

INNOVATIVE PRACTICES IN CHEMISTRY INSTRUCTION IN THE CASE OF DEVELOPING COUNTRIES OF AFRICA: A REVIEW

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ABSTRACT

Chemistry education plays a critical role in fostering scientific literacy and promoting socio-economic development. However, the challenges faced by educational systems in the developing regions of Africa, often hinder effective chemistry Instruction. This review aims to explore Innovative practices in chemistry instruction specifically to developing countries to Africa, with a focus on, Innovative practices in chemistry curriculum, Innovative practices in chemistry Instruction, and important considerations for improvising equipment and experiments because this is very significant part for Innovative Instruction. The review highlights the Innovative approaches, such as: Adjustment of Students, Student/Learner Centered Approach, Inductive Approach, Process Approach to Teaching, Student Motivation Approach, Socratic Approach, Problem-based Instruction, and Inquiry based Instruction. So, in using them properly, they are important to improve the quality of chemistry Instruction. [*African Journal of Chemical Education—AJCE 14(2), May 2024*]

INTRODUCTION

Concept of Innovation

Innovation has become a first choice for a lot of institutions in the world. Strong global competition and technological advancement have made innovation a source of competitive advantage [1]. Innovation is a "new idea, creative thoughts, and new imaginations in form of device or method" [2]. Thus, the definition of innovation has been becoming an area of interest for scientists and various industries. It has however been noted that, the way innovation has been defined within a given institution or an organization will determine what activities will take place within it. Scientists and industry used a different approach from many perspectives regarding the definition of innovation, including radical or incremental changes in products and processes [1].

The main objective of instruction is to provide knowledge to the students [3]. Any method that can replace the traditional chalk-talk method and help to the achievement of the objectives is considered as innovative [4]. Hence, in the traditional way of teaching, the teacher completely regulates the teaching and learning, the teacher stresses on facts, i.e the teacher gives lecture and the student is simply a passive listener[5]. In teaching of science, the teacher should have full confidence in the subject matter before going to the students and this is helpful for successful teaching. Teachers are expected to play a big role to create an all-rounded student, for this the appropriateness of

delivery of lessons is very important. The teacher should be experienced and has the interest to use innovative teaching methods[6].

Innovation in education as focused by many scholars is a deliberate, systematic, new, specific and constant change in the system of a given society, and is targeted at the betterment of the system, for a more valuable and effective way to the educational needs [7]. Thus, [8] considered innovation as a process when integrated in education particularly in chemistry would make the instruction simple and attractive, and eventually make the life of individuals better. [9], stated that Innovation in Education is a inventive, latest educational and innovational strategy, a creative way to amend education, a creative solution, a creation of new educational culture, a new opening, and a new thought to overcome challenges in education. Hence, it is essential that the ordinary way of teaching chemistry in this fast growing and dynamic world should be altered, and the introduction of innovative strategies that are helpful to the art of chemistry instruction at all stages of education is must.

This is an observation from various science tutors including [3]. Similarly, [4], in any healthy educational system, the system should always run to introduce new ways of teaching, shift to achieve latest scientific goals, produce new products and become more rather than less. Innovation is

applicable to all fields of studies, like, Education, Health, Communication, Agriculture, Industry, Governance, etc., but this paper is about innovative practices in Chemistry instruction.

Obviously, Chemistry has become one of the prominent fields of study and it is a precondition for scientific and technological advancements. It gives the chance for students to get knowledge and skills related with scientific processes required for the progress of science and technology. In chemistry, students are motivated to obtain and carry out the scientific skills. Chemistry has an indispensable role for the betterment of the life of human being, so, the child/student should know chemistry. For this, suitable techniques of teaching chemistry must be introduced, and the appropriate and the modern is the innovative instruction. If this is properly used, the burdens of the society can be minimized from time to time.

