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Learning Chemistry with the Hierarchy Mode of Electronic Concept Mapping Strategy

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Abstract

An electronic hierarchy concept mapping instructional package has been designed, developed and validated, to be employed as a learning strategy for learning chemistry. This study assesses the attitude of students exposed to the strategy. Design-based research was employed using the mixed-method approach divided into two stages. In the first stage, the design and development of the package were carried out, qualitative and quantitative expert validation was done thereafter. The second stage involved the assessment of the developed package by assessing students' attitudes to the package. Experts' judgments revealed that the developed package meets up with the required standard of instructional design and development and is suitable for learning. The findings in this study also showed that the use of the strategy elicited a highly positive attitude from students. It can be concluded therefore, those electronic hierarchy concept mapping strategies are better innovative approaches to learning chemistry in Nigerian schools.

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INTRODUCTION

Concept maps are graphic organizers that assist students in organizing and representing knowledge. Alfonso and Marta (2014) defined concept mapping as a knowledge representation model that promotes the construction of a mental image of the information thereby making the visual identification of the most important concepts easier, as well as the relationships among them and their hierarchical organization. This graphic representation of concepts provides students and teachers with a suitable tool to organize, summarize and communicate their knowledge about any topic, showing information in a schematic and organised way. Consequently, students can use concept mapping as a learning strategy for any subject since it promotes individual or collaborative, reflexive and meaningful learning (Bunting, Coll & Campbell, 2006).

A concept map as described by Yin, et. al. (2005), include nodes (terms or concepts), linking lines (from one concept to another normally with a one-way pointer), and linking phrases which depicts the connection between nodes. Linking lines having linking phrases are labeled lines, while a proposition comprises of two nodes connected with a labeled line . It Should be known tat the-structures of such maps are determined by the arrangement of concepts and orientation of linking line. This may either give rise to a hierarchical or non-hierarchical concept map. For Novak and Cañas (2006), concept maps have the hierarchical structure in which the most general and inclusive concepts are put at the top and the more concrete and specific ones are at the bottom of the map. The ideal concept map has hierarchy. The flow chart concept map is almost like the hierarchy concept map in terms of is linear arrangement.

Concept maps are made by students to describe the same topic over and over again in the course of learning (Eskilsson & Hellden, 2003). Concept maps are used in teaching practice to enhance the quality of the dialogue between teachers and students through the use of concept mapping since the method facilitates an exchange of individual knowledge and understanding (Kinchin, 2003; Kinchin, 2004; Kinchin, deLeij& Hay, 2005; Kinchin & Hay, 2007).

Due to new technologies and accessibility to different modes of expression, traditional forms of representing concepts and their relations are being challenged. Loveless (2003: 19) opined, new technologies and the digital resources they access only provide opportunities for "interaction, participation, and the active demonstration of imagination, production, purpose, originality and value". ICT-based concept mapping provides automated construction of 'scaffolds' and 'pre-inventive structures' reducing cognitive load in terms of the mechanical processes involved in constructing and revising of maps and in terms of compositional structures memorization. This provisionality, automation and capacity enable cognitive resources to be directed to the mental processes involved in creative narrative construction. Koc (2012) opined that the creativity in literacy tasks as a result of increase in the quality of connections between concepts may therefore be influenced by ICT-based concept mapping, labeling links and increasing the narrative propositions formed in pre-compositional drafting, leading to higher-quality story writing and general improvement in creativity assessments through an increased ability to visualize and identify connections and relations.

In the course of developing the electronic hierarchy concept mapping strategy, a critical look was taken at various instructional design models and the Seels and Glasgow model was employed. The Seels and Glasgow model contains the elements necessary to design effective Learning strategies. The model was developed to create facilitated or self-study products to be delivered via non-Internet technologies (paper-based, multimedia, audio and video). The model therefore has the strength that could be exploited in the development of instructional strategies for learning. The instructional design issues that were considered in the design of the electronic hierarchy concept mapping learning strategy were: structure, content, motivation and feedback, interaction (communication), and involvement (activities).

