An Evaluation of Advanced Level Chemistry Teaching in Gweru District Schools, Zimbabwe

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Abstract

This study evaluated the implementation of the Advanced level chemistry curriculum in Gweru district secondary schools in Zimbabwe. To guide this study seven research questions were raised and answered. The study employed a descriptive survey design and three instruments were used to collect data from 6 secondary schools selected from 12 schools in the district using the Probability Proportionate to Size (PPS) sampling technique. Six (6) school heads, 10 chemistry teachers and 130 students participated in the study. The instruments used for data collection were a questionnaire, interviews and personal observations. The study established that the important factors that limit the quality of chemistry teaching and learning include overloaded curriculum content and inadequate time for teaching chemistry; inadequate resources, apparatus, equipment and consumables. Insufficient funding of science, lack of support staff and ineffective teaching methodologies further limit the quality of chemistry teaching and learning. The study recommends the in servicing of chemistry teachers to give them a better orientation on what is expected of them and expose them to current methods of teaching and presenting content materials to learners. The Ministry of Education Arts, Sports and Culture should for partnerships with private sector and nongovernmental organizations to provide the necessary infrastructure and enabling environment to make chemistry education thrive.

Keywords: instructional methods, learning outcome, content coverage, assessment

1. Introduction

Today, the need to promote a society of scientifically literate citizens is regarded as urgent in many countries and is accepted as one of the main goals of science education (Jenkins, 1997). It is generally accepted that achieving functional scientific literacy involves providing People with an understanding of science that they can use as they make decisions and engage in debate about scientific and technological issues outside formal education settings (Ryder,2001). In this sense, educating for scientific literacy entails not only teaching science concepts and theories but also learning about the nature of these concepts and how they function in relation to other beliefs about the physical world (Eichinger, Abell, & Dagher, 1997)

Increasingly, scientific literacy is being described as the overall aim of science education (Bybee,1997). The teaching of chemistry therefore, as a scientific discipline must help students gain scientific literacy abilities and to grow into scientific literate citizens. Chemistry is a very important subject as its knowledge is required for the successful study in very many important professions. Because of this importance, chemistry is occupying a prime place in the senior secondary School curriculum. It is therefore necessary that students studying chemistry should understand the subject so that they can apply their knowledge to their everyday interaction with people and their ever changing environment. The Zimbabwe Schools Examinations Council (ZIMSEC) Advanced level chemistry syllabus for 2008 to 2012 was designed to:

• to provide, through well designed studies of experimental and practical chemistry, a worthwhile educational experience for all students, whether or not they go on to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to become confident citizens in a technological world, able to take or develop an informed interest in scientific matters.

• to stimulate students, create and sustain their interest in Chemistry, and understand its relevance to society.

• to give a thorough introduction to the study of Chemistry and scientific methods

• to develop skills and abilities that are relevant to the safe practice of science and to everyday life:concern for accuracy and precision, objectivity, integrity, the skills of enquiry, initiative and insight.

• to enable candidates to become confident citizens in a technological world and to take an informed interest in matters of scientific importance.

• to stimulate interest in, and care for, the environment.

•to promote an awareness that the study and practice of science are co-operative and cumulative activities, and are subject to social, economic, technological, ethical and cultural influences and limitations.

These goals can only be achieved by the teacher through giving the right types of instructions to the chemistry students. Quality teaching is a backbone of any educational system for developing scientifically literate citizens and what students learn is greatly influenced by how they are taught. Therefore students cannot achieve high levels of performance in the absence of skilled, talented and dedicated professional teachers. No matter how well-developed and comprehensive a curriculum is, its success is dependent on the quality of the teachers implementing it hence no nation's educational system can rise above the quality of her teachers (Ughamadu 2005).

Besides the quality of teachers, chemistry teaching standards have to be followed if the above stated national goals have to be achieved. These standards include: (i) provision of an inquiry and practical based programme for learners (ii) providing opportunities to learn for all learners and supporting their inquiries (iii) assessment of student learning and teachers' teaching skills (iv) providing learners with adequate time, resources and facilities for chemistry learning (v) active involvement of teachers in planning and development of school science programmes (Ajaja, 2009). However, developing nations like Zimbabwe do lack adequate resources to enforce these standards in chemistry teaching.

