

Evaluating ICT Challenges Associated with the Teaching and Learning of "A" Level Chemistry in Eight High Schools in Glen View Mufakose District, Harare, Zimbabwe.

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Abstract: *The purpose of the research was to evaluate A Level Chemistry teachers' challenges towards use of Information and Communication Technologies (ICTs) for pedagogical purposes in secondary school education in Glen View Mufakose District, Harare, Zimbabwe. The introduction and integration of various ICTs in schools has not reduced the gap in teacher competencies hence they still adopt very traditional methods of the "chalk and talk" approach. The conceptual and theoretical literature reviewed showed that many teachers do not feel as fully equipped, comfortable and efficient in using ICT in the teaching and learning processes. Interestingly, the literature reviewed also showed that ICTs are learner centered and the learner takes an active role in his or her learning especially in what has been termed as web based learning. The mixed methodology of the quantitative and qualitative paradigms informed the research and so was the descriptive survey method which was employed. The population was made up of eight schools and 30 A level chemistry teachers giving an overall sample of 5 schools and 25 A level chemistry teachers, 60 students and 6 Heads of Schools giving a total of 91. Purposive and Simple random sampling was used to select the five schools and the A level chemistry teachers whilst systematic sampling was used for the students. Interviews, questionnaires and field observations were used to collect both qualitative and quantitative data. Data was collected and analysed using the SPSS package, Correlation and regression analysis before being presented and interpreted. It was discovered that some A level chemistry teachers lack exposure and training in ICT use coupled with lack of resources like computers and internet connectivity which impeded full ICT integration and utilisation. Although teachers were aware of potential benefits of ICTs over traditional methods of teaching, they lacked knowledge of different ICTs that could be integrated in teaching and learning. It was concluded that most A level chemistry teachers have a positive attitude towards ICT use, with female teachers having a more positive attitude than the male teachers but the female teachers showed that they faced more challenges. The teachers whose ICT background was not more advanced also were reported to face more challenges in using ICT tools in teaching. The research recommended that clear ICT educational strategies to improve the pedagogical skills of teachers must be put in place. At the same time provision of resources like computers and ICT training courses must be put into place. It was also recommended that teacher training colleges and universities should also provide pre-service teachers with positive technological experiences and exposure in a variety of ICTs that can be easily implemented in A Level Chemistry. The study recommended the academic body to carry out further investigations on the ways to help not only Chemistry teachers but all teachers to break through the challenges identified in this study to be able to use ICT in teaching.*

Keywords: Information and Communication Technology, ICT challenges, Traditional methods, Web based learning

1. Main Objectives

- 1) To analyse the current situation with regards to the teaching and learning of Chemistry at "A" level in Glen View Mufakose district schools in Harare, Zimbabwe.
- 2) To investigate whether ICT Challenges on teachers in Harare, Zimbabwe would influence ICT integration with respect to demographic variables of gender, age and type of school.
- 3) To evaluate ICT challenges in relation to three levels, student level, teacher level and organizational level.
- 4) To assess the significance of ICTs in scheming, lesson delivery and record keeping in teaching and learning
- 5) To make recommendations on how ICT can be integrated to improve on scheming, lesson delivery and record keeping.

2. Introduction

The study was initiated after the teacher observed that though computers and other technological gadgets are available to almost every teacher; few teachers are using these technologies in the teaching and learning of chemistry. This observation was made at Glen View 2 High School. However, the use of information and communication technologies in the education process has been divided into two broad categories: ICTs for Education and ICTs in Education. ICTs for education connote the development of information and communications technology specifically for teaching/learning purposes, while the ICTs in Education involves the adoption of general components of information and communication technologies in the teaching learning process (Olakulehin, 2007). The researcher looked at literature and found that some researchers in other countries studied the barriers that stand between education and the use of ICT. Some of the findings were that the most significant

barriers identified were linked to staff attitude and training staff in the use of ICT, access and ICT skill in general (Marshall, Elgort & Mitchell, 2003)

This researcher also lies on the background observed from literature that in other countries ICT has been seen as an aid in effective teaching and learning. It is known that there are software that has already been put into use by other teachers such as Discrete Educational Software (DES), integrated learning system (ILS), Computer-assisted Instruction (CAI), and Computer-based instruction (CBI). These software applications are also the most widely available applications of educational technology in schools today, along with word-processing software, and have assisted in classroom for more than 20 years (Becker, Ravity and Wong, 1999). Murphy et al., (2001) explains that teachers use DES not only to supplement instruction, as in the past, but to introduce topics, provide means for self study, and offer opportunities to learn concepts otherwise inaccessible to students. It is also against this background that the researcher saw it necessary to investigate the challenges faced by local teachers in adopting ICT since the use ICT has been discussed in other countries and was found to be beneficial.

Before coming up with this researcher topic, the researcher understood that the field of education has been affected by ICTs, which have undoubtedly affected teaching, learning, and research (Yusuf, 2005). It became clear that a great deal of research has proven the benefits to the quality of education. ICTs have the potential to innovate, accelerate, enrich, and deepen skills, to motivate and engage students, to help relate school experience to work practices, create economic viability for tomorrow's workers, as well as strengthening teaching and helping schools change. The situation in the past shows that teaching emphasized on content. Teachers have taught through lectures and presentations interspersed with tutorials. In Zimbabwe there is now a new curriculum that promotes competency and performance. The new Curriculum emphasizes on capabilities concerned more with how the information will be used than with what the information is. The researcher understood that ICTs are able to provide strong support for all these requirements and there are now many outstanding examples, like in America (Oliver, 2000) where the integration of information and communication technologies has helped revitalize teachers and students. The researcher therefore opted to investigate the reasons why the ICT is rarely used. Computers and other technologies available to teachers are very useful instruments that other teachers in other schools are using to plan, deliver and evaluate teaching and learning. The researcher opted to carry out this study by looking at the schools in Glen view Mufakose district.