The conventional instruction on the bonding concept frequently presents various nonscientific conceptual frameworks such as the octet rule and the various ways of assorting chemical bonds

(Hurst, 2002). Unfortunately, the traditional pedagogical approach used for studying bonding is not only found in senior school textbooks but also in general chemistry textbooks intended for newly admitted tertiary institution students. In many chemistry textbooks, elements are conveniently classified as metals or nonmetals, sometimes a few semimetals are mentioned. Very often, this dichotomy among elements leads to a dichotomous classification of bonding related to compounds. Covalent being between nonmetallic elements and ionic being between a metal and a nonmetal. The teaching of this concept is often too simplistic.

It is therefore important to develop an effective instructional strategy that teachers and learners can use to enhance meaningful learning of chemistry concepts and theories. Since instructional strategy is an important determinant of the outcome of teaching and learning process, this study therefore designed and developed an electronic concept mapping strategy, as well as determined the attitude of chemistry students to the developed strategy.

Research Objective

The objectives of this study were to design, develop, and validate an electronic hierarchy concept mapping instructional package as a learning strategy for understanding various concepts and their relationships within the Nigerian senior school chemistry curriculum. Additionally, the study aimed to assess the attitudes of students exposed to this instructional strategy in chemistry.

Research Questions

This study raised two key research questions: What are the processes involved in developing an electronic hierarchy concept mapping instructional package using this strategy for learning chemistry in Nigerian senior schools? Additionally, what are the attitudes of students exposed to the electronic hierarchy concept mapping strategy?

METHODS

Research Design

This study adopted a design-based research using the mixed-method approach. A design-based research integrates the development of solutions to practical problems in learning environments while identifying reusable design principles. A design- based research employs a methodology that requires: addressing complex problems in real contexts in collaboration with practitioners; integrating known and hypothetical design principles with technological affordances to render plausible solutions to these complex problems; and conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles. All these were taken into consideration when designing the conceptual model for this study.

The mixed-method was divided into two stages. In the first stage, the design and development of the electronic hierarchy concept mapping instructional package was carried out. After this, qualitative and quantitative expert validation was done. The second stage involved the assessment of the developed package to be used as learning strategy by assessing students' attitude to the package.

Sample and Sampling Techniques

The sample that carried out the assessment of the quality of the instructional package comprised of educational technology experts, computer scientists and specialists in software development, chemistry lecturers and senior school chemistry teachers, all of whom were selected using purposive non–probability sampling technique. The two educational technologists and computer specialists were selected based on their in depth knowledge and experience in instructional package design, development and evaluation. The chemistry lecturers and senior school chemistry teachers on the other hand were selected because they have been involved in the teaching of chemistry in their respective institutions for not less than 10 years, and therefore qualified to assess what is required to be taught to chemistry students at the senior school level. The distribution of the sample of experts that carried out the assessment of the quality of the Electronic Hierarchy Concept Mapping Instructional Package (EHCMIP) is as shown in Table 1.

Table 1. Expert Validation of EHCMIP

S/N	Experts	Number	Percentage (%)
1	Chemistry Lecturers	2	25
2	Chemistry Teachers	2	25
3	Computer Software Specialists	2	25
4	Educational Technologists	2	25
	Total	**8**	**100**

Reseach Instruments

The research Instruments used for this study consisted of the following:

(i) Treatment Instrument: This comprised of Electronic Hierarchy Concept Mapping Instructional Package (EHCMIP). The Electronic Hierarchy Concept Mapping Instructional Package (EHCMIP) on chemical bonding aspect of chemistry was used for learning the instructional content of the Electronic Hierarchy Concept Mapping Strategy (ii) Electronic Hierarchy Concept Mapping Strategy Rating Scale (EHCMSRS). This is a validated 25 item rating scale for assessing the quality of the developed electronic hierarchy concept mapping instructional packages.

(iii) Test instrument: Test instrument designed by the researcher was used to collect data for the assessment of the quality and instructional effectiveness of the developed learning strategies. The Chemistry Learners' Achievement Test (CLAT) consists of 30 item questions in which respondents were expected to answer all. A guide to scoring the correct answers has been prepared by the researcher to enhance appropriate scoring. The 30 items were drawn from the topic "chemical bonding", an aspect of senior school chemistry syllabus relevant to the selected research topics.

