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B. M. Bugaje (2024)

INNOVATIVE TEACHING STRATEGIES FOR FUTURE DEVELOPMENT OF CHEMISTRY EDUCATION IN NIGERIA

Dr. B. M. Bugaje
Department of Chemistry,
Federal University of Education, Zaria
bugajebadiyya12@gmail.com
+2348060097092

Abstract
Innovation in education refers to changes in the system which is aimed at improving the system or creating new one for a more effective and efficient means of attending to the educational needs. This paper discusses innovative teaching strategies which include use of computer aided instruction, use of analogy, concept mapping and cooperative learning. Also, looking towards the development of chemistry education, it is crucial to integrate the principles of green chemistry and artificial intelligence (AI) into the chemistry teacher curriculum. This integration will equip chemistry teachers with the necessary competencies and knowledge to enhance students' academic achievement and preparing students for careers in scientific research. The benefits of innovative teaching strategy were highlighted. The paper recommended that AI and green chemistry should be incorporated into the chemistry teacher education curriculum. Also intensive in - service programs should be organized to get the chemistry teachers acquainted with and trained on how to effectively utilize innovative teaching strategies.

Keywords: Innovative Teaching, Strategies, Future Development Chemistry and Education

Introduction

Innovation is the process of introducing new ideas and integrating new teaching strategies that foster critical thinking and creativity. It is also the act of constructive thinking, grouping knowledge, skills and attitude into new, original and rational ideas (Mary, 2014). With innovation educators can design lessons that are not only informative but also engaging; making science more approachable and relatable to students. In education, innovation can appear as a new pedagogic theory, methodological approach,

Teaching technique, instructional tool, learning process, or institutional structure that, when implemented, produces a significant change in teaching and learning, which leads to better student learning (Serdyukov, 2017). Innovation is of vital importance in transforming and reconstructing the learning environments along with the curricula, the role of the teacher and teacher training (Dilek ilhan, 2016).

Traditional teaching methods such as lecture - based instruction dominate Nigerian classroom and have been criticized for failing to actively engage students or foster critical thinking (Kalimaposo and Chivunda, 2023). Engaging students actively in the learning process is important for fostering a deeper understanding of chemical concepts (Shukla, 2024). The American psychological association therefore calls for reforms in the ways we teach science at all levels and in all disciplines (Hassan and Salihu, 2020).

Innovative teaching is a proactive approach to integrate new teaching strategies and methods into a classroom. It also involves creativity on the part of the teacher. Innovative teachers sometimes reorganize

the educational process (Ahmad and Arshad, 2018). New innovative teaching strategies when adopted and integrated in the teaching and learning of chemistry will greatly influence a better understanding of some difficult concepts. A large number of investigations revealed that students taught chemistry with innovative teaching strategies show higher academic achievements rather than those taught with traditional teaching technique (Ahmad and Arshad, 2018; Okumus *et al.,* 2020; Aurah and Mulavu, 2022; Chinde and Ekpete, 2023; Shukla, 2024). Some of the innovative teaching strategies which include use of computer assisted instruction, use of analogy, concept mapping and cooperative learning are discussed as follows:

Computer Assisted Instruction

Computer assisted instruction (CAI) is one of the innovative teaching strategy that is student – centered and activity oriented. It is a method which uses a computer as a learning media to strengthen students' motivation, give opportunities to both students to learn by their own speed and combine active learning with computer technology. The students learn by reading the text materials presented or by observing the graphic information displayed. Each segment of text is followed by questions for students' responses. Feedback on responses is indicated immediately. CAI can be characterized as interactive and individualized learning as it usually involves a dialogue between a student and a computer program (Jamilu, 2024). CAI is the use of computer software programs to improve teaching and learning activities in both the traditional and virtual classroom (Ahmed and Ahmed, 2023). Use of computers for instruction enables learners' progress at their own pace and allows learners perfect learning skill and procedure by repetition of specific learning task as an opportunity to master certain concepts quickly and effectively.