The competence of a chemistry teacher can be judged by what goes on in the chemistry classroom. Research results (Ajaja 2005) have indicated that science teachers continue to teach science using the lecture method despite the recommended guided discovery/inquiry methods. The inability of science teachers to apply guided discovery/inquiry approaches in their teaching is attributed to problems which include; lack of laboratories equipped with facilities in schools and competency problems arising from the training of science teachers.

Daily observation of chemistry teachers in the classrooms indicate that most of the teaching skills chemistry teachers acquired before certification are not put into practice. The deficiencies in chemistry teaching range from; non coverage of content in schemes of work, non giving and marking of assignments, non supervision of instruction, non-organization of practical lessons, non-organization of extra lessons to cover lost grounds and non-assessment of learning outcomes regularly. Again all these tend to suggest that teachers are to be blamed for the lack of proper exposure of the chemistry students-which result in poor learning outcomes among the chemistry students.

2. Aims of the Study

This study was carried out in an attempt to identify the problems hindering the effective teaching and learning of chemistry in secondary schools in Gweru district, Zimbabwe. The teaching and learning of chemistry has standards to be followed by chemistry teachers if effective learning by students is to be achieved. Zimbabwean literature in this area appears very scanty and as a result, our knowledge of what chemistry teachers do in the classrooms is very limited. This therefore calls for more research efforts directed towards this very important aspect of chemistry teaching. It is also very important to compare our standards in chemistry teaching as presently constituted with the international standards to enable us improve in chemistry teaching. This study is mainly aimed at determining the picture of what is actually happening in the teaching of chemistry at advanced level. The study will investigate among other things the adequacy of time allocated for the teaching of the subject; chemistry teaching, learning and assessment practices; student participation in chemistry; factors limiting the quality of chemistry teaching; organization of practical lessons, organization of extra lessons at no cost, and evaluation of learning outcomes.

3. Research Questions

The study was guided by the following research questions:

1. How many periods are allocated to chemistry teaching in school time table?

2. What is the pattern of interaction in the chemistry classroom and what instructional methods are used for teaching chemistry in schools?

3. What is the extent of content coverage in chemistry schemes of work in schools and how often are assignments given and marked in chemistry?

4. How is chemistry instruction supervised in schools?

5. How often are chemistry practical lessons organized in our schools?

6. How is learning-outcome evaluated in schools and what learning-outcomes are evaluated in school chemistry?

7. What factors are limiting the quality of chemistry teaching in our schools?

4. Methodology

4.1 Research Design

The design employed for this study was a descriptive survey in which multiple methods were used to obtain, explain and understand the viewpoints of participants in this research.

4.2 Population and Sample of the Study

The population of study consisted of all the High schools in Gweru education district offering Advanced level chemistry. The district has 12 high schools. The samples of the study consisted of 6 high schools. The study employed a proportional stratified random sampling technique in the selection of the 6 participating high schools. The 12 high school were first divided into two strata: government and nongovernment schools. Each strata contained 6 schools. Using balloting (withdrawal without replacement) 3 schools were randomly selected from each strata. The school head, the A' level chemistry teacher(s) and the upper 6 students from each of the selected schools automatically became participants in the study. Thus a total of 6 school heads, 10 teachers and 130 students participated in the study.

4.3 Research Instruments

The major instrument used for data collection was a questionnaire. The questionnaire consisted of 12 items which generated data for answering the research questions. Other strategies employed in data collection include: interviews and personal observation of what goes on in chemistry classrooms

4.4 Procedure for Data Collection

The researcher employed the services of a research assistant in the collection of data. The researcher together with research assistant administered the questionnaires on the 6 school heads and 10 chemistry teachers in the sampled schools. All the questionnaires were collected from the respondents as soon as they finished with their responses. Their responses were scored, summarized and presented in tables. Using an observation schedule termed the chemistry classroom interaction category the researcher also personally observed and interviewed three science students in each chemistry classroom in each school visited and for 10 minutes each. The major statistic used for the analysis of collected data was simple percentage.