(iv) Chemistry Learners' Attitude to Electronic Hierarchy Concept Mapping Strategy in Chemistry Inventory (CLACCI). This is made up of a 20 item inventory that was used to elicit chemistry learner's attitude to the instructional package.

Validation of the Research Instruments

The validation of the Electronic Hierarchy concept mapping strategy was done by professional educational technologists and experts in the field of chemistry from a Nigerian university. Science education specialists were also involved in the validation of the instructional package to be used as a learning strategy. The educational technologists validated the learning strategy in terms of its suitability for learning, logicality of arrangement of its content, explicitness, appropriate emphasis on key concepts, proper illustration and interface switching. The professional educational technologists also ascertained the appropriateness of the strategy in terms of its packaging, layout, accessibility to users, interface, navigation, animations, language of presentation and functionality. This was established with minor corrections.

Experts in the field of chemistry whose efforts were complemented by professionally qualified chemistry instructors, who were also science education specialists in Nigerian senior schools, were also involved in validating the content of the instructional package, as well as its appropriateness for learning. They were requested to carry out the content validation of the by ensuring that the content of the instructional package was appropriate for the level of students who were to make use of it.

The test instrument was validated by test and measurement experts as well as seasoned science educators from the department of Educational Foundations and Counseling of two Nigerian universities. The validation of the CLAT was also carried out by professionally qualified chemistry instructors who were also science education specialists in Nigerian senior schools, who have been involved in chemistry assessment at the senior school level for not less than fifteen years. Two test and measurement experts in the Department of Educational Foundations and Counselling of a Nigerian university validated the CLACCI. These experts assessed the face and content validity of the instruments. All necessary corrections were appropriately effected.

Reliability of Research Instruments

A pilot study was used to determine the reliability of the research instruments. This was done by administering the test instruments (CLAT and CLACCI) on groups of students from two schools that were not part of the study. The same test instruments were re- administered 3 weeks after. The pilot study was carried out on an experimental group and a control group. This was to establish the reliability of the items in both the achievement test and the inventory. The experimental group consists of students exposed to EHCMS. A test retest reliability method was employed for the pilot study. The achievement test (CLAT) was administered pre and post on the experimental group and the control, the inventory (CLACCI) was administered pre and post on the experimental group and the control. To determine the reliability of both the achievement test and the inventory, the two instruments were administered on the control group while the reliability of the learning strategy (EHCMS) was determined by the difference in performance of the achievement test (in the experimental group). That is, pre-test and post-test scores were compared along-side with the inventory.

Using test-retest method of reliability test and Pearson product moment correlation statistics to determine the internal and external consistency, a reliability coefficient of 0.730 was obtained for the CLAT and the CLACCI had a reliability value of 0.861. Since these reliability coefficients were high above 0.5, then the test instruments were adjudged good for the purpose for which they were constructed.

Designing EHCM Instructional Package for use as Learning Strategy

The instructional package is computer software developed using Microsoft Visual Basic 6.0 and includes several key features. The first screen provides information about the developer, followed by an introduction to the package along with a brief user guide. The third screen presents clearly defined instructional objectives. Users are then welcomed with a prompt to enter a username to access the package. The home page features a dictionary for chemical bonding, a concept map, explanatory videos for major concepts, and detailed documentation saved in rich text format.

The home page also includes menu bars with options such as “Exit,” “Log Out,” “Take Test,” “Periodic Table,” “Help,” and “Take a Tour.” The exit button prompts the user to confirm whether they want to quit, while the test menu requires a valid password before the test begins. Additionally, the package includes a comprehensive periodic table and a help menu with detailed software usage instructions. By selecting the "Take a Tour" option, users are guided through an extensive demonstration on effectively using the instructional package. The software contains about 2000 lines of executable codes. It has a setup that must be installed before it can be used.

