using ICT tools. It should be noted that lack of ICT skills is a serious obstacle to the integration of technologies into chemistry lessons. Effective integration of ICT into classroom instructions requires acquisition of skills in the following areas: Word processing, (MS Word), Spreadsheet (Excel), Presentation (Power Point), Website navigation and Internet searching (Internet Explorer, Netscape), E-mailing, Website development/designing, Graphic and drawing, data base, data entry, and programming. It should be realized that equipping teachers with ICT skills facilitates the effective integration of ICT into chemistry lessons.

**Unfamiliarity with commercially available software (for chemistry education) and their specific features:** 69.2% of the respondents perceived that lack of adequate knowledge of available software for teaching chemistry is one of the major hindrances to integration of ICT into their lessons. A major problem for teachers is to get familiar with the available instructional software. To learn more about the software available in the school or on the schools network, teachers need to consult the school media specialist, curriculum resource teacher, and technology facilitator. Another similar problem confronting teachers is the complexity of software for teaching and learning chemistry. While knowledge about principles and functionality of software is necessary for teaching chemistry, it is very hard for chemistry teachers to be familiar with all the specific features of all the software packages that are commercially available for teaching, because software is continually being developed and improved. To render assistance to teachers in overcoming this problem, free in-service training based on the use of software and integration of ICT into teaching can be organized.

**Teachers' attitude and inherent resistance to change:** Teachers' attitude and resistance to change by many teachers was perceived as a barrier to ICT integration into the teaching of chemistry by 61.5% of the respondents. This finding is supported by Gomes (2005) who reported that science teachers' resistance to change concerning the use of new strategies is an obstacle to ICT integration into science teaching. According to Earle (2002), the change from a present level to a desired level of performance is facilitated by driving (encouraging) forces such as the power of new developments, rapid availability, creativity, Internet access, or ease of communication, it is however delayed by resisting (discouraging) forces such as lack of technical support, teacher expertise, or time for planning. Another plausible reason for resisting the use of ICT devices for teaching is offered by Cox, Preston, Cox (1999). According to them, teachers are unlikely to use new technologies in their teaching if they see no need to change their professional practice.



### **School-Level Barriers**

**Lack of access to hardware and software:** A significant number of teachers (92.3%) perceived that lack of access to hardware and software serves as a barrier to the use of new technology in teaching chemistry. Inadequate number of computers, insufficient number of copies of instructional software and insufficient Internet access made uptake of ICT by chemistry teachers difficult. The barriers associated with the accessibility of hardware and software for teachers are not only peculiar to Nigeria. Other countries of the world (e.g., Turkey, Saudi Arabia and Syria) are also experiencing similar situation based on the reports from Al-Alwani (2005), Toprakci (2006) and Albirini (2006). While dealing with the problem of accessibility of ICT resources, schools should also consider the fact that accessibility of ICT infrastructure does not guarantee its effective utilization for teaching activities. As observed by Newhouse (2002), poor choice of hardware and software and a lack of consideration of what is suitable for the learning objectives are problems facing teachers.

**Lack of effective training:** 84.6% of the chemistry teachers' responses indicated that there were not enough training opportunities for teachers in the use of ICTs in a classroom environment.

Responses from the chemistry teachers revealed that lack of training in the use of computers for lesson delivery is a major obstacle in the implementation of ICT in classroom practice. These findings reinforce the conclusion of Pelgrum (2001), who reported that there were not enough training opportunities for teachers in the use of ICTs in a classroom environment. The commitment to the professional development of teachers is one of the key strategies that government through the Ministry of Education should employ to overcome this problem of lack of training. Many teachers have complained about non exposure to training on the use of ICT in their pedagogy. Therefore, professional development programmes have to be carefully designed and implemented to provide support to less-technologically component teachers.

**Students' low level of digital literacy:** 69.2% of the respondents perceived that students' low level of digital literacy constitutes a major barrier to ICT integration into chemistry lessons.

Successful integration of ICT into chemistry lesson requires both teachers and students to acquire a high degree of digital literacy. To this end, it is important that students possess some computer skills in order to survive in an ICT-mediated chemistry lessons. Digital literacy describes the ability to make use of ICT in learning and work activities (Erstad, 2006; Krumsvisk, 2006). Implicit in the concept of digital literacy is the realization of the potential inherent in ICT for better learning. In order to achieve the objectives of chemistry education in any technology-based learning environment, students must have acquired high degree of experiences in handling computers and acting in virtual environments such as browsing, communication via e-mail, forums and chat systems, searching the net for information and other ICT skills. Providing ICT learning resources and study materials and ICT skills training sessions for those students lacking the skills will assist them to derive many benefits offered by ICT integration.

**Epileptic supply of electricity:** 61.5% of the chemistry teacher responses indicated that one of the major barriers to the use of ICT in chemistry classrooms is irregular supply of electricity. To put ICT tools into use during instructional process, regular supply of electricity must be provided in the schools. It is disheartening as revealed in this study that irregular supply of electricity creates problem for effective integration of computers and other electronic devices into classroom instructions.

### **Budget constraints**

61.5% of the respondents indicated that lack of adequate funding of the schools is one of the barriers to the successful utilization of computer and other ICT tools in Nigerian schools. At present, most of the public secondary schools in Nigeria lack modern technology devices for the instructional process. In spite of the reduction in the

price of ICT tools, most schools are still financially handicapped in procuring computers as well as in getting connected to the internet. Learning and instructional resources centre department of the Ministry of Education failed to supply computers and other ICT to the schools.