3. Literature Review

3.1 Importance of ICT staff development

Previous studies into teacher use of ICTs have identified staff development as one of the contributing factors in using ICT effectively in the classroom. McCarney (2004) gave a report on an investigation into effective staff development in ICT for teachers. A sample of Scottish primary school

teachers have been surveyed to investigate the impact of different models of staff development in ICT on the teacher and to explore the knowledge and skills gained by teachers from staff development and issues like technical, academic/content-related and pedagogy were highlighted. Kujeke, Kennedy and Nyaruwata(2014) carried out a research on ICT integration and its relationship to ICT challenges and work motivation of lecturers in Zimbabwean universities and the results indicated the need for much greater emphasis to be placed on the pedagogy of ICT. This should be of interest to all involved in teacher education and the continuing professional development of teachers and lecturers.

3.1.1 ICT as an aid in teaching methods

Moseley et al. (1999 in UNESCO, 2004), in a study of primary school teachers known to be achieving either average or above average gains on measures of relative attainment by pupils, that focused on pedagogy using ICT. Observations showed that the most successful teachers were those who used examples and counter examples and involved students in explaining and modeling in the class. Teachers who favoured ICT were likely to have well-developed ICT skills and to see ICT as an important tool for learning and instruction. They were also likely to value collaborative working, enquiry and decision making by students. Teachers' pedagogical approaches are in turn affected by a number of key factors.

Cox et al., (1999) report findings of a small project to investigate the factors which have contributed to the continuing use of ICT by experienced ICT and ICT teachers in their teaching. The factors which were found to be most important to these teachers in their teaching were: making the lessons more interesting, easier, more fun for them and their pupils, more diverse, more motivating for the pupils and more enjoyable. Additionally, more personal factors were improving presentation of materials, allowing greater access to computers for personal use, giving more power to the teacher in the school, giving the teacher more prestige, making the teachers' administration more efficient and providing professional support through the Internet. Gray and Souter (2004) in a study of secondary science teachers use of ICT conducted in America focuses on the data from one aspect of the use of ICT in secondary subject areas, and the perceptions of teachers in these areas. A comparison of science teachers' perceptions is made with teachers from other disciplines. In addition, little was reported in the way of pupil use of ICT in science classes. Although there appeared to be an awareness of the potential for ICT in science, teachers indicated that they did not see the introduction of ICT radically changing the way in which teaching took place, nor changing the teacher-student relationship. Science teachers were reasonably confident in their use of ICT but felt that they needed much more in the way of support and professional development to maximize their use of ICT in the classroom. Bottino (2003) and Sharma (2003) mention that the use of ICT can improve performance, teaching, administration, and develop relevant skills in the disadvantaged communities. It also improves the quality of education by facilitating learning by doing, real time conversation, delayed time conversation, directed instruction, self-learning, problem solving, information

seeking and analysis, and critical thinking, as well as the ability to communicate, collaborate and learn (Yuen et al, 2003)

Having reviewed relevant literature on this study, the focus still remains to examine the challenges faced by the teachers in using ICT in the teaching of science subjects like Chemistry. This is the very focus of this study. The report by Gray and Souter, (2004) is important in this study as it shows that individual perceptions of the teacher affect how these teachers adopt ICT. It is more likely that the challenges that will be found in this study will have different impact on different teachers and in different schools because people hold different perceptions about ICT. The literature reviewed indicated that the nature of students as well as their technological motivation impacts much on how teachers approach them with ICT when teaching them. The weakness in the reviewed literature is that most of these studies were carried in developed nations so the context in which the reports were made is slightly different from that in developing countries. The literature was also drawn from studies that were too broad in their variables for example Cox et.al (1999) that looked at the teaching of all science subjects. This study was however developed using a specific science subject-that is chemistry. Contributions by Kujeke, Kennedy and Nyaruwata(2014) were more relevant as the research was carried in a developing country, Zimbabwe.

3.2 Approaches used by other teachers when using ICT

Several approaches were reviewed which included the **Integrated approach** (planning the use of ICT within the subject to enhance particular concepts and skills and improve students' attainment. This involves a careful and considered review of the curriculum area, selecting the appropriate ICT resource which will contribute to the aims and objectives of the curriculum and scheme of work, and then integrating that use in relevant lessons). **Enhancement approach** (planning the use of an ICT resource which will enhance the existing topic through some aspect of the lessons and tasks). For example, using an electronic whiteboard for presenting theory about a topic. In this approach, the teacher plans to complement the lesson with an innovative presentation method to promote class discussion and the visualization of problems. **Complementary approach** (using an ICT resource to empower the pupils' learning, for example by enabling them to improve their class work by taking notes on the computer, or by sending homework by email to the teacher from home, or by word processing their homework. All three approaches can enhance attainment, but the effects may be different. In the integrated approach, students' learning is enhanced because they are confronted with challenges to their existing knowledge and given deeper insights into the subject being studied. The enhancement approach could improve students' learning through presenting knowledge in new ways, promoting debates among students, and encouraging them to formulate their own explanations. The complementary approach draws on the approach that suggests that learning can be enhanced by reducing the mundane and repetitive aspects of tasks such as writing essays and homework by hand, freeing the learner to focus on more challenging and subject-focused tasks (Kemmis et al., 1977 in UNESCO,

2004). These different types of use require the teacher to have an extensive knowledge of ICT and to be able to fit its use either into their existing pedagogy or to extend their pedagogical knowledge so they can accommodate ICT effectively in their teaching.