Statement of the problem

Nowadays, the usual method of instruction can't be preferred by the students of the new generation, even, if you try to use the common method of instruction, they can't listen; some students are always before the teacher, because they do have the exposure to the new advancements of the world. So, to cope up with the time of science and technology, using of innovative practices in

chemistry instruction is not a question of choice, but must. If this is so, the reviewers, have not found any reviewed paper in this regard, and the main purpose of this work is to fill this gap.

Objectives

The General objective of this review is to give an insight of the innovative practices of chemistry instruction. The specific objectives of the review are, to review the innovative practices in chemistry curriculum, instruction and the practices of innovative improvisation in chemistry instruction.

REVIEW METHOD

The paper is designed to give evidence of the need to review innovative practices in chemistry curriculum, instruction, and the innovative practices in chemistry instruction. 50 articles were downloaded from the African Journal of Chemical Education (AJCE), and from these, 16 articles which were published from the year 2013 to 2023 were selected, afterwards, 10 articles which focus on high schools of developing countries of Africa were filtered, and eventually, 8 articles relevant to the review title were selected for review. All these selected articles focus on

Innovative chemistry Instruction. The Key words used to find the required information were, Innovative, Innovative Chemistry Instruction, Improvisation.

THE INNOVATIVE PRACTICES IN CHEMISTRY CURRICULUM, INSTRUCTION, AND THE INNOVATIVE IMPROVISATION

Innovative Practices in Chemistry curriculum

According to [10] curriculum is a vehicle through which education takes place and it occupies the learner, the teacher, the content, the subject, the resources, the methods of teaching, the method of evaluation, the physical and psychological environment, which should be proper for learning to happen. Let's discuss three of them.

Teacher

In the innovative chemistry curriculum, a teacher with good background or good result of chemistry from his/her stay in high school, Colleges/Universities as a student and a teacher with higher chemistry research concentration should be given the chance to teach chemistry. But in the near past, chemistry graduates (degree holders) were unable to deliver chemistry properly and not willing to teach for the required grade level. As a reason they say that we shouldn't suffer because the government is not investing in it, and so, the course is carelessly handled. Even the school

administration knows this fact but ignores it. As a result, understanding of the students is not encouraging.

Content

The contents of the subject should be logically organized, and very much experienced professionals of chemistry are essential in the preparation and evaluation, and it will be very important if, the contents of chemistry, are supported with educational tours to different industries.

Resource

Due to the nature of the course, educational institutions should budget proper amount of money to prepare enough resources to chemistry instruction.

In general, to conduct effective instruction of chemistry through innovative approach, the match of chemistry curriculum with mental development, background and environment of the students is crucial, otherwise the curriculum is inappropriate, and students can't innovate and the published curriculum should be in agreement with the economic development of the country. Hence, innovative chemistry curriculum must be developed in order to introduce modern scientific techniques.

Some African countries, like Nigeria, Tanzania, Lesotho, Rwanda, and Ethiopia have incorporated innovative chemistry curriculum practices.

Innovative Practices in Chemistry instruction

The main objective of teaching is passing of information or knowledge to the student. Any method using the technology or modifying the present traditional chalk-talk method are considered as innovative if they serve to the attainment of objective of teaching [4].

Awoniyi in [11] observed that to be effective, the teacher has to be many things: a source of information and a guide, an organizer of opportunities for learning, someone who can structure a suitable ground for learning, and an advisor. The teacher has to be familiar with innovations in chemistry instruction so as to be able to determine the most appropriate strategy for an effective lesson delivery. As a teaching strategy, teachers must use various innovations that will help to provoke the students' interest and encourage them to develop positive attitude for effective learning outcome.

In innovative Practices, the responsibility of the teacher, the principal and the family are significant in many ways. But the teacher is very critical and irreplaceable to show all the important directions to the student.

For effective instruction of chemistry, the teacher is expected to communicate effectively and utilize appropriate innovative instructional strategies. This review, therefore, discussed the following innovative techniques to chemistry: I) Adjustment of Students, II) Student/Learner

Centered, III) Inductive Approach, IV) Process Approach , V) Student Motivation Approach, VI) Socratic Approach, VII) Problem-based, and VIII) Inquiry based.

