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Full Length Research Paper

Using culturally-based analogical concepts in teaching secondary school science: Model of a lesson plan

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The paper traces the ever increasing list of concepts science students perceive as difficult to use inadequate techniques by teachers in presenting the concepts in classroom situations. This is despite the attempts by science teachers in using systematic analogical teaching strategies to clarify concepts. The authors blame this failure on the use of analogies drawn from divergent cultural milieus and thus stressed the need for science teachers, especially in a multicultural society like Nigeria, to have a focus on culturally-based analogy generators. The paper went ahead to exemplify such analogies as well as devised a model of lesson plan based on the Teaching-With-Analogy model for a chemistry base topic. The paper concludes that should secondary school science teachers follow this imprint, the ever increasing long list of difficult science concepts would be shortened for secondary school students for good.

Key words: Concepts, science, culture, analogy, learning, lesson.

INTRODUCTION

There is no doubt that some aspects of science courses and subjects parade many concepts perceived by students as difficult. In biology for instance, it has long been noted that topics like ecology and genetics contain many concepts that students perceive as difficult and that the list has continued to grow (Okebukola and Jegede, 1989) In agreement with this assertion, such topics and issues in biology as energy crisis and resource control, sexuality education and HIV/AIDS, evolution, reproduction in man and related issues of abortion and cloning have not helped in shortening the list of difficult concepts in biology. Students of physics and chemistry are not different in this regard. Topics like pressure in fluids, radioactivity, electrolysis (Okebukola and Jegede, 1989), heat (Allan and Treagust, 1993), metals, electrochemistry, stoichiometry and energy changes (Onwukwe and Onwukwe, 2010) are but a few of some specific areas that students of physics and chemistry always perform below expectations in both internal and external examinations due to perceived difficulties of the concepts involved.

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The ever increasing list of difficult concepts in science no doubt has attendant consequences both for the teachers and learners of science, especially at basic levels of school. One secondary school biology teacher summed it up this way: Students do not do well in biology due to poor attitude to it. We are not sure of what leads them to this poor attitude (Agoha, 2005). There is no doubt that the difficulty in learning biology concepts is a main contributory factor. According to Agbowuro (2008) there is a strong link between poor cognitive achievements and non-meaningful learning of biology concepts to low metacognition of biological concepts. Physics and chemistry students are no less affected and the link is the same.

There is however, a consensus in science education literature that use of analogical teaching strategies is a sure way of helping teachers and students to overcome difficulties associated with teaching and learning difficult science concepts. This is because some of the difficulty experienced by students in these topics no doubt stem from lack of insight in the internal workings as well as inter and intra-particle/ phenomenal interactions that result in the observable outcomes. This is where analogies come in to broaden understanding (Onwukwe and Onwukwe, 2010). An analogy (or even metaphor) helps learners to understand (build knowledge of) new

concepts presented in class by calling up knowledge (memory) of concepts they have already mastered or become familiar with (Glynn, 1991; Allan and Treagust, 1993; Dunican, 2002)

To make analogical teaching more systematic and hence more helpful, the Teaching-With-Analogy (T-W-A) model was proposed (Glynn, 1991; 1994). The T-W-A model helps the science teacher to take the students through six basic steps:

1. Introducing the target (unfamiliar) concept to be learned
2. Cueing in the recall of the analog (familiar) concept from students' memories
3. Identification of similarities among elements (features) of the familiar and unfamiliar (target) concepts
4. Mental mapping of similarities between the familiar (analog) and unfamiliar (target) concepts
5. Drawing conclusions
6. Identifying the features of the analog and target concepts that do not match.

While these steps are essential, they must not be ordered as presented above. For instance, steps 5 and 6 can be reversed.

In spite of all these attempts to clarify concepts, some students still continue to experience difficulty, confusion and even digression when analogies are applied in science classrooms. Some reasons have been adduced for this: Drawing analogies from widely divergent backgrounds or from different cultural climates (Garner, 2005; Rigas and Valanides 2003). This may be why Ikobi (1999) opined that analogies best do their work of clarifying concepts if they put the new concept into a language that students can understand because only then will it relate to familiar, real life activities that provide some visualization advantages.

The need for culturally-based analogy generators for secondary school science classrooms

According to Agbawuro (2008) one of the overriding objectives of biology teaching is to ensure that students learn biological concepts meaningfully. This can only be said to have been achieved if a teaching process results in a biology student who consciously and explicitly relates new knowledge to relevant concepts or propositions, which he/she already possesses. This assertion is in no way peculiar to biology but applies to all science students. To achieve the target for our science students and teachers as stated above, Ikashi et al. (2005) are of the view that,

> "Efforts must therefore be made in developing curriculum to ensure that it is culturally oriented… It is however wrong to base the educative process only on psychological knowledge. Cultural anthropology, social psychology, and cultural sociology threw more light on curriculum issues when they stressed the importance of culture in the education of the child".