3.3 ICT enhancing the learning environment

ICT provides opportunities to access an abundance of information using multiple information resources and viewing information from multiple perspectives, thus fostering the authenticity of learning environments. ICT may also make complex processes easier to understand through simulations that, again, contribute to authentic learning environments. Thus, ICT may function as a facilitator of active learning and higher-order thinking (Alexander, 1999; Jonassen, 1999). The use of ICT may foster co-operative learning and reflection about the content (Susman, 1998). The ICT environment has been developed by using different software and also the extended experience in developing web based and multimedia materials. ICTs have an important role to play in changing and modernizing educational systems and ways of learning.

3.3.1 ICT enhancing the scholastic performance

ICTs are said to help expand access to education, strengthen the relevance of education to the increasingly digital workplace, and raise educational quality. However, the experience of introducing different ICTs in the classroom and other educational settings all over the world over the past several decades suggests that the full realization of the potential educational benefits of ICT. The direct link between ICT use and students' academic performance has been the focus of extensive literature during the last two decades. ICT helps students to their learning by improving the communication between them and the instructors (Valasidou and Bousiou, 2005).

The analysis of the effects of the methodological and technological innovations on the students' attitude towards the learning process and on students' performance seems to be evolving towards a consensus, according to which an appropriate use of digital technologies in education can have significant positive effects both on students' attitude and their achievement. Research has shown that the appropriate use of ICTs can catalyze the paradigmatic shift in both content and pedagogy that is at the heart of education reform in the 21st century.

Kulik's (1994) meta-analysis study revealed that, on average, students who used ICT-based instruction scored higher than students without computers. The students also learned more in less time and liked their classes more when ICT-based instruction was included. Fuchs and Woessman (2004) used international data from the Programme for International Student Assessment (PISA), they showed that while the bivariate correlation between the availability of ICT and students' performance is strongly and significantly positive, the correlation becomes small and insignificant when other student environment characteristics are taken into consideration.

Attwell and Battle (1999) examined the relationship between having a home computer and school performance, their findings suggest that students who have access to a computer at home for educational purposes, have improved scores in reading and math. Becker (2000) found that ICT increases student engagement, which leads to an increased amount of time students spend working outside class. Coates et al. (2004) showed that students in on-campus courses usually score better than their online counterparts, but this difference is not significant here. ICTs especially computers and Internet technologies enable new ways of teaching and learning rather than simply allow teachers and students to do what they have done before in a better way.

ICT helps in providing a catalyst for rethinking teaching practice (Flecknoe, 2002; McCormick & Scrimshaw, 2001) developing the kind of graduates and citizens required in an information society (Department of Education, 2001); improving educational outcomes (especially pass rates) and enhancing and improving the quality of teaching and learning (Wagner, 2001; Garrison & Anderson, 2003). ICT can help deepen students' content knowledge, engage them in constructing their own knowledge, and support the development of complex thinking skills (Kozma, 2005; Kulik, 2003; Webb & Cox, 2004). Studies have identified a variety of constructivist learning strategies (e.g., students work in collaborative groups or students create products that represent what they are learning) that can change the way students interact with the content (Windschitl, 2002). Albert Bandura, Girasoli and Hannafin (2008) urge the use of asynchronous CMC tools to promote student self-efficacy and hence academic performance. Fister et al (2008) also depict the power of tablet PCs to improve a level chemistry instruction. ICTs have the potential for increasing access to and improving the relevance and quality of education. The use of ICT in educational settings, by itself acts as a catalyst for change in this domain. Students using ICTs for learning purposes become immersed in the process of learning and as more and more students use computers as information sources and cognitive tools (Reeves and Jonassen, 1996), the influence of the technology on supporting how students learn will continue to increase.

3.3.2 ICT enhancing learning motivation

ICTs, especially computers and Internet technologies, enable new ways of teaching and learning rather than simply allow teachers and students to do what they have done before in a better way. ICT has an impact not only on what students should learn, but it also plays a major role on how the students should learn. Along with a shift of curricula from —content-centered” to —competence-based”, the mode of curricula delivery has now shifted from —teacher centered” forms of delivery to —student-centered” forms of delivery. ICT provides- Motivation to Learn. ICTs such as videos, television and multimedia computer software that combine text, sound, and colourful moving images can be used to provide challenging and authentic content that will engage the student in the learning process. Interactive radio likewise makes use of sound effects, songs, dramatizations, comic skits, and other performance conventions to compel the students to listen and become more involved in the lessons being delivered.