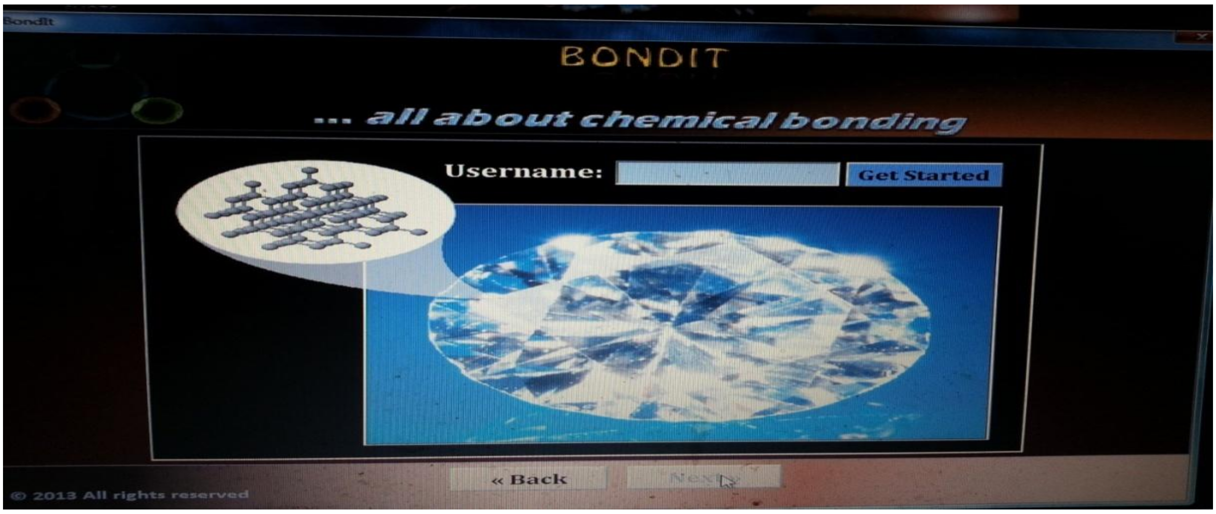

Figure 1. User Entry Page of Electronic Hierarchy Concept Mapping Instructional Package