Globally, majority of students find chemistry related concepts complicated and difficult to comprehend due to the teaching methodologies employed in teaching of the subject (Katuku *et al.,* 2023). Chemistry and particularly structure and bonding deal with materials and concept that are more abstract than real hence integration of ICT in teaching can concretize the concept enhancing learners' understanding. Other topics in chemistry that could be taught by the use of CAI include electrolysis, organic chemical nomenclature, collision theory, rate of reaction, order of reaction and effect of temperature and catalyst on the rate of reaction, (Jane *et al.,* 2017; Fernando and Mahanama 2021, Nweze, and Ogwu, 2022)

Use of Analogy in Teaching Chemistry

Analogy is comparison of the similarities of two concepts. The familiar concept is called the analog and the unfamiliar one the target (Maharaj - Sharma and Sharma, 2015). It can also be defined as something that shows how two things are alike, but with the end most goal of making a point about this comparison is meaningful learning. In an attempt to address the problem of student's difficulties in understanding science and technology, Debora (2014) suggested analogy as one of the instructional strategies that could be used for the teaching of abstract or difficult concepts in science and technology. This is because analogy instructional strategy which is based on Novak's theory of human constructivism sees production of new knowledge as a human construct.

It is one of the most important instructional tools that can be used to address students' misconception (Rahayu and Sutrisno, 2019). Teaching with an analogy helps students to

understand, visualize and remember what they have learned in class. Many studies also revealed that analogies have a positive effect on changing students' interest/ attitude towards chemistry concepts (Tsegaye *et al.,* 2020; Saleem and Akbar, 2022). However, Hajian, (2018) observed that despite the advantages and usefulness, analogies can cause incorrect impaired learning depending on the analog - target relationship. For example, the development of systematic understanding is difficult if the analog is unfamiliar to the learner.

Common examples of analogy in chemistry include the following:

1. Boiling water to produce steam at home (a familiar concept) can be used to explain the change of state from liquid to gas (an unfamiliar concept).
2. The use of a syringe to control the volume of fluid by force explains Boyle's law (Ikechuku and Helpus, 2024).
3. The commonly used analogy of atomic structure is the solar system; in this case the spatial and dynamic features of the sun and the surrounding planet are analogous to the atomic nucleus (Taber, 2013).

Concept Mapping Teaching Strategy

According to Zheng (2019), concept map is a graphical tool for organizing and structuring knowledge in teaching, learning and assessment. Concept maps may be used as an active learning strategy when a teacher employs it in the process of teaching and learning. Its approaches to classroom situations are practical, hence the learners have opportunities to be highly involved in the process of teaching and learning (Francis and Baba, 2023).

Concept maps can be used in chemistry education as a method of learning, as a teaching method, as a curriculum and lesson planning method and as evaluation method of students' performance. In addition, it helps to identify misconceptions held by students (Kordaki and Psomos, 2015). Concept mapping measures the cognitive activities of the learner. It teaches mental skills as opposed to psychomotor activities. The use of concept mapping in the teaching of chemistry is of great benefit as it would make the learners fully participate in the classroom activities, therefore making the process interesting and practical (Francis and Baba, 2023). It can be used to teach various topics in chemistry, including organic chemistry, inorganic chemistry, physical chemistry and analytical chemistry. For instance, organic chemistry is a study of the structure, properties, reactions of compounds containing carbon (Sibomana *et al.,* 2021).

The subject is complex and requires students to understand the relationship between different carbon compounds (aliphatic, alicyclic, aromatic and heterocyclic). Using concept mapping could help students visualize the connections between them, making it easier for them to understand and remember the information. According to Ariaga and Nwanekezi (2018) a hierarchical concept map on organic compound can be illustrated below:

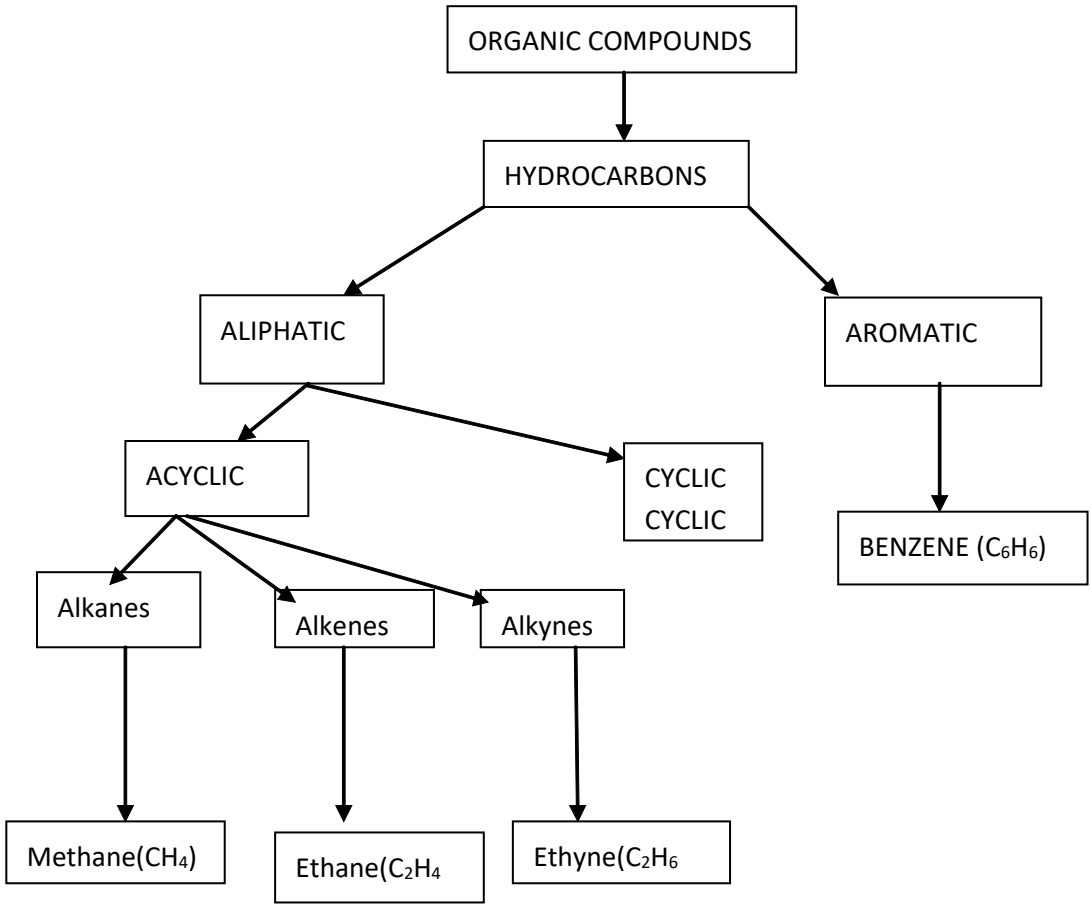

Figure 1: Example of a Hierarchical concept map on organic compounds

Cooperative Learning Teaching Strategy

Cooperative learning is an approach of organizing classroom activities into academic and social learning experience (Chebii *et al.*, 2018). Students work in groups to complete a task collectively. The teacher become facilitator while the learners get fully engaged in the process of learning. Activities are structured so that students needs each other to succeed, promoting positive interdependence (Igwe, *et al.*, 2024). Students are more positive about each other when they learn cooperatively than when they learn alone, competitively or individualistically regardless of differences in ability, ethnic background or being handicapped or not (Mehta and Kulshrestha, 2014).

Learners that participate in cooperative learning have more peaceful relationship with their peers, as well as improved acceptance and understanding of diversity, social and interpersonal abilities. It encourages students to actively participate in the process of creating knowledge, which in turn fosters a growing interest in the field (Geletu, 2022).

Cooperative learning utilizes a variety of methods and models (Simesso *et al.*, 2024). Cooperative learning methods can be divided into two primary groups: formal group techniques and organized teamwork. Formal cooperative learning groups ensure that students are actively involved in the intellectual work of organizing materials, explaining it, summarizing it and integrating

it into conceptual structures. In organized team work, members get rewards according to their progress in learning and each member is held accountable, meaning that individual learning rather than collective output determines success.

According to Shukla (2024), some benefits of innovative teaching methods in chemistry, include:

1. facilitated deeper understanding of chemical concepts
2. enhance problem solving and critical thinking.
3. encourage students' active participation in teaching and learning process.
4. enhance students' performance.
5. promote self-evaluation.

Integrating Green Chemistry into the Curriculum of Teacher Education Programs

Chemistry teacher education plays a vital role in shaping the future of scientific education and sustainable development. With growing concern for environmental sustainability, there is an increasing need to integrate green chemistry principles into the curriculum of chemistry teacher education programs.