ICT changes the characteristics of problems and learning tasks, and hence play an important task as mediator of cognitive development, enhancing the acquisition of generic cognitive competencies as essential for life in our knowledge society. Students using ICTs for learning purposes become immersed in the process of learning and as more and more students use computers as information sources and cognitive tools (Reeves and Jonassen, 1996), the influence of the technology on supporting how students learn will continue to increase. Learning approaches using contemporary ICTs provide many opportunities for constructivist learning through their provision and support for resource-based, student centered settings and by enabling learning to be related to context and to practice (Berge, 1998; Barron, 1998). The teachers could make their lecture more attractive and lively by using multi-media and on the other hand the students were able to capture the lessons taught to them easily. ICT-enhanced learning is student-directed and diagnostic. Unlike static, text- or print-based educational technologies, ICT-enhanced learning recognizes that there are many different learning pathways and many different articulations of knowledge. ICTs allow learners to explore and discover rather than merely listen and remember. The World Wide Web (WWW) also provides a virtual international gallery for students' work (Loveless, 2003). ICT can engage and inspire students, and this has been cited as a factor influencing ready adaptors of ICT (Long, 2001; Wood, 2004).

3.3.3 ICT enhancing the quality and accessibility of education

ICT increases the flexibility of delivery of education so that learners can access knowledge anytime and from anywhere. It can influence the way students are taught and how they learn as now the processes are learner driven and not by teachers. This in turn would better prepare the learners for lifelong learning as well as to improve the quality of learning. In concert with geographical flexibility, technology-facilitated educational programs also remove many of the temporal constraints that face learners with special needs (Moore & Kearsley, 1996). Students are starting to appreciate the capability to undertake education anywhere, anytime and anyplace.

One of the most vital contributions of ICT in the field of education is- Easy Access to Learning. With the help of ICT, students can now browse through e-books, sample examination papers, previous year papers etc. and can also have an easy access to resource persons, mentors, experts, researchers, professionals, and peers—all over the world. This flexibility has heightened the availability of just-in-time learning and provided learning opportunities for many more learners who previously were constrained by other commitments (Young, 2002).

Wider availability of best practices and best course material in education, which can be shared by means of ICT, can foster better teaching. ICT also allows the academic institutions to reach disadvantaged groups and new international educational markets. As well as learning at anytime, teachers are also finding the capabilities of teaching at any time to be opportunistic and able to be used to advantage. Mobile technologies and seamless

communications technologies support 24x7 teaching and learning. Choosing how much time will be used within the 24x7 envelope and what periods of time are challenges that will face the educators of the future (Young, 2002). Thus, ICT enabled education will ultimately lead to the democratization of education. Especially in developing countries like India, effective use of ICT for the purpose of education has the potential to bridge the digital divide.

India has a billion-plus population and a high proportion of the young and hence it has a large formal education system. The demand for education in developing countries like India has skyrocketed as education is still regarded as an important bridge of social, economic and political mobility (Amutabi and Oketch, 2003). There exist infrastructure, socio-economic, linguistic and physical barriers in India for people who wish to access education (Bhattacharya and Sharma, 2007). This includes infrastructure, teacher and the processes quality. There exist drawbacks in general education in India as well as all over the world like lack of learning materials, teachers, remoteness of education facilities, high dropout rate etc (UNESCO, 2002). Innovative use of Information and Communication Technology can potentially solve this problem. Internet usage in home and work place has grown exponentially (McGorry, 2002). ICT has the potential to remove the barriers that are causing the problems of low rate of education in any country. It can be used as a tool to overcome the issues of cost, less number of teachers, and poor quality of education as well as to overcome time and distance barriers (McGorry, 2002).

ICT provides new educational approaches (Sanyal, 2001). It can provide speedy dissemination of education to target disadvantaged groups (UNESCO, 2002; Chandra and Patkar, 2007). ICT enhances the international dimension of educational services (UNESCO, 2002). It can also be used for non-formal education like health campaigns and literacy campaigns (UNESCO, 2002). Use of ICT in education develops higher order skills such as collaborating across time and place and solving complex real world problems (Bottino, 2003; Bhattacharya and Sharma, 2007; Mason, 2000; Lim and Hang, 2003). It improves the perception and understanding of the world of the student. Thus, ICT can be used to prepare the workforce for the information society and the new global economy (Kozma, 2005). Plomp et al (2007) state that the experience of many teachers, who are early innovators, is that the use of ICT is motivating for the students as well as for the teachers themselves.

Bottino (2003) and Sharma (2003) mention that the use of ICT can improve performance, teaching, administration, and develop relevant skills in the disadvantaged communities. It also improves the quality of education by facilitating learning by doing, real time conversation, delayed time conversation, directed instruction, self-learning, problem solving, information seeking and analysis, and critical thinking, as well as the ability to communicate, collaborate and learn (Yuen et al, 2003). A great deal of research has proven the benefits to the quality of education (Al-Ansari 2006). Hepp, Hinostroza, Laval and Rehbein (2004) state that the literature contains many unsubstantiated claims about the revolutionary potential of ICTs to improve the quality of education. They also note that some claims are now deferred

to a near future when hardware will be presumably more affordable and software will become, at last, an effective learning tool.

3.3.4 General Conclusions of the review

In order to conclude the researcher will try to proceed to synthesize from a general viewpoint the results obtained, taking into consideration the relevant aspects of the literature. This literature review has sought to explore the role of ICT in education as we progress into the 21st century. The researcher used this literature to formulate the basis of the challenges faced by the teachers in adopting ICT since the continued use and development of ICTs within education will have a strong impact on teaching and learning process; quality and accessibility of education; learning motivation, learning environment and academic performance. The researcher identified that there is a gap in this knowledge base for example little was done by the previous researchers on identifying why most Chemistry teachers are still using the chalk and talk way of teaching amidst plenty of ICT.