5. Findings and Discussion

5.1 Periods Allocated for Chemistry Teaching

As shown in Table 1 the number of periods allocated for teaching of chemistry per week is 8. The distribution of the periods indicates three double and two single periods. Each period lasts 35 minutes. The pattern is the same for both government and nongovernment schools. Thus there are five theory lessons per week for the subject. The subject is also allocated four periods of practical session per week thus giving a total of 12 periods per week for the subject. The periods allocated to the subject per week is in line with Ministry of Education Sport, Arts and culture policy of 10 – 12 periods (35 – 40 minutes long) per week. However due to congestion on the timetable most schools allocate 35 minutes for a period. Both teachers and students felt that the time allocated for the subject was adequate enough for them to cover the stipulated content.

Table 1. Period allocation for chemistry teaching in the school timetable

School	Number of Periods	Distribution of Periods
A (government)	8	3 double periods
		2 single periods
B (government)	8	3 double periods
		2 single periods
C (government)	8	3 double periods
		2 single periods
D (nongovernment)	8	3 double periods
		2 single periods
E (nongovernment)	8	3 double periods
		2 single periods
F (nongovernment)	**8**	3 double periods
		2 single periods

5.2 Pattern of Interaction and Instructional Methods Used in the Chemistry Classroom

Table 2 indicates that the pattern of interaction in the chemistry classroom in both government and nongovernment schools is teacher initiated and teacher dominated teacher – student interaction. On average about 80% of the class time is spent on teacher –student interaction. This does not agree with international standards which call upon teachers to plan inquiry based programs for learners as well as supporting student inquiries (Ajaja , 2009). Inquiry approaches expose students to the nature of science and the scientific enterprise, and provide an effective approach to meaningful learning, which is grounded in personal experience of natural phenomena and engagement in the learning process. Experimental investigation is central to the pursuit of science and the learning of chemistry. Minds-on, as well as hands-on, practical work is an essential component of the chemistry curriculum. These findings are not in agreement with Kazembe (2010) who notes that science education should be a student-centered learning process with the teacher trying to understand the student's construction of knowledge and providing guidance. The teacher should facilitate learning process by asking effective questions and guide students to the right resources. The student should reflect, arrange, and inter-relate the different bits of information.

Table 2. Interaction in the chemistry classroom

School	% of Teacher - Student Interaction time	% of Student - Student Interaction time
A (government)	80	20
B (government)	85	15
C (government)	84	16
D (nongovernment)	70	30
E (nongovernment)	80	20
F (nongovernment)	85	15

The findings also fell below the recommendations of cooperative learning for teaching for effective learning (Whicker, Bol, and Nunnery, 1997) which encourage student – student interaction. Yip (1998) noted that cooperative learning in small groups give students an opportunity to identify and remedy their misconceptions in a non-threatening environment. Students who work collaboratively learn faster and more efficiently, have greater retention and feel more positive about the learning experience. Cooperative learning has significant effects on academic peer relationships and social development. The students help each other to comprehend and accomplish tasks as well as put in more effort into their work and even criticize one another if necessary. Cooperative learning activities enable students to develop a feeling of community in the classroom and create a positive force that promotes achievement through commitment and mutual goals in learning. Cooperative learning activities nurture an environment in which a wider range of student learning styles is supported, and most collaborative references indicate that the best cooperative groups mix students with different learning styles.

Borich (2004) also notes that because of student-student interaction, in co-operative learning groups, students gradually take responsibility for each other's learning.