I. Adjustment of Students

In innovative approach of chemistry instruction, adjustment of student is very important, because chemistry is a practical subject, hence, there a lot of lessons performed at the laboratory, so before the start of the work, to have a healthy class, at the beginning of the day or class all treats that may be obstacles to the students learning should be avoided. This can be done by providing general orientations starting from sitting arrangement up to how to use or handle chemicals, the rules and regulations of the laboratory. There should be a governing system at the schools. Accordingly, students can build confidence to work in the laboratory, by doing so, anxiety can be minimized. This idea is also supported by [6] and states that if the students are not assisted, they may not appreciate learning since the main duty of the teacher is to remove obstacles.

In general, there are a lot of things that should be adjusted, like: The laboratory should be available and favorable, ensure the consistency with the proposed learning goals, incorporate pre-laboratory works, because this can help students to prepare for learning in a difficult situation, adjusting opportunities for innovation and so on.

II. Student/Learner Centered Approach

In this modern time, the center of instruction is always the student. So, to satisfy the interest of the student, different innovative teaching methodologies, like, peer discussion, group discussion, panel discussion, debating, group work, . . . suggested by different scholars are in practice in the world today. Priority to the student! According to, [12] the student-centered innovative methods consist of; planed discussion, advisory approach, panel discussion, small group discussion, seminar, debate, committee and group work, problem solving, research, case study, etc.

III. Inductive Approach

Inductive approach to chemistry instruction is crucial because it helps to study and introduce fundamental new concepts, laws, truths, and new methods of solving a particular problem or finding solutions.

Inductive approach is a way from singular statement to universal ones, known to unknown and from concrete to abstract [11].

Example I

An element with atomic number:

- a) 3 can form + 1

- b) 11 can form +1, and
 - c) 19 can form +1 oxidation state in reactions.
- **Hence, all elements with an outermost shell of one electron can form +1 oxidation state in reactions.**

Example II

Elements with atomic number 11, 12, 13, and 7, 8, and 9 and so on lose 1, 2, 3 and gain 3, 2, 1 electron in reactions, respectively.

- **Hence, it can be concluded that, in chemical reactions, all elements except hydrogen, loses or gains electrons to have eight electrons or an electron configuration of the next noble gas.**

IV. Process Approach to Teaching

Process approach is significant, because students get the opportunity to actually participate actively by their selves; so that they better learn the lessons and [13] added that, process approach is one of the best ways to teach chemistry.

A teacher can use innovative procedures to cover different lessons of chemistry, like the following.

Example A

In a certain community where a certain teacher is living observed that the people has a problem in how to handle and use wastes, generally the environment they are living in is not friendly, and this has become a health problem and the lesson of the coming week will be about environmental protection (in the course environmental chemistry), to reduce the challenges of the community and to make the students their lessons more understandable, the teacher can orient and take his/her students to actually participate in the community in sanitation, and make them to participate in planting different seedlings, afterwards, he/she can make him/her to write a brief report of their work.

Example B

A chemistry teacher has lessons dealing about soap and cement, respectively, so, he/she can make his/her students to visit the cement factory in one day and the soap factory in the other day to observe the real processes, and he/she can make the students to write a report.

V. Student Motivation Approach

Generally, appropriate motivational strategy is important for students to completely bring their attention and interest towards their education and specifically for hard science subjects, like

Chemistry, innovative motivating strategy is important for students to become a good learner and [6] added that students are more effective learners if they are intrinsically motivated towards learning than if they are extrinsically motivated. So, in the instruction of Chemistry a teacher can motivate his /her students using the following:

Questions

- a) Mention three properties of transition elements?
- b) Write the electron configuration of Iron using the, K, L, M, N (atom number= 26)?