3.4 Theoretical Framework

This research is supported by a number of theories in education and in the adoption of ICT. These models and theories form part of the conceptual framework on which this study was informed.

3.4.1 Technology Acceptance Model (TAM)

According to Cox, Preston and Cox (1999), when teachers adopt the use of ICT they may follow a model or theory called the Technology Acceptance Model. TAM was developed by Davis, Bagozzi and Warshaw (1989) which was an adaptation of theory of reason action by Ajzen and Fishbein (1980) to investigate the reasons why teachers use ICTs. Their model links the usefulness and ease of use with attitude towards using ICT and they found that people's computer use was predicted by their intentions to use it.

3.4.2 Theory of Reasoned Actions (TRA)

The theory originates from social psychology, and it is a special case of the Theory of Planned Behavior (TPB) (Ajzen, 2010). Fishbein and Ajzen (1975) developed TRA to define the links between the beliefs, attitudes, norms, intentions, and behaviors of individuals. The theory assumes that a person's behavior is determined by the person's behavioral intention to perform it, and the intention itself is determined by the person's attitudes and his or her subjective norms towards the behavior. The subjective norm refers to the person's perception that most people who are important to him think he should or should not perform the behavior in question is focused on the prediction and understanding of human behavior to help in solving applied problems and making policy decisions.

3.4.3 Theory of Planned Behavior (TPB)

The theory focuses on cognitive self-regulation. It is very similar to the TRA model, but the difference is that it takes into account an additional construct, namely perceived behavioral control. Perceived behavioral control refers to the perception of control over the performance of a given behavior. In TRA rational considerations determine the

choices and behaviors of individuals, and individual intentions determine behavior. Intentions refer to individuals' plans and motivations to commit a specific act. Intentions also reflect individual attitudes and the extent to which individuals perceive a specific act as desirable or favorable. The theory suggests that human behavior is governed by personal attitudes, but also by social pressures and a sense of control.

3.4.4 Unified Theory of Acceptance and Use of Technology (UTAUT)

The fifth most cited theory was the Unified Theory of Acceptance and Use of Technology (UTAUT). Venkatesh et al. (2003) developed the unified model through reviewing eight models which explain ICT usage, namely TRA, TAM, the motivational model, TPB, a model combining TAM and TPB, the model of PC utilization, DOI, and the social cognitive theory. The purpose of UTAUT is to explain a user's intentions to use ICT and the subsequent user behavior. The model considers four constructs as direct determinants of user acceptance and usage behavior, namely performance expectancy, effort expectancy, social influence, and facilitating conditions. There are four key moderating variables: gender, age, experience, and voluntariness of use. The authors stated that UTAUT provides a tool for managers to assess the likelihood of success of technology introductions and to understand the drivers of acceptance in order to design interventions, which include, e.g., training or marketing. UTAUT focuses on users who may be less willing to adopt and use new systems.

3.4.5 Model of the IT Implementation Process

The model is based on the organizational change, innovation, and technological diffusion literature. The purpose of the model is to offer a directing and organizing framework for ICT implementation research. Six stages, namely initiation, organizational adoption, adaptation, acceptance and adoption, reutilization and infusion. Thus, the model covers an implementation process from the scanning of organizational needs to a full and effective use of the technology in daily practice. The model also identifies five contextual factors which impact on processes and products in each implementation stage: the characteristics of the user community, the organization, the technology being adopted, the task, and the organizational environment.

3.4.6 Organizational decision making on ICT adoption

These factors were innovation characteristics (e.g., the complexity of the technology), organizational characteristics (e.g., top management support, perceived technological benefits), or environmental characteristics (e.g., external pressure). As a contribution, this group generated the most new models and concepts compared to the other thematic groups. For example, Chwelos et al. (2001) developed an electronic data interchange (EDI) adoption model with three determining factors: readiness, perceived benefit, and external pressure.

3.4.7 Diffusion of Innovation Theory

Diffusion of Innovation theory was developed by Rogers in 1995. Rogers (1995) defines diffusion as the process by which an innovation is communicated through certain channels over time among members of a social system. The

innovation-diffusion model states that an innovation (technology) is passed on from its source to end users through a medium of agents and its diffusion in potential users for the most part dependent on the personal attributes of the individual user. The model assumes that the technology in question is appropriate for use unless hindered by the lack of effective communication.

3.4.8 New Model for Education

This New Model has three principal components, the use of expert "skeleton concept" maps to scaffold learning. "Expert skeleton" concept maps are small (10-15) concepts arranged hierarchically by an expert in the knowledge domain for learners to use as a starting point to "scaffold" their learning. The teacher gives specifically drawn up tasks to learners to work on using internet and computer software. The theory is based on the basic theories of education including multiple intelligences, right- and left-brain learning, activity theory, learning styles, Piaget's cognitive development. All these theories view learning as a process of active engagement, based on individual and socially constructed learner differences. According to Plato and Socrates (Moore, 2002), learners are not empty vessels, blank slates, or passive observers, rather they have some kind of information that come from various sources other than the school.

3.4.9 Theory of Cognitive Development

This theory suggests that learners—from a very young age—make sense of the world, actively creating-meaning while reading texts, interacting with the environment or talking with others. Even if students are quietly watching a teacher speak, they can be actively engaged in a process of comprehension. Bransford, Brown, and Cocking (2000) wrote that very young children are competent, active agents of their own conceptual development. This cognitive turn in psychology is often referred to as a constructivist approach to learning.