Table 3 shows that teacher-student interaction was dominant among the sampled schools because of the method of instruction which is expository (classroom teaching method or lecture method). The inquiry approach has been recognized as a crucial teaching strategy for improving students' learning of science and that teaching of science in schools should be by guided-discovery and inquiry approaches (Ajewole,1994). However, this study indicates that inquiry teaching and learning approaches are rarely practiced in the chemistry classrooms because of the lack of resources for effective practical work and preparation for laboratory work makes much demand on their time among other factors. Teachers pointed out that the broad scope of the chemistry curriculum and emphasis on quantity of content coverage as the major constraints on inquiry approaches in chemistry teaching and learning in Gweru district schools. The teachers suggest that when teach less content, they teach it better by introducing ideas in a variety of ways and thus encourage students' learning. Research in science education (Chang and Mao, 1998) has also found that teachers who encourage inquiry approaches in their teaching have students who perform better than those taught using traditional approaches when higher-level cognitive processes were emphasized, but performed equally well on low-level cognitive processes. Thus the inquiry-based approach helps to develop higher-level cognitive skills in learners and improves learning outcomes among students.

Table 3. Methods of Instruction used in the chemistry classroom

Method of Instruction	Frequency of use(%)
Expository method	83
Inquiry method	0
Discovery method	0
Laboratory method	17

5.3 Content Coverage and Written Assignments in Chemistry

As shown in Table 4 none of the schools covered the scheme of work at the end of the course in both government and nongovernment schools. On average, the levels of coverage of schemes of work are 98% for nongovernment schools and 89% for government schools. The findings indicate was that a reasonable percentage of content materials are not covered in the government schools. The non-coverage of a reasonable amount of science content materials in government schools can be explained to be the direct effects of sit-ins /go slows of teachers in the public schools embark on to press home their demands. Government schools also fail to attract qualified teachers due to low incentives offered in these schools as a result qualified teachers opt for private /nongovernment schools were there are better local incentives hence government schools lag behind in curriculum implementation due to unavailability of teachers.

Table 4. Extent of content coverage in schemes of work

School	Extent of coverage(%)
A (government)	90
B (government)	88
C (government)	90
D (nongovernment)	98
E (nongovernment)	98
F (nongovernment)	97

5.4 Giving and Marking Assignments in Chemistry

Table 5 shows that the giving and marking of assignments by chemistry teachers is done once a week in both government and nongovernment school. The findings indicate that the teachers do adhere to the Ministry of Education policy guidelines in science which stipulate that 3 to 4 tests and 6 to 8 written exercises are to be given to learners per school term as written work. A school term has 12 teaching weeks. The findings are in agreement with international standards in science education which call for teachers to regularly engage in ongoing assessment of their students and of their teaching and resulting students learning Trowbridge and Bybee (1996). Assessment is an integral part of the teaching and learning process, and it should enhance the quality of both teaching and learning. Assessment in science is the collection and interpretation of information about learners' knowledge, understandings, skills and attitudes relating to the science outcomes. This information is used to report progress to students, parents and others, and contributes to establishing accountability, but it also is used to provide feedback which informs the future action of both learners and teachers. Learners should be

helped to use the feedback to develop the skills of monitoring their own learning in science. Teachers need to use the feedback to develop and enhance the effectiveness of their science teaching programs. Assessment tasks should be developed as part of the teaching and learning program so that they reflect the learning outcomes for science and match the needs and levels of development of the students. Hackling, Goodrum, & Rennie (2001) note that assessment must be designed to assess students' understandings and skills as well as their knowledge. Assessment tasks should be authentic in that they reflect the nature of the teaching and learning activities, and varied, in order to cater for the different needs and interests of students. A variety of assessment tasks accommodates preferred learning styles and differences among learners in order to give them opportunities to demonstrate what they know and can do in science. Opportunities can be provided for teachers and students to negotiate the nature of the assessment tasks and the ways in which the tasks will be conducted. Findings from this research suggests that 90% of the high school chemistry teachers' current assessment practice is not effective in these regards.