Green chemistry is characterized by careful planning of chemical synthesis and molecular design to reduce adverse consequences. It goes beyond the research laboratory in isolation and has touched industry, environment, education and the public (Mohammed *et al.*, 2020). By incorporating green chemistry principles, into the curriculum, chemistry teachers can be equipped with the knowledge and skills to promote sustainable practices in their classrooms and inspire next generation of scientist and engineers.

According to Chhangani (2023), the integration of green chemistry principles in chemistry teacher education holds several implications as follows:

i. it provides teachers with a clearer understanding of the environmental impact of traditional chemical processes and products. This enables them to make informed decisions about their teaching practices.
ii. it encourages the use of greener alternatives and promotes the development of innovative teaching strategies that emphasize sustainability.
iii. it fosters holistic approach to science education, integrating concepts from chemistry, environmental science and social responsibility.

Integrating Artificial Intelligence into the Curriculum of Teacher Education Program

Artificial intelligence (AI) in education involves the integration of AI technologies to enhance the learning experience for students and support educators. As technological advancements continue to reshape various industries, likewise the field of education is experiencing significant transformations particularly with the integration of AI.

In chemistry education, there is a growing interest in incorporating AI in various aspects of the curriculum. These include laboratory experiments, simulations, virtual laboratory, data analysis and assessment (Clark, 2023). AI is a computer software that works like the human brain and can do difficult task such as been able to see, understand, and respond to spoken or written language, analyze data and make recommendations. The utilization of AI in chemistry education revolutionizes the way students learn, process and apply chemistry

knowledge in a variety of contexts (Kim *et al.,* 2024). Through the use of this technology, students can access a personalized learning environment that adapts to their learning style and pace and provides real - time feedback and assistance (Chiu, 2021). In simulations and virtual laboratory experiments, students observe molecular interactions and chemical reactions in ways that are not possible using traditional laboratory settings (Shi *et al.,* 2021). Thus the integration of AI in chemistry education creates a more engaging, interactive, and efficient learning experiences for students.

Despite the potential benefits of AI in chemistry education, there remain several questions and challenges that must be addressed. For example, it is not clear how effective this technology is at improving student performance, and how it can be implemented most effectively within the classroom environment (Chiu *et al.,* 2023). Additionally, there are concerns about the ethical implications of using AI in education, including issues around privacy, bias, and transparency (Okagbue *et al.,* 2023). More importantly, our great concern is how AI algorithm can be employed to optimize instructional strategies and curriculum design in chemistry education.

Conclusion

The use of innovations in the teaching of chemistry is a tool that when well implemented will enhance the students' performance and improve the learner's active participation in chemistry. However, it is obvious that there are already known teaching strategies in chemistry education that actively engages students in the class such as concept of cooperative learning, use of computer assisted instruction etc. The use of these will assist the learners to meet their basic needs, because they support students' preference for learning by doing, and support teachers to engage students with hands - on inquiry learning. Also, the integration of green chemistry and artificial intelligence will equip chemistry teachers with the necessary competencies and knowledge to enhance students' academic achievement and preparing students for careers in scientific research.

Recommendations

1. Artificial intelligence and green chemistry should be incorporated into the chemistry teacher education curriculum.
2. Intensive in - service programs should be organized to get the chemistry teachers acquainted with and trained on how to effectively utilize innovative teaching strategies.
3. Researchers should investigate the effectiveness of use of AI in chemistry classroom instruction in order to find out whether it improves student performance.

References

Ahmad, S. and Irshad, M. (2018). Innovative teaching strategies and chemistry achievements at secondary level. *American Based Research Journal,* 7 (12), 67 -74.

Ahmed, M.M. and Ahmed A. M. (2023). A systematic literature review on advances in computer assisted instruction. *Online Journal for TVET Practitioners,* 8(1), 107 - 117.

Ariaga, B. A. and Nwanekezi, A. U. (2018). Concept mapping strategy and its effects on students' performance in senior secondary school organic chemistry in Imo state of Nigeria. *International Journal of Scientific*

Research in Education, 11(4), 797 - 809.