The teacher's role has been to stand before her class and dispense information to her students for them to memorize. Evaluation consisted of multiple-choice tests that require little more than recall of information and no evidence that the meaning of this information is understood. This model has survived for years, even though it should have collapsed after the invention of the printing press in 1440 and certainly after the development of cheap computers and the Internet in the 1990's. For most school and university classes, the traditional model of teaching remains dominant today, albeit there are some noteworthy exceptions.

3.5 Theory of Classical Conditioning

According to Bransford (2000), ICT can be used in leaning as explained in the theory of classical conditioning. Learners can be conditioned in mastery of learning area content through the use of ICT tools. New information can be introduced to learners while it is paired simultaneously with an impulse generated by an ICT tool. In the adage example of classical conditioning there were dogs that were conditioned to the sound of a bell as a stimulus to learn the time to eat. The bell was rung prior to the sight of food. After repeating this procedure for a long time the dogs became conditioned. It was observed that they were able to

salivate when they heard the sound of the bell. The dogs were said to be classically conditioned. This theory can be used to explain how learners can also be conditioned for example to obtain knowledge by pairing new information with ICT tools. In another example mice were conditioned to press a foot-pedal to get food. The same can be applied to the learners to an extent that the learners can research and learn by clicking the right button on an ICT tool.

3.6 General overview and summary

From the discussions and findings above there seems to be evidence and a relationship between ICT integration in universities and ICT challenges and Work motivation. The motivation theories outlined above gave some scientific explanations on how workers are motivated in their organizations. The contribution made by these classical and

4. Research Methodology

4.1 The Quantitative Methodology Approach

The research philosophy which informed the research was the mixed methodology comprising of both the quantitative and qualitative paradigms due to how the deductive and inductive (interpretive approach) complement each other. These methodologies helped in determining the research design and type of data collecting tools which were administered to solicit data from the respondents. Mixed method designs are usually adopted because one method alone will not provide a comprehensive answer to the phenomena under study. According to Kujeke, Kennedy and Nyaruwata(2014) the quantitative and qualitative paradigms provided the researcher with opportunities to measure and evaluate variable relationships ICT challenges and teaching and learning of Chemistry in secondary schools in Harare, Zimbabwe. The methodology adopted also assisted the researcher to make an appropriate choice of the research design, which in this case was the descriptive survey.

4.2 Research Design

Makore-Rukuni et al (2001) in Shumbayaonda (2011:48) defined a research design as a plan or structure for an investigation as it is a set of plans and procedures that reduce error and simultaneously help the researcher obtain empirical evidence about isolated variable interest. The survey design makes use of sample subjects, questionnaires and interviews to collect data. They can be used for studies which are descriptive, exploratory and explanatory (Babie 1993). The researcher decided to use a descriptive survey design because the method clearly describes and explains belief, attitudes, opinions, values and behaviour of a selected group of people and in this instance are teachers and students.

4.3 Population of the Study

According to Moore, (2002), a population is a group of objects or people with the same characteristics from which a sample can be obtained. Parahoo (1997:218) defines population as –the total number of units from which data can

be collected”, such as individuals, artifacts, events or organizations. Burns and Grove (2003:213) describe population as all the elements that meet the criteria for inclusion in a study. Burns and Grove (2003: 234) define eligibility criteria as —a list of characteristics that are required for the membership in the target population”. The population of this study comprised all public secondary school A level Chemistry teachers in Glen View and Mufakose district in Harare. The overall sample size derived from the aggregate population comprised of 32 teachers, 30 students and 8 School Heads giving a cumulative total of 70.

Table 3.1: Distribution of A Level Chemistry teachers in Glen View and Mufakose District in Harare =32

	Males	Females	Total
Teachers	20	12	32
Heads			8
Students			30
Total			70

4.4 Sample and sampling procedure of the study

According to Morse (2000:3) a sample is a selection of objects or people that is selected from a population having the same measurable characteristic. Polit et al (2001:234) define a sample as —a proportion of a population”. A carefully selected sample can provide data representative of the population from which it is drawn. In this research, elements of the population were chosen at random and had a known probability of selection and the strategy is known as probability sampling which gave rise to 70 respondents as shown in Table 3.1. The individual teachers were selected deliberately for their specific characteristics that are of importance to the study—that is those teachers who were using ICT in the schools. For students, it was purposive since all of them were taking chemistry whilst school heads represented their institutions with valuable insights into the organizational operations.

4.5 Research Instruments

Contributions from UNESCO (2004), Parahoo (1997:52) and Kujeke, Kennedy and Nyaruwata(2014) share the same view that research instruments are the documents, audio recorders, interviews and questionnaires used to solicit intended or targeted data to validate the research and in most cases designed to measure knowledge, attitude and skills. In this research the researcher used five instruments namely questionnaire, interview, focus group discussion and observation checklist. The construction of the instruments took into cognizance all issues related to validity and reliability. The instruments which had been designed by the researcher were sent to experts in the fields of Education Management and ICT experts in nearby Colleges, Polytechnics and Universities.