Motivating strategy

A teacher can motivate the students by saying, for those who got the answer: You will be given a modern periodic table chart, or you will go to soap or cement factory for visiting for two days next week, and the expenses will be covered by the school.

When students are motivated, they pay attention, they begin working on the tasks immediately, they ask questions and volunteer answers, and they appear to be happy, eager, and they love the subject.

Most commonly, there are five key elements influencing student motivation: student, teacher, content, method/process, and environment. For instance, the student should have the access, ability, interest, and value to education. The teacher should be professional, committed, and should have the

capacity to handle all the educational activities with no difficulties. The content should satisfy the current and future interest of the student, it should also have the predictive capacity of the future. The methodology should be innovative and has to be connected with the real-life situation of the students, and the environment should be appropriate and suitable.

VI. Socratic Approach

This approach involves the use of asking questions to extract the secret idea of the students, and respectively follows: Clarifying concepts, Probing assumptions, Probing rationale, reasons and evidence, questioning perspectives, Probing implications and consequences, and eventually questioning the question, i.e, the teacher will ask questions to the many of the students and the students will answer, after this the teacher will know where his/her students are, and accordingly he/she will arrange him/her self for better instruction. This is a good way of knowing the knowledge and experiences of the students. Socratic method helps students in building sense of self expression and serves as means of giving practical experience and awareness [11].

Example

A certain chemistry teacher wants to ask the formation of a compound from the reaction of sodium and nitrogen, and he/she can assess the understanding of his/her students in each step, by applying the Socratic Method, as follows.

Socratic steps

- a) What are the atomic numbers of Sodium and nitrogen respectively?
- b) Write the electron configuration of Sodium and nitrogen?
- c) What are the valence electrons of sodium and nitrogen?
- d) Write the compound formed, by the reaction of Sodium and nitrogen?

The above steps show how the teacher comes to his/her intended objective or question, and this is very interesting method of instructing chemistry. So, a lot of chemistry concepts can be handled like the above.

VII. Problem-based Instruction

Problem-based is a student-centered technique where the problem forces the learning with the center of attention on students' active engagement to solve problems. The task of the teacher is

a facilitator and coaches to the student to get knowledge and become a self-directed and confident learner.

The main characteristics of the problem-based instruction are, the students work in groups, access instructional material and share ideas among themselves, they research, explain, and cooperate to find significant solutions to real life problems [14]. Hence, problem-based instruction is a constructivist strategy.

There are seven phases involved in developing a good problem-based teaching and learning.

1. The teacher presents a real like problem.
2. Students argue the problem and prepare a hypothesis.
3. Students first retrieve prior knowledge and practices relative to the problem.
4. They recognize knowledge deficiencies.
5. Start doing their research.
6. Students apply their knowledge to check the validity of their hypotheses in light of what they have learned.
7. At the end, students make their own reflection [15, 16].

Example

In chemistry lesson of writing formula of compounds, students are facing a problem that, some of them are unable to write, the formula of compounds very well. Hence, their teacher can make them to form a group, and he/she can seriously direct them, by letting them pass through the above steps, i.e., students should know: The periodic table, the electron configuration, the properties of the elements, and so on. But the teacher should properly guide them properly.

VIII. Inquiry-based

Refers to the complete involvement of students in which they develop their own knowledge and understanding of scientific ideas[15]. National research council describes inquiry as ‘a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanations and predictions; and communicating results’ [17].

Types of Inquiry

[18] classified inquiry-based learning as follows.

a. Confirmation

The teacher tells students to outcome a problem and gives instructions on how to carry out an experiment or investigation in order to confirm the outcome. This can be highly done in chemistry laboratory.

b. Structured inquiry

Students are given a structured step by step process in how to investigate a given question.