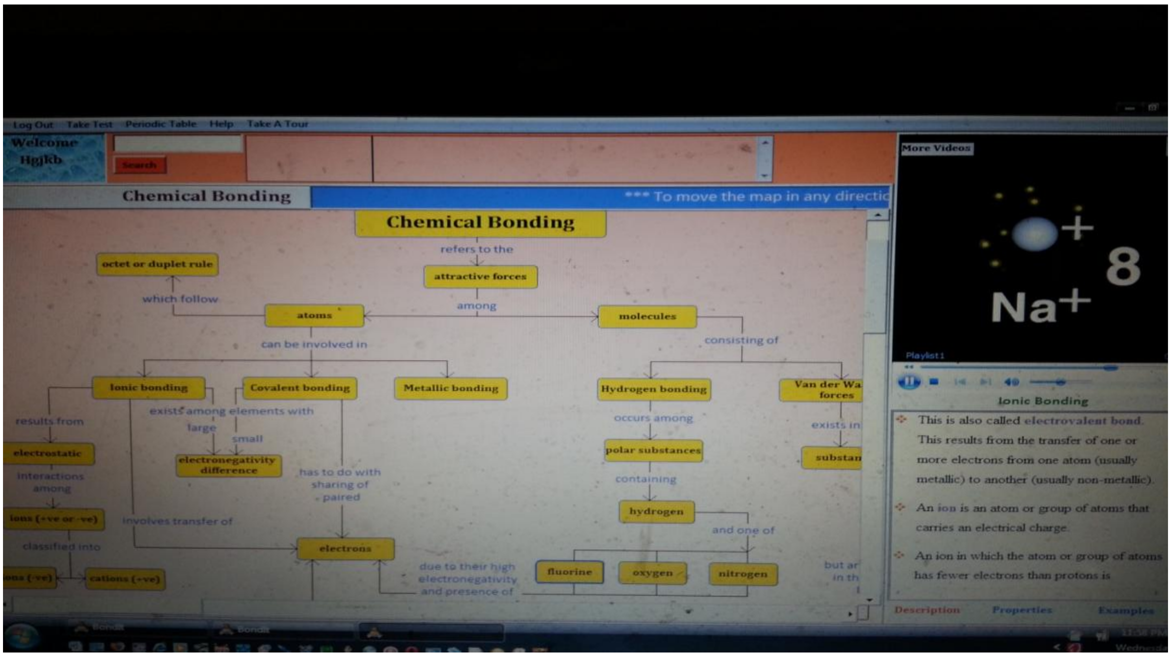

Figure 2. A Page of Electronic Hierarchy Concept Mapping Instructional Package

RESULT

Research Question One

What are the processes involved in the development of instructional packages employing Electronic Hierarchy Concept Mapping Strategies (EHCMS) for learning chemistry in Nigerian senior schools?

The process involved in the development of instructional packages employing electronic hierarchy concept mapping strategy for learning chemistry in Nigerian senior schools involve the assessment of the quality of the instructional package by eight experts among whom were: educational technology experts; computer scientists and specialists in software development; chemistry lecturers and senior school chemistry teachers. A 25 item Electronic Concept Mapping Strategy Rating Scale (ECMSRS) was used to assess the quality of the developed instructional package. The assessment was based on the components of the developed instructional package, and scores obtained from experts were displayed in Table 2.

Table 2. Mean Rating Scale of EHCMS by Experts

S/N	Items	Mean Rating
1	The content is reliable	4.13
2	Balanced presentation of information	4.75
3	Information of sufficient scope and depth	4.63
4	Correct use of grammar	4.63
5	Logical progression of topics	4.38
6	Design of the package is based on reliable learning and instructional theories and is directly related with the content of the curriculum.	4.63
7	The content is structured in a clear and understandable manner	4.38
8	The structure of the package permits learners to advance, review, see examples, repeat the unit, or escape to explore another unit	4.38
9	The package promotes collaborative learning	4.00
10	The package encourages discussion and collaboration among learners	4.13
11	The package provides opportunities for interaction at least every three or four screens / frame	4.13
12	The content is chunked into small segments and includes build in questions, reviews, and summaries for each segment	4.38
13	The package allows learners to discover information through active exploration	4.38
14	Help key to get procedural information	4.50
15	Glossary key for seeing the definition of any term	4.38
16	Content map key for seeing a list of options available	4.38
17	The placement of feedback is varied according to the level of objectives. (Provide feedback after each response for lower level objectives, and at the end of the session for the higher level ones)	3.75
18	For incorrect responses, information is given to the student about how to correct their answers, or hints to try again	4.75
19	The package allows students to check their performance	4.75
20	Screens are designed in a clear and understandable manner	3.13
21	The presentation of information can captivate the attention of students	4.38
22	Sound is an alternative means of presenting information and not a necessity (except for music and language courses)	4.25
23	The content can be updated and/or modified with new knowledge that will appear soon after the development of package	4.38
24	There are instructions for the installation and use of the package	4.00
25	The package allows to keep (save) every step of the activities	4.00
Grand Mean		4.30

From Table 2, a grand mean of 4.30 was obtained for the 25 items in the mean rating scale which is a further confirmation of the suitability of the strategies and quality of the instructional packages for instructional delivery.

After the strategy has been effectively designed, developed and produced, it was subjected to expert judgment during which the strategy was qualitatively and quantitatively assessed. During qualitative assessment, positive comments were made by assessors which confirmed that the strategy was suitable and appropriate for the purpose for which it was meant. As for the quantitative assessment, a 25 item rating scale was administered to eight experts: two qualified and well experienced educational technologists, a computer engineer and programmer, a software development expert, two senior chemistry lecturers, and two experienced teachers of chemistry in senior schools. The result of their assessment of the instructional packages is presented in Table 2.

Research Question Two

What are the attitudes of students exposed to EHCMS?

The result of students' attitude to the EHCMS is indicated in Table 3.