4.6 Construction of research instruments and Field work details

4.6.1 Questionnaires

Moore, (2002) views a questionnaire as a set of questions on a piece of paper that is given to a respondent to respond according to a selection of possible answers. The researcher

designed questionnaires which had closed questions since there are no standardized ones which could serve the same purpose. Because the items were Likert type, summated scoring was done by assigning 5 to the most positive response and 1 to the extreme negative response. So in this way scores weighting was Strongly Agree (5), Agree (4), Not Sure (3), Disagree (2), Strongly Disagree (1) were given to each item. This enabled the researcher to collect large amounts of information from a large number of people in a short period of time and in a relatively cost effective way. The researcher compiled 32 questionnaires for the Chemistry teachers, 30 questionnaires for the students and 8 questionnaires that were administered to the School heads. The questionnaires were distributed on the first day of the visit to the schools and were collected after a week. The researcher sent out research assistants who were co-workers to distribute and collect the questionnaires. Since the questionnaires could not give all the information like changes of emotions, behaviour, feelings etc, the researcher also used interview.

4.6.2 Interview

Research interviews were described by Langley, (1987) as highly structured discussions used to collect a lot of quantifiable data directly from a respondent. Again the researcher designed the interview schedules for data collection. The researcher did not focus on lots of structured questions, to really explore what the interviewee wanted to tell but the researcher also used less structured questions to give the interviewee the chance to talk and collect primarily qualitative data. The researcher interviewed 16 teachers and 8 School Heads. The purpose of these interviews was to collect direct information on the challenges faced by the teachers as well as the School Administrators in using ICT in the schools. The interviews allowed the researcher to follow up the thoughts, feelings and ideas behind the responses given, in a way that questionnaire completion cannot capture.

The researcher maintained eye contact with the participants. The researcher used grand as well as mini tour questions to elicit information from participants. Grand tour questions were broad questions asked to introduce the topic. The interview techniques of probing (verbal and non-verbal) were used. These included probing or "exploring", silence, prompting as well as summarizing. The researcher used phrases such as "Could you elaborate more on that point?" maintained eye contact to encourage participants to continue speaking. The researcher summarized the last statements of the participants and encouraged more talk (Holloway & Wheeler 2002:84). The researcher used a semi-structured interview guide, but the line of questioning and responses from participants maintained flexibility and consistency. The researcher asked if there were more questions or comments and this assisted in closure of the interview. The researcher summarized the interview proceedings by restating in her own words the ideas and opinions of the participants, to ensure understanding. The participants were told of the need for follow-up interviews should there be any aspects that were not clear. According to Holloway and Wheeler (2002:237), note taking is an important activity, but it might disturb the participants. To limit this, the researcher informed the participants that notes would be taken during

the interview. A non-participant took notes so that non-verbal behaviour of the participants as well as the researcher's reactions and comments could be recorded (Holloway & Wheeler 2002:237).

4.6.3 Focus group discussion

According to Parahoo (1997:296), a focus group discussion is an interaction between one or more researchers and more than one participant for the purpose of collecting data. Holloway and Wheeler (2002:110) state that in focus group discussion researchers interview participants with common characteristics or experience for the purpose of eliciting ideas, thoughts and perceptions about specific topics or certain issues linked to an area of interest. In this study the researcher interviewed teachers, students and administrators to solicit their ideas on ICT adoption in education. All participants including the researcher had an opportunity to ask questions, and these produced more information than individual interviews. Informants could build on the answers of others whilst the researcher can clarify conflicts between and among participants. Though the instrument can provide opportunity for behavior modification, the validity and reliability of the findings are difficult to ascertain on their own hence the need for triangulation of data collecting tools.

4.6.4 Observation

Crawshaw and Chambers (1996) described observation as the inherent trait in any scientific research whereby a researcher uses the senses to collect information that would be difficult to abstain through interviews or questionnaires. The researcher used participant and non participant observation methods to variable extents. The researcher used Participant Observation in some cases to visit the teacher's in-class to see the technology they would be using. The other type of observation method that the researcher used was Non-Participant-Observation and in this method the researcher used students or other teachers to make observations on the researcher's behalf then updated the researcher on the findings later on.

4.7 Data presentation and analysis

The results of the analysis are presented in various forms which include tables, frequency polygons, line graphs and bar charts to explain the results from document analysis, questionnaires and interviews. The researcher used reflexivity, bracketing and intuiting to lay aside her preconceptions regarding the phenomenon under investigation. Data analysis occurs simultaneously with data collection (Holloway & Wheeler 2002:235). Field and Morse (1996:82) identify intellectual processes that play a role in data analysis: This systematic sorting out of data involved comprehending, synthesizing and theorizing. Correlation was used to assess the relationship between variables. For qualitative data, the researcher coded the given responses as statements and deduced patterns which were later analysed to give meanings which were formulated from extrapolation. The presentation of the data which was in frequency tables and statistical analysis was important as it enabled the researcher to visualize the trends and observe important structures from the methods used in data collection. It should be appreciated from the researcher's

point of view that the analysis of data gave meaning to data and generated information which enabled the researcher to come up with decisive conclusions and recommendations.

5. Research Findings

The results from this study were based on the mixed methodology to present the results in a more logical and comprehensive manner. Frequency tables and graphs were used to present the findings as they have strength that they quickly show the distribution of the data. According to Crawshaw and Chambers (1996) graphs have a weakness that they may overemphasize on structure of the distribution but underestimating the existence of averages and deviation. The researcher therefore used calculations and Chi square tests to draw the existence of possible relationships between the variables under study.