Table 5. Giving and marking assignments

School	Every lesson	weekly	fortnightly	monthly	Not at all
A (government)		√			
B (government)		√			
C (government)		√			
D (nongovernment)		√			
E (nongovernment)		√			
F (nongovernment)		√			

5.5 Supervision of Chemistry Instruction

Supervision of instruction in all chemistry classrooms done by the School heads, their deputies and head of the science department. The form of supervision includes assessment of schemes of work, learners' exercise books as well as classroom instruction. Table 6 shows the frequency of the supervisions. The findings show that instructional supervision is thoroughly done in nongovernment schools than in government schools. School heads in government schools supervise teachers when expecting ministry of education inspectors is not healthy for proper teaching and learning. The normal supervision of instruction that will guarantee effective and quality teaching and learning is the one done by the subject specialist and routinely done.

Table 6. Supervision of chemistry instruction in classrooms

	School Head			Deputy Head			Head of Department		
School	schemes	exercise books	lessons	schemes	exercise books	lessons	schemes	exercise books	lessons
A government	≠	≠	≠	↗	↕	↕	↗	↗	↕
B government	≠	≠	≠	↗	↕	↕	↗	↗	↕
C government	≠	≠	≠	↗	↕	↕	↗	↗	↕
D non government	↗	↗	↕	√	√	↗	√	√	√
E non government	↗	↗	↕	√	√	↗	√	√	√
F non government	↗	↗	↕	√	√	↗	√	√	√
Key	√	every 2 weeks		↕	once in a while				
	↗	monthly		≠	expecting school	inspector			

OECD(1994) notes that quality teaching is a process that helps teachers to focus on the educational improvement of learners through the integration of adequate knowledge of the curriculum content areas, functional pedagogic skills, critical reflective teaching, empathy and commitment to the educational process, and the acquisition of managerial competencies within and outside the school context. From the above, it is clear that quality teaching fundamentally involves teachers' knowledge of content and pedagogical skills, knowledge of the curriculum and effective supervision and classroom management as well as reflection to improve the learning outcomes of the learners. If quality teaching in chemistry is to be realized then instructional supervision should be done routinely in such a way that at the end of the day the teacher benefits from the inspector in teaching improvement.

5.6 Organization of Practical Lessons in Schools

Table 7 shows that chemistry practical lessons are organized on a monthly basis in government schools. Also shown in the table, nongovernment schools organize practical lessons after every two weeks. The nongovernment schools do have enough resources to conduct practical lessons twice a month. The findings indicate that learners in nongovernment schools are more exposed to practical chemistry than their counterparts in government schools. The practical lessons are what make chemistry real and remove it from abstraction. Practical lessons help to demonstrate concepts learned in theory. The organization of practical lessons in both government and nongovernment schools is in line with national and international standards. Goldrum et al (2001) notes that inquiry approaches expose students to the nature of science and the scientific enterprise, and provide an effective approach to meaningful learning, which is grounded in personal experience of natural phenomena and engagement in the learning process. Experimental investigation is central to the pursuit of science and the learning of science. Minds-on, as well as hands-on, practical work is an essential component of the science curriculum. Inquiry approaches in chemistry thus enable teachers' to be creative and enrich students' abilities in understanding chemistry concepts and processes.

Table 7. Organization of practical lessons

School	weekly	fortnightly	monthly	Every term	Not at all
A (government)			√		
B (government)			√		
C (government)			√		
D (nongovernment)		√			
E (nongovernment)		√			
F (nongovernment)		√			

5.7 Assessment of Learning-Outcome

Table 8 shows that the assessment of learning outcome in chemistry in both government and nongovernment schools is by using a combination of school set and ministry of education (ZIMSEC) set examinations. All the schools mainly use school set examinations in assessing their chemistry students before they sit for the final national examinations. School based assessment is done during the first, second and third terms when students are in their Lower sixth form (form 5) as well as during the first and second terms of their upper sixth form (form 6). In the third term of their upper sixth form (form 6) all the government and nongovernment schools write one examination that is centrally set by Ministry of Education through its examination body, the Zimbabwe Schools Examinations Council (ZIMSEC). Findings from this study indicate that one private school offers Cambridge International Examinations to its students. The preference of Cambridge over ZIMSEC examinations is that the school has cast doubts on the integrity and credibility of examinations, which were undermined by persistent strikes by teachers, exam leakages as well as delay in the publishing of the exam results.