The authors went on to stress the fact that such psychological characteristics as intelligence and personality may be best expressed if culturally conditioned, especially in a multi-cultural society like Nigeria. This is in agreement with Onwukwe (2009) who is of the opinion that the ideological expressions advanced by the semiotic theory of the curve linear forms in the African novel (Umezinwa, 1990) links African dance, arts speech patterns, songs and so on in a harmonious rhythm. A warning is thereby sounded that in planning educational experiences in an African setting, the inseparable harmony between African language pattern and thinking must be considered, otherwise, it will be false and therefore must fail to produce the desired goals.

The observations and assertions made of the place of culture in educative processes must of necessity include the use of analogical concepts in science classrooms. According to Okebukola in Owolabi (2002) teachers have failed in this perhaps, because they are unaware of how to generate and use analogies without getting the students confused. In addition, majority of teachers at the basic levels may not possess the requisite skills of generating analogies of specific cultural metaphorical origins. The call by Owolabi (2002) that "A teaching with analogies model is therefore desirable and should be designed to guide the teachers towards effective teaching in all the basic sciences (physics, chemistry and biology)" can only be effectively answered if such an answer incorporates cultural dimensions.

The present authors, in proffering a solution in the direction of the stated need, suggest that science teachers, especially in primary and secondary schools, should first select appropriate generators of analogies that are culturally based. These could be plays (drama sketches), e.g. the "Courtroom of Crazy Elements" (Onwukwe, 2005) – a drama book for teaching and learning chemistry, a political system e.g. Nigeria's "Option A4" voting system, a rite or ritual e.g. marriage or religious observances, and so on. Teachers would then proceed to derive analogies usable to teach specified aspect/s of stated science subject. Thereafter, the teacher should develop a lesson plan based on the T-W-A model. These suggestions are exemplified below by the authors for the guidance of science teachers.

Abridged form of a model lesson plan based on play-simulations and culturally-related analogies.

Below is a list of analogies generated from the culturally based play "Courtroom of Crazy Elements" and from Nigeria's Ideological concepts usable in teaching such chemistry topics as metals and electrolysis. Following the

list is an abridged lesson plan based on the T-W-A model, as adapted from Onwukwe and Onwukwe (2010):

1. A metal in an electrovalent combination is likened to a person who, in aspiration to chieftaincy title (nobility) donates to the needy so as to be accepted/recognized as self-sufficient (Royalty).
2. In electrovalent combination, metals are likened to men while non-metals are likened to women in a relationship: men more readily give gifts to women, for mutual benefits.
3. In making donations to the needy, each donor gives according to the abundance of his wealth. This is likened to the number of electrons a metal can donate in order to form an ion.
4. An atom losing/gaining electrons and becoming an ion is like a man who just acquired religion, his behaviors are permanently modified.
5. The properties of chloride ion (Cl^-) in solution can be regarded as "friendly" when compared with those of the poisonous chlorine gas ($Cl_{2(g)}$).
6. Chemical reactions taking place in water as a medium is like when people hold meetings in a conference hall – exchanges of ideas/opinions as well as political and social influences are experienced.
7. Activity or electrochemical series are like graded residential neighborhoods, the uptown is for the upper political class and downtown for the lower class. Exercise of authority is from up to down town.
8. Electricity is like an influence on substances as are on spiced meals are on people – they only stimulate people do more readily what they are already willing to do.
9. Strong electrolytes are like leaders who share all they have to empower more people while weak electrolytes are like men who give out miserly; they empower only very, very few people.
10. Non-electrolytes are like people who come to market neither to sell nor to buy; they have no customer.
11. The influence of an anode and a cathode in an ionic solution is like "Option A4" voting system: Each voter must line up behind his/her candidate. Otherwise, every voter wonders about until the contestants take their seats.
12. The wires that connect the direct current (dc) supply with the electrodes in electrolysis are like the entry and exit routes to a walled market. An example of T-W-A Lesson Plan, Using Play-Simulations and culturally based analogical concepts hereby follows:

Topic: Electrolytic extraction of metals
Class: Senior Secondary Class 3 (SS3)
Average age of class: 16 ½ years
Entry behavior: As applicable to particular groups.

Objectives of the lesson

At the end of the lesson, students will be able to:

i) Explain the concept of extraction of metals, position of ions in the ECS.
ii) Explain extraction of metals generally as a reduction process (electron gain).
iii) Explain the principle behind the electrolytic method of extracting metals.
iv) Etc.

Content development

For brevity, only an abridged form of the content development will be expressed in Table 1.

DISCUSSION

Two empirical studies are cited to buttress the claims of the authors that culturally mediated analogical concepts, applied in a systematic way during science teaching are very effective. According Onwukwe, (2008) the transition rate of senior secondary class 1 (SS1) chemistry students increased firm to 36.9 to 77.2% over a period of three years (1996 to 1998) when the TWA, method, using culturally based analogies one source was used the researcher used the TWA model consistently for the period under review, using the chemistry drama book, courtroom of crazy elements (unpublishing by then) as the generator of analogies. The study indicated that when the teaching method was dropped, the transition rate also dropped to 52.8%. The implication was that more beginners were able to cope with the subject chemistry – until they offered it as a school certificate subject in senior secondary school class 3 (SS3) when taught with culturally medicated analogies generated from a particular sources than when taught with the conventional method. Okereke (2009) generated the analogies for the study on influence of gender and location in the use of play simulation on students' achievement in chemistry from a drama book. The book, Queen Ester's father (Onwukwe, 2005) is written to enhance generation of analogies for the teaching of secondary school organic chemistry.