- On gender of learners (n=60), there were 42 males (70%) and 18 females (30%). This shows that there are more male students learning the subject of Chemistry than females and the perceptions of learners towards the use of ICT is heavily influenced by their gender roles.
- For ICT tools used by learners (n=60), 90% of the respondents made use of Computers which agrees with Ringstaff and Kelley (2002) that students can learn from computers where technology is used as a tool that can be applied to a variety of goals in the learning process and can serve as a resource to help develop higher order thinking, creativity and research skills
- With regards to ICT tools used in teaching A Level Chemistry about 95% indicated that the most frequently used ICT tool in teaching A Level Chemistry was the computer and the LCD projector.
- Students Internet access showed that about 65% of the students accessed the internet 3 to 10 hours a week whilst 35% accessed the internet for less than 3 hours per week.
- Most teachers (80%) strongly agreed that computer workshops should be done to improve the use of ICT
- At least 90% of the students agreed that cellphones can be used to learn in class and can assist in accomplishing tasks set as homework.
- The distribution of frequencies showed that at least 35% of the learners equally agreed that the use of ICTs helps them to master their content.
- On availability of ICT tools in schools, 60% of the teachers in the schools under study indicated that there were less than 10 personal laptops as part of schools' hardware infrastructure.
- About 60% of the teachers cited lack of knowledge being the actual challenge faced by the A Level Chemistry teachers whilst 100% of the teachers perceive lack of resources as the major barrier to effective use of ICT in teaching and learning.
- Most of the A Level Chemistry teachers (76%) have personal challenges when it comes to using ICTs
- On whether teachers do not use ICT because, 80% of the teachers strongly agreed that the administration was not supportive of full ICT integration and utilization
- Interestingly 70% of the administrators strongly agreed that teachers should bring their own ICT into the schools and use it to teach. This shows that the teachers do not use

their own ICT believing that the ICT should be made available by the schools

- About 60% of the respondents strongly agreed that the Ministry of Education should lobby through the Ministry of ICT for a reduction in duty when acquiring ICT infrastructure in school to ensure all teachers had access and also increase computer - ratio.
- The findings reflect that eighty percent (80%) of the male teachers had faced challenges in the use of ICT whereas ninety-one percent (91%) of the females had faced challenges more than males.

6. Conclusions

- It can also be concluded that female Chemistry teachers have a more positive attitude towards ICT use than male Chemistry teachers but they face more challenges as they try to adopt the use of ICT.
- All Chemistry teachers are aware of the importance of ICT usage in teaching and learning environments.
- All the teachers, indicated that ICTs have benefits over traditional methods of teaching hence appreciating and embracing the web based delivery methods.
- Chemistry teachers who value the importance of ICTs over the traditional teaching methods have less challenges in using ICT in teaching.
- Chemistry teachers with more computer competence and access face less challenges towards ICT use in teaching and learning as compared to their counterparts.
- It can be concluded that lack of resources and lack of knowledge are the most hindrance to effective ICT use by teachers. At the same time provision of resources like computers and ICT training courses enhances the effective integration and use of ICTs by Chemistry teachers.
- It was discovered that the majority of teachers are not using ICTs during lessons. The only ICT commonly in use is the computer and the LCD projector.
- From the findings it can also be noted that Chemistry teachers are not aware of the different ICTs (hardware and software) that they can use in teaching and learning of Chemistry.
- Again what the above implies is that the Chemistry teachers are not aware of how the different ICTs can be integrated in teaching and learning to enhance students learning to discover, share and create knowledge.
- From the findings concerning teachers' gender and, it was discovered that both female and male teachers have no objection on the benefits of using ICTs. The female teachers (100%) and male teachers (100%) all agreed that ICTs offer a lot of benefits over the traditional methods of teaching.
- From the findings pertaining ICT training, fifty-three (53%) indicated that ICT was part of their training and they had attended a course in ICT
- This shows that some Chemistry teachers lack skills and knowledge in the use of ICT.
- Most Chemistry teachers only understand ICT as a tool to transfer instructional material. There is need for training in the integration of technology in the Chemistry curriculum.

6.1 Implications of the Study

- The results of this study have a number of important practical implications for teachers and educational authorities in Zimbabwe. From the research findings a considerable amount of evaluative insights and awareness on the use of ICT in the teaching and learning processes have been observed and articulated.
- The researcher interrogated a number of theories of learning which helped in greater understanding of natural phenomena and the study made some significant contributions to the literature in a number of ways by linking the relationship in both independent variables, teaching and learning chemistry at A level to the dependent variable, ICT challenges.

6.2 Recommendations

- Policy makers are also encouraged to make the integration of ICTs in Chemistry compulsory through drafting of relevant circulars. This will urge the teachers and school authorities to implement the use of ICTs.
- Teacher training colleges and universities should also provide pre-service teachers with positive technological experiences and exposure in a variety of ICTs that can be easily be implemented in Chemistry.
- School heads are encouraged to assist Chemistry teachers by acquiring the required resources like computers, LCD projectors, smart boards, and software and internet connectivity for use in Chemistry lessons.
- Teachers are encouraged to have their personal initiatives towards the available ICTs so as to enhance the teaching and learning process and their professional development.
- The developers of e-learning software are encouraged to develop programs that are user friendly in the teaching and learning process of Chemistry

6.2.1 Recommendations for further research

- More studies can be carried out to make a comparative analysis of the relationship between the teachers' levels of income and the utilisation of ICT.
- In the researcher's opinion, the same evaluation study can be used to make comparisons between school types and their geographical locations.

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