**Lack of technical support:** 53.8% of the respondents perceived that lack of technical experts in schools who can deal with maintenance issues and resolve problems such as viruses and other technical problems constitutes a barrier to technology implementation in their chemistry lessons. Respondents find this as a serious problem that needs to be urgently addressed by the Ministry of Education at both Federal and State levels. Similar findings as the one reported above were revealed in a study carried out by Sicilia in 2005. According to her, technical barriers that do hinder the integration of ICT into lesson delivery include waiting for websites to open, failing to connect to the Internet, printer not printing, malfunctioning computers, and teachers having to work on old computers. In science teaching, research findings indicated that lack of technical support impeded the smooth flow of information during instructional process. As perceived by Gomes (2005), technologies integration in science teaching requires a technician/computer operator. Lack of this technical support can be an obstacle to the natural flow of the classroom activity.

**Insufficient time to plan ICT-mediated instruction:** 46% of the chemistry teachers perceived that lack of time is an important factor affecting the utilization of new technologies in chemistry lessons. Becta's (2004) study revealed that the problem of lack of time exists for teachers in many aspects of their work as it affects their ability to complete tasks, with some of the participant teachers specifically stating which aspects of ICT require more time. These include the time needed to locate internet advice, prepare lessons, explore and practice using the technology, deal with technical problems, and receive adequate training. In Nigeria despite the fact that teachers resume work as early on 7:00am and stay on duty till 2:00pm, there is still little or no time left for them to work on integrating ICT into classroom instructions. In the same vein, Al- Alwani (2005) observed

that Saudi teachers work from 7:00am until 2:00pm, the average number of class sessions taught by science teachers is 18 per week and that both the teachers and students have insufficient time to plan ICT-mediated science instruction. According to Sicilia (2005), the most common challenge reported by all the teachers was lack of time they had to plan technology enhanced lessons, explore the different Internet sites, or look at various aspects of instructional software. Gomes (2005) concluded that one of the major reasons for non-utilization of ICT for instructional purposes is lack of time necessary to accomplish plans.

### **Conclusion and implications**

The provision of a functioning strategic plan for the delivery of instructional contents via Internet, intranet/ extranet, mobile phone, audio and videotape, satellite and CD-ROM is the responsibility of both the federal and state Ministries of Education in a developing country like Nigeria. In the year 2004, the federal ministry of education released a document termed the ministerial initiative on e-education for the Nigerian educational system. The document appraised e- education worldwide and made justification for its adoption. It also highlighted the strategies for its adoption. The emphasis given to the integration of ICT into the educational system in the document is rather encouraging. Nonetheless, the significant question remains. Is there any impediment to the successful integration of technology into the teaching process? The finding of this study offered answers to this question. Ten barriers to successful integration of ICT into the teaching of chemistry as perceived by teachers were teachers insufficient ICT knowledge and skills (92.3%), teachers' attitude and inherent resistance to change (61.5%), unfamiliarity with commercially available software (for chemistry education) and their specific features (69.2%), lack of access to hardware and software (92.3%), lack of effective training (84.6%), students' low level of computer literacy (69.2%), epileptic supply of electricity (61.5%), lack of technical supports (53.8%), budget

constraints (61.5%) and insufficient time to plan ICT- mediated instructions (46.0%).

It should be noted that there is existence of relationships among some of the perceived barriers to ICT integration into instructional process in schools. For instance, lack of accessibility to educational technological materials as a barrier is closely associated with budget constraints. Likewise, budget constraint as a barrier to ICT integration into education is closely related to lack technical support. In a situation whereby adequate fund is not readily available for connecting schools to Internet and procuring technical equipment, teachers do not have access to ICT resources. Once there is no accessibility to such materials, then training of the teachers in the use of modern technology will be seriously affected. The end results are the breeding of incompetent teachers. Similarly, recruitment of technical ICT experts or computer operators who are to offer technical supports to the teachers is strongly dependent on fund made available to schools. Experience shows that such experts are not likely to remain in school system if their salaries are not attractive like their counterparts working in banks, engineering companies and other business ventures. In addition to the previous examples, teachers' insufficient ICT knowledge and skills has a direct link with the insufficient time to plan ICT-mediated chemistry instruction. Training teachers for utilization of ICT for teaching and learning purposes, for example utilization computer programmes such as Microsoft world, spreadsheet, Power Point, email and Internet requires time. In essence, enough time must be available for training teachers on how to plan ICT-mediated instruction. Teacher lesson planning is vital when using ICTs; where little planning has occurred; research shows that student work is often unfocused and can result in lower attainment. Teachers whose schools give ample time to develop their skills in using ICT devices for instructional process can be more creative than their counterparts who do not have enough time to plan ICT- mediated instruction.

The findings of this study provide detail about the impeding factors to technology integration in the instructional process as related to Nigeria context. Some implications for teachers and schools for successful integration of ICT into chemistry education arising from the result of this study are discussed below.

One of the most important implications is that the Teaching Service Commission (TESCOM) in collaboration with the Ministry of Education needs to provide a series of technology related staff development opportunities on early released days after school and on Saturdays. These development programmes need to be ongoing and must not occur in isolated, short, 'stand-alone' sessions in which technology and pedagogy are not linked or connected. Single workshops with no follow-up tend to fail (Fox and Herrmann, 2000). It is much better if activities are spread over time and include a mix of theory and practice in the use of ICT devices for classroom teaching.

Another implication concerns the release of sufficient grants to schools. Government should make concerted efforts to connect all schools to Internets and supply necessary ICT facilities to all schools. In dealing with the budget constraints as a barrier, budgeting allocations should be made specifically for procurement of ICT tools. In addition, more efforts should be intensified to ensure uninterrupted supply of electricity in schools.

Finally, it is important for the school principals and vice principals (administration) to cooperate with teachers by making ample time available to implement new technologies in the classroom. For example, one way of making sufficient time available to plan ICT-mediated instruction is to lower the teachers' teaching load and assign school counsellors to deal with student disciplinary problems.

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