Table 8. Assessment of learning – outcome

School	School based Exams	National Exams (ZIMSEC)	Cambridge International Examinations (CIE)
A (government)	√	√	
B (government)	√	√	
C (government)	√	√	
D (nongovernment)	√	√	
E (nongovernment)	√	√	
F (nongovernment)	√	√	√

The findings from this study are in agreement with Goldrum et al (2001) who note that assessment is an integral part of the teaching and learning process, and it should enhance the quality of both teaching and learning. Assessment in science is the collection and interpretation of information about learners' knowledge, understandings, skills and attitudes relating to the science outcomes. This information is used to report progress to students, parents and others, and contributes to establishing accountability, but it also is used to provide feedback which informs the future action of both learners and teachers. Learners should be helped to use the feedback to develop the skills of monitoring their own learning in science. Teachers need to use the feedback to develop and enhance the effectiveness of their science teaching programs. Learning is cumulative and assessment should allow learners' progress to be monitored. Assessment tasks should be developed as part of the teaching and learning program so that they reflect the learning outcomes for science and match the needs and levels of development of the students. Assessment must be designed to assess students' understandings and skills as well as their knowledge. Table 9 shows the type of learning outcomes assessed by teachers.

Table 9. Type of learning-outcome assessed by science teachers

School	Cognitive	Psychomotor	Affective
A (government)	√	√	√
B (government)	√	√	√
C (government)	√	√	√
D (nongovernment)	√	√	√
E (nongovernment)	√	√	√
F (nongovernment)	√	√	√

Table 9 shows that assessment of students is in line with both national and international standards that learners should be assessed roundly and that assessment should be continuous. The all-round assessment means assessment of Cognitive, Affective and Psychomotor domains. Data gathered in this study also indicate that there is a greater use of formative assessment for improving teaching and learning.

5.8 Factors Limiting the Quality of Advanced Level Chemistry Teaching

In the questionnaire and interviews, teachers were asked to identify the factors that limited the quality of chemistry teaching in their schools. The factors most frequently identified were inadequate resources and budget, inadequate laboratory equipment and consumables, inadequate time for preparation, collaboration and reflection, poor access to computers and inadequate time to teach chemistry. Teacher questionnaire and interview data clearly indicates that resources limitations are a significant constraint to the quality of teaching and learning of chemistry.

Due inadequate science budgets most schools do not have enough funds to purchase equipment and laboratory apparatus as well as consumables in the form of chemicals. This in itself acts as a barrier to the successful implementation of the A Level chemistry curriculum. The teachers also noted inadequate time for preparing to teach chemistry lessons, the overloaded school curriculum which limits the time available for teaching chemistry and lack of support staff to assist with organising and storing materials as the other limiting factors.

6. Conclusion

The findings of this study indicate that the teaching of chemistry is faced with a number of challenges which include the overloaded curriculum such that there is too much to cover in the available time, inadequate resources, equipment apparatus and consumables. Inadequate equipment, apparatus and consumables do limit the conduction of laboratory practical work in the schools. Apart from the lack of resources which significantly limit the teaching and learning of chemistry, the chemistry teachers themselves are not well positioned to teach chemistry effectively due to deficiencies arising from the use of inappropriate teaching methods for teaching chemistry. The teachers also do not have support staff that are essential adjuncts to allow teachers the time required to plan and implement an inquiry-based chemistry curriculum.

7. Recommendations

Based on the findings of this study, the following recommendations were made:

The government should employ more chemistry teachers to lower the work load of chemistry teachers, for them to be more effective.

The current chemistry teachers should be retrained and inserviced to give them a better orientation on what is expected of them and expose them to current methods of teaching and presenting content materials to learners.

The Ministry of Education Arts, Sports and Culture should provide the necessary infrastructure and enabling environment to make chemistry education thrive.

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