Aura, C. and Mulavu, W. (2022). Effect of innovative instructional approaches and self- efficacy on achievement of chemistry among secondary school students in Kenya. *World Journal of Innovative Research,* 13 (2), 14 -21.

Chebii, R., Wachanga, S. W. and Anditi, Z.O. (2018). Effects of cooperative E - learning on approach on students' chemistry achievement in Koibatek sub - country, Kenya. *Creative Education,*9 (12), 1872 - 1880.

Chinde, W. and Ekpete, O. A. (2023). Repositioning 21st century chemistry education through innovative teaching strategies: the problem of problem based learning teaching strategy in Nigeria. *African Journal of Chemical Education, 13 (2), 21 - 46*

Chiu, W . K. (2021). Pedagogy of emerging technologies in chemical education during the era of digitalization and artificial intelligence: a systematic review. *Education Science,*11 (11), 709.

Chiu, T. K. F., Xia, Q, Zhou, X., Chai, C. S. and Cheng, M. (2023). Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education, *Computer and Education: Artificial Intelligence,* 4, 100118.

Clark, T. M. (2023). Investigating the use of an artificial intelligence chatbot with general chemistry exam questions, *Journal of Chemical Education,* 100 (5), 1905 - 1916.

Dilek ilhan, F. F. (2016). Realization of a desired future: innovation in education, *Universal Journal of Educational Research,* 4 (11), 2574 - 2580.

Debora, A. (2014). Effect of interactive engagement and analogy enhanced instructional strategies on self-efficacy of senior secondary school chemistry students, *Research Journals, Journal of Education,* 2 (6), 1- 12.

Francis, T. T. and Baba, S. J. (2023). Effect of concept mapping teaching approach on students' academic performance in chemistry in senior secondary schools. *Indonesian Journal of Educational Research and Technology,* 3(1), 69 -78.

Chhangani, M. K. S. (2023). Revitalizing chemistry teacher education: Enriching the curriculum with green chemistry principles. *International Research Journal of modernization in engineering, Technology and Science,* 5 (6), 3887 - 3891.

Fernando, L.S.L.K. and Mahanama, R. (2021). Conceptualization of chemical kinetics using a visually enhanced teaching technique; a developed MS excel work sheet/ system. *Turkish Journal of Computer and Mathematics Education,* 12 (11), 3331 -3337.

Geletu, G. M. (2022). The effects of teachers' professional and

pedagogical competences on implementing cooperative learning and enhancing students' learning engagement and outcomes in science practices and changes, *Cogent Education,* 9 (1) https://doi.org/10.1080/2331186X.2022.2153434

Hajian, S. (2018). The benefits and challenges of analogical comparison in learning and transfer. *Simon Fraser University Educational Review,* 11 (1), 60 – 74.

Hassan, L. G. and Salihu, M. (2020). Application of innovative pedagogies to enhance the teaching and learning of chemistry. *SER,* 19 (1), 108 – 122.

Ikechuku, A. E. and Helpus, E. A. (2024). Effects of analogy and target task approach (TTA) on students' achievement in gas laws in senior secondary schools, in Delta state, Nigeria, *European Journal of Education Studies,* 11 (1), 47 - 61.

Jamilu, A. G. (2024). Effects of computer assisted instruction on students' academic performance and retention in chemistry concepts. *Journal of Science, Technology and Mathematics Pedagogy,* 2 (1), 64 - 73

Jane, M. W., Wachanga, S. W. and Anditi, Z. O. (2017). Effects of computer - based simulations teaching approach on students' achievement in the learning of chemistry among secondary school students in Nakuru sub country, Kenya. *Journal of Education and Practice,* 8 (5), 65 – 75.

Kalimaposo, K. and Chivunda, K. (2023). Issues associated with excessive use of lecture method as a teaching technique among teachers in secondary schools of Lusaka, Zambia. *IRE Journals,* 6 (12), 99 - 107.

Katuka, K. J, Twoli, N. W. and Waititu, M.M. (2023). Computer assisted learning and its effect on secondary school students' achievement in chemistry, case of makueni county, Kenya. *Journal of Education Practice*, 4 (1), 71 - 95.

Kim, S. Y., Jeon, I., Kang, S. J. (2024). Integrating data science and machine learning to chemistry education, predicting classification and boiling point of compounds. *Journal of Chemical Education*. https://doi.org/10.1021/acs.jchemed.3c01040.