Example

A teacher first of all has taught the building up principle (Aufbau), next he/she can ask his/he students to write the electron configuration of an atom with any atomic number.

c. Guided inquiry

The teacher gives a question, and students find their own way to answer the question. For example, a chemistry teacher can ask his/her students to define acids and bases, so, for this, some students can use Arrhenius definition, some can use Bronsted-Lowry and some Lewis definitions. Again, the teacher can ask in which group does hydrogen atom found? Here, some can say in

group 1A, some can say in group 11A, some can say in group V1A and so on.

d. Open Inquiry

Students initiate their own questions and formulate their own processes to answer their questions.

Innovative Improvisation in Chemistry Instruction

[19] defines improvisation is the practice of purposely searching the students' immediate environment for materials and their proper arrangements in order to create known events for the student's sensory perceptual experience antecedent to, or concomitantly with and for purposes of instruction, and when improvisation is used in teaching chemistry, students provide a lot of answers and the teacher does not assess any given answer, but facilitates the improvisation among the students, with the aim of directing them toward finding of their own facts.

It can be generalized from the above that, innovative improvisation is a material replacement, altering of instructional material, inventing a new idea/new material formulation. Instruction of chemistry via innovative improvisation is both easier and effective because it in tails the use of at least three sense organs.

Let's see the following examples.

1. If an element has a hybrid orbital of sp^3 , what is/are the possible reaction/s when reacted with Oxygen? Draw the possible structure/s of the product using locally available materials.
2. Prepare a distillation setup using locally available materials?

Important Considerations for Improvising Equipment and Experiments

To improvise equipment and experiments, one must be open, receptive and observant.

The following list of useful points may be considered when making improvised equipment and conducting experiments [20]:

- Make use of materials that pupils are familiar with, for example, ordinary drinking glasses, instead of test tubes or glass beakers, and an iron nail as the soft iron core in an electromagnet.
- Keep the equipment as simple as possible.
- Students should be actively involved by collecting the materials, constructing the apparatus, and presenting demonstrations of improvised apparatus and experiments.
- Improvised apparatus and experiments should be tested beforehand to make sure they work.

- The use of improvised apparatus and experiments is not limited to teacher demonstrations but could just as well be used in practical work in groups or by individuals.

Benefits of improvisation

Due to the political and economic state of the developing countries, demand for chemistry equipment will continue to remain high and the most possible way to cope with high demand is to resort to the improvisation of teaching equipment and materials as much as possible. So, some of the benefits of improvisation are the following:

- The process of improvisation gives teachers the knowledge of creativity, manipulative skills, and critical thinking.
- Improvisation helps in saving costs of looking of readymade instructional media which are more costly. It encourages self-reliance and a feeling of confidence during instructional delivery.
- Generally, improvisation is beneficial to students, teachers and to the government in general.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Innovative practices are activities engaged by man through which new inventions are introduced into the society. Innovative practices are possible in every fields of study, like in Health, Communication, Agriculture, Industry, Governance, Education etc, and as this review is about chemistry, so, innovative practices in chemistry instruction is critical , because, it is a prerequisite for scientific and technological development, hence, innovative approaches to effective instruction of chemistry: adjustment of students, Student/Learner Centered Approach, Inductive Approach, Process Approach, Student Motivation Approach, and Socratic Approach are essential, and because of the difficulties in economy of the developing countries, improvisation practices in chemistry instruction are important.

Recommendations

According to the reviewed papers, the following points were forwarded as possible recommendations. The awareness of the people living in developing countries towards innovation, improvisation is very minimum, hence:

- ✓ The governments should be able to work hard to change the attitude of the people generally and specifically on Chemistry teachers.
- ✓ The governments should have a state plan on innovation and improvisation of chemistry.
- ✓ Innovation and improvisation should be deeply incorporated in chemistry curriculum.
- ✓ Teachers and stake holders should get exposure to innovation and improvisation.
- ✓ There should be experts in the area of innovation and improvisation in bureaus of education, if possible, at school level.
- ✓ For teachers who are actively engaged in innovation and improvisation, Special incentives should be provided.
- ✓ Students should be encouraged and for that, mechanisms should be devised.
- ✓ Trust! Trust! As innovation is the only way for advancement.

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