The results of the study showed that the students that were exposed to the play performed significantly higher than those that were not exposed to the play – culturally based analogies generated from one source. These studies and more help to highlight the need to guide practicing teachers on how to plan and apply the technique in classroom situations.

CONCLUSION

The paper posits that the difficulty science teachers and students face with difficult concepts, especially at the basic levels is linked with inability of the teachers to use appropriate teaching methods like analogical teaching

Table 1. Content development.

Content	Teacher's activities	Students' activities
Set Induction (Play-Simulation)	Teacher: Exposes the students to the relevant portions of the play courtroom of crazy elements, either in print or electronically displayed. Provide students with a list of analogies earlier prepared. Says "we will now stop so far. Let's see how we can use these impressions to deepen understanding of our chemistry lesson. Are we ready?"	Read / watch on screen the relevant portion/s or all of the play "courtroom of crazy elements", go through the list of analogies prepared by the teacher and discuss their impressions in class, etc. Yes Aunty/Uncle
Extraction of metals: Definition:	Extraction of metals is all about the various techniques/methods used to convert metallic ions or atoms found in or mixed with natural compounds into free atoms (pure elemental forms) Now do you remember what Madam Water said about her house girls in the play? Correct! It means that Water is a compound and the elements that constitute it are H and O. Certain reactions separate them into the elemental forms. In like manner, metallic ions can be made to separate from their natural compounds and exist as free atoms. However, take note that H_2O, H_2 and O_2 are not human beings, they cannot talk. It is only intended to help us understand our lesson. Writes equations to illustrate. Etc.	Listen, take notes, answer and ask questions. Yes: she said "my house girls rarely meet but as soon as Mr. Sodium had a vigorous action on me, it caused the liberation of misses hydrogen and oxygen from my inner chambers". Etc.
Electrolytic method of extraction of metals	States: In this method, chlorides or hydroxides form the electrolytes and hence metallic ions of various electrode potentials Now, can you remember what Madam Water said to Judge Gold about her counsel, Barr Copper? What did she say? Correct: That statement is in reference to the *positions of H^+ and Cu^{2+} in the ECS.* To deposit a metal in electrolysis is like forcing someone out of a neighborhood/street by a more influential upper class citizen. Note that metallic ions uppermost in the ECS 'force' those below them to accept e^{-s} and become discharged from solution: $M^+_{(aq)} + e^- \rightarrow M_{(s)}$:The charge on M ion has reduced from +1 to 0.(A reduction process) However, the 'force' required to deposit a metal is due to differences in electrode potentials/readiness to accept electrons, of the elements.(Displays chat) It is not a 'physical force' that human beings can use. Hydrogen ion is not a human being, so it cannot apply "physical force" on Cu^{2+}. Now compare Madam Water's statement with Miss Hydrogen's statement during her witness. "I hope… Very good! All those statements are referring to the precipitation of Cu^{2+} by H^+ in ionic solutions. Do you think metals can really get angry? In electrolytic method of extraction therefore, $H_{2(g)}$ is formed at the cathode(by e^- gain) in the absence of Cu^{2+}, no matter the other metallic ions present. This is why fused chlorides are used in extracting very reactive metals, this is to avoid the presence of H^+ in solution.	Yes She said "...he is aware of how the ionic miss hydrogen drives him out of our neighborhood. He lives just below her in the magnificent ECS road" I hope you are not organizing a revenge of what I do to your less noble brothers in ionic solutions" No. they are not human beings, they cannot get angry.

Table 1. Contd.

Extraction of sodium	Method – electrolytic Electrolyte – fused NaCl Process – Down's process Anodic Reactions $Cl^- \longrightarrow Cl + e^-$ $Cl + Cl \longrightarrow Cl_2(g)$ evolved Cathodic Reactions $Na^+ + e^- \longrightarrow Na_{(s)}$ deposited Over all Reaction $2Na + 2Cl^- \longrightarrow 2Na + Cl_2$ If a metallic ion accepts electrons, is it oxidation or reduction. What type of reaction are cathodic reactions then? Note, opposites of reduction and cathode are oxidation and Anode respectively etc	Reduction reaction Reduction reactions etc

techniques. That these problems persist even in situations where the Teaching-With-Analogy (T-W-A) model of science lesson delivery method is followed is linked with selecting analogies that are inconsistent with the cultural milieus of the students. The authors advocate a procedure that will take a science teacher through first, choosing an analogy generator imbedded in the culture of the students, listing possible analogies usable to teach specified topics in science and then preparing lesson notes in the T-W-A format to be used in class. The paper therefore, concludes that following this procedure will drastically reduce the ever growing list of science concepts perceived as difficult by both science teachers and students and thereby result in meaningful leaning of science concepts, principles and models.

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