Kordaki, M. and Psomos, P. (2015). Diagnosis and treatment of students' misconceptions with an intelligent concept mapping tool. *Procedia - Social and Behavioral Sciences,* 191, 838 - 842.

Maharaj – Sharma, R. and Sharma, A. (2015). Observations from secondary school classrooms in Trinidad and Tobago: science teachers' use of analogies. *Science Education International,* 25 (4), 557 - 572.

Mary, S. S. (2014). Current pedagogical teaching strategies being used by the college of nursing campuses across varied subjects and their views regarding innovative methodologies. A dissertation, Department of Nursing, Durban University of Technology, South Africa.

Mehta, S. and kulshrestha, A. K. (2014). Implementation of cooperative learning in science: A developmental -cum- experimental study. *Educational Research International.* Article 10. 431542 page 7.

Mohammed, W. A., Ali, A. Q. and Erryes, A. O. (2020). Green chemistry: principles, applications, and disadvantages. *Chemical Methodologies,* 4, 408 - 423.

Nweze, B. N. and Ogwu, C. N (2022). Effect of computer - aided instruction on chemistry students' achievement in organic chemical nomenclature in Enugu education zone of Enugu state, Nigeria. *British Journal of Education,* 10 (13), 68 - 77.

Okagbue, E. F., Ezeachikulo, U.P., Akintunde, T.Y., Tsakuwa, M.B., Ilokanulo, S. N., Obiasoanya, K.M., Ilodbe, C. E. and Ouattara, C. A.T. (2023). A comprehensive overview of artificial intelligence and machine learning in education pedagogy: 21 years (2000-2021) of research indexed in the scopus database. *Social Sciences and Humanities Open,* 81(1), 100655.

Okumus, S. Ozdilek, Z. and Arslan, A. (2020). The effect of cooperative learning methods and individual learning method on pre - service science teachers' sub - micro level conceptual understanding at equilibrium chemistry. *Educational Policy Analysis and Strategic Research,* 15 (3), 394 - 425.

Rahayu, R. Y., and Sutrisno, H. (2019). The analysis of analogy use in chemistry teaching. International Seminar on Science Education, doi: 10.1088/1742 -6596/1233/1/012022.

Saleem, A. and Akbar, R. A. (2022). Effect of analogy based teaching on students' chemistry learning at secondary school level. *Annals of Human and Social Sciences,* 3 (3), 477 - 493

Serdyukov, P. (2017). Innovation in education: what works, what doesn't, and what to do about it. *Journal of Research in Innovative Teaching and Learning,* 10 (1),4 - 33.

Shukla, Y. (2024). Innovative teaching methods in chemistry education. *International Journal of Multidisplinary Research in Art, Science and Technology*, 2 (2), 9 - 16.

Shi, Y., Prieto, P.L., Zapel, T., Grunert, S. and Hein, J.E. (2021). Automated experimentation powers data science in chemistry, *Access Chemical Research,* 54 (3), 546 - 555.

Sibomana, A., Karegeya, C. and Sentongo, J. (2021). Students' conceptual understanding of organic chemistry and classroom implications in the Rwandan perspectives: A literature

review. *African Journal of Educational Studies in Mathematics and Sciences,* 16 (2), 13 - 32.

Simesso, M. D., Gutu, T. S. and Tarekegn, W. M. (2024). The contribution of using cooperative learning methods on students' achievement and retention in secondary schools during chemistry lesson. *Educational Research International,* https: //doi.org/10.1155/ 2024/1830124.

Taber, K. S. (2013). Upper secondary students' understanding of the basic physical interaction analog systems, *Research in Science Education,* 43 (4), 1377 - 1406.

Tsegeye, Z., Temesgen, A. and Bogale, Y. (2020). Effect of analogy approach on the concepts of rates of chemical reactions on students' achievement and attitude. *African Journal of Chemical Education,* 10 (2), 33 - 77.

Zheng, L., Li, X, Zhang, X. and Sun, W. (2019). The effect of group metacognitive scaffolding on group metacognitive behaviors, group performance, and cognitive load in computer- supported collaborative learning. *The Internet and Higher Education,* 42, 13 - 24