Table 3. Chemistry Learners' Attitude to EHCMS Inventory

S/N	Items	Mean Ratings
1.	I have seen a package like EHCMS in chemistry before.	1.8
2.	I feel comfortable with the use of EHCMS for learning chemistry.	3.9
3.	I am not phobic to learning chemistry through EHCMS.	4.3
4.	I find EHCMS for learning chemistry easy to navigate.	4.2
5.	Learning chemistry with EHCMS is not too difficult for me	4.4
6.	It is easier to learn chemistry with EHCMS than with other modes of classroom instruction.	4.3
7.	I enjoy learning chemistry with EHCMS	4.2
8.	I do not feel bored learning chemistry with EHCMS	4.1
9.	I do not get lost in the EHCMS environment for learning chemistry	4.3
10.	Having EHCMS discouraged me from attending conventional classroom classes in Chemistry.	4.3
11.	I prefer learning chemistry with EHCMS to learning chemistry with any other instructional package.	4.1
12.	EHCMS help me understand the chemistry course content better.	4.3
13.	I did not face any difficulty learning chemistry with EHCMS	4.3
14.	EHCMS is an appropriate medium to present the chemistry course material.	4.2
15.	I can access EHCMS in chemistry without problem.	4.1
16.	I need my instructor (or teacher) to facilitate learning chemistry with EHCMS	2.7
17.	The use of EHCMS to supplement conventional classroom instruction is useful for learning chemistry.	3.9
18.	I would like to know more about EHCMS for learning chemistry	3.9
19.	I will like to use other forms of EHCMS for learning chemistry in future	3.9
20.	I would like to design EHCMS for learning chemistry by myself in future	4.0
	Grand Mean	3.96

Table 3 showed a grand mean of 3.96 for the Electronic Hierarchy Concept Mapping Strategy (EHCMS) which is above the average mean of 2.5. This indicates a positive attitude to the EHCMS on the part of the students, which confirms that the strategy was suitable for learning liked by learners.

DISCUSSION

Findings on experts' assessment of EHCMS:

Qualitative and quantitative expert judgment of the developed electronic hierarchy concept mapping strategy indicated that it was suitable and appropriate for the purpose for which it was meant. This finding is in line with Buehl and Fives (2011), who stated that concept mapping is suitable for developing reflexive and collaborative learning and can be used both as teaching or assessing tools. The finding is also in line with that of Andrews, Tressie, and Mintzes (2008);

Miranda-Correia, Silva and Romano-Junior (2010); and Proctor and Bernstein (2013), who all concluded that concept mapping is a valuable teaching methodology that provides a measure of conceptual understanding for the learner.

Findings on experts' assessment of EHCMS:

Mean rating of the average attitude of chemistry students to EHCMS gave a strong indication of their very positive attitude to the learning strategy. Therefore, it can be inferred that students were very comfortable with the use of the instructional package and they enjoy learning through it. These findings were supported by earlier findings of Hilbert and Renkl (2008); Oliver (2009), who stated that the use of concept map fosters knowledge acquisition and elicits positive attitude.

Mayer and Coleman (2000) also arrived at a positive students' attitude when exposed to electronic learning strategies, thereby supporting this finding. This even though not totally in variance, is however quite at variance with the findings of Sofowora (2001), who discovered that students' attitude may either be positive or negative depending on a lot of other factors. These other factors have been kept constant in the current study. Chemistry instructors should therefore endeavour to incorporate the use of electronic hierarchy concept mapping strategy into their instructional delivery system.

CONCLUSION

Experts' judgment revealed that the learning package designed and developed in this study, which was used as learning strategy, have appropriate content, was properly designed and developed, meet up with the required standard of instructional design and development and is suitable for learning. The findings in this study also showed that the use of Electronic Hierarchy Concept Mapping strategy (EHCMS) elicited a highly positive attitude from students. It can be concluded therefore, that electronic hierarchy concept mapping strategy are better innovative approaches to learning chemistry in Nigerian schools.

RECOMMENDATIONS

Chemistry instructors should strive to incorporate electronic hierarchy concept mapping strategies into their teaching methods. This approach can foster a more engaging, qualitative, and effective learning experience. Given the positive student attitude toward this strategy, it is recommended not only for learning chemistry but also for other science subjects in Nigerian senior schools

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