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Pre-Service Chemistry Teachers' Understanding of Structural Isomerism in Alkane

¹G. SHEHU, ¹A. A. OLATUNJI, ¹B. M. MAIBULANGU, and ⁴M. Z. YUNUSA

¹Chemistry Department, School of Science, Aminu Saleh College of Education Azare, Bauchi State.

⁴School of Educational Service, Aminu Saleh College of Education Azare, Bauchi State.

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ABSTRACT

The study investigated the pre-service chemistry teachers' understanding of structural isomerism in alkane of chemistry major students of Aminu Saleh College of Education Azare. The sample for the study comprised of one hundred (100) pre-service chemistry teachers, randomly selected from the entire population of 100 and 200 levels, Fifty (50) students from each level. The instrument used for the data collection was the chemistry concept test (CCT), which was structured short ten-item (10). Objective test constructed by the researchers. The CCT was validated for content and construct validity. Six (6) hypotheses and four (4) research questions were formulated. Simple frequency count, average and percentages were used to determine the performance of each student, while t-test was used to compare the mean performance of the grouping involved in the study. The results of analysis of data revealed that male students performed better than female students irrespective of their levels and there was no significant difference in mean performance by gender of the students across the levels. Based on the findings, recommendations were made.

Keywords: Pre-service teachers, structural isomerism, Alkane, Understanding.

Introduction

In the era of scientific and technological advances, the teaching and learning of science has been greatly emphasized. Chemistry which is the branch of natural science that deals with study of composition and constitution of substances and the changes they undergo as a consequence of alterations in the constitution of their molecules. The language of chemistry is a whole that consists of symbols, formulae, chemical equations and many terms with specific meaning to understand chemistry.

Organic chemistry on the other hand, is the chemistry discipline that is concerned with the study of compounds containing carbon that is chemically bonded to hydrogen. Organic chemistry encompasses the synthesis, identification, modeling and chemical reactions of such compound. Such chemical field include molecular structure, aromatic compounds, substitution, elimination, addition reaction mechanism, isomerism, functional group and spectroscopy (Julia dictionary inc, Melis, 2016).

Alkanes are organic compound that consists entirely of single-bonded carbon and hydrogen atoms and lack any functional group. Alkane has the general formula C_nH_{2n+2} and is subdivided into three groups, these are Linear Straight-Chain alkane, Branched alkane and Cycloalkane.

Isomerism is phenomenon in organic chemistry which means the occurrence of two or more compound with the same molecular formula but different molecular structure (Bala, 2005). Those with different arrangements of bonded atoms are constitutional (or structural) isomers; alkanes with a given number of carbon atoms but different skeleton are examples. The smallest alkanes to exhibits constitutional isomerism have four carbon atoms: two different compounds have the formula C_4H_{10} . The unbranched one is butane (common name, n-butane; n-stands for normal or straight chain) and the other is 2-methylpropane (common name isobutane). Similarly, three compounds have the formula C_5H_{12} . These are the n-pentane, 2-methylbutane and 2,2-methylpropane. Isomerism is one of the basic concepts in organic chemistry that has wider application. Therefore, proper understanding of the concept would make the learning of subsequent related concepts easier (Andre and Nathan, 2011).

The major problem in chemistry education today is how to improve the conceptual comprehension of students and to make it easier to learn the concept. The West African senior secondary certificate examination (WSSCE, 2009 & 2013), observed that students inability to grasp the International Union of Pure and Applied chemistry (IUPAC) nomenclature affects their understanding of many concepts in organic chemistry more especially the structural isomerism in alkane. Eastwood (2013) has applied an educational team activity on the topic of nomenclature, isomerism and basic reactions schemes; he observed that teaching through game was a meaningful method for students to learn chemistry. Kibar, *et al.* (2013) assesses prospective chemistry teachers understanding of gasses through qualitative and quantitative

analysis of their concept maps. Their study revealed that the students could not form hierarchical maps even after being shown examples of the basic elements and meaningful propositions between concepts when asked to write concepts maps using a list of given concepts related to gases. Other research studies undertaken to improve students comprehending organic concepts include that of Ellis (1994). A study conducted by Samide & Wilson (2014), revealed that besides note taking in classic education, also active participating in the lesson increases students mastering of the subjects. Sender & Toprak (2013a) reported that, students stated that organic chemistry was one of the most difficult subject areas in chemistry. However, it has occupied large area in our lives, these ranges from plastics drugs & medicine, cosmetics, dyes, petroleum products and perfumes. Because of these reasons it is necessary for a teacher to think and create alternative teaching methods and techniques for topics and then they should use alternative assessment methods to help the students to harm proper understanding of the concepts and related concept (Necla and Neslilah, 2016).

Looking at gender of the students and to see whether it affects their understanding Isomerism in Alkane, many studies have been carried out in order to find such an effect. Gender refers to the socio-culturally constructed or created roles which are ascribed to males and females in any society. This has to do with particular responsibility or roles a member of a community is expected to play (Okeke, 2008). In teaching and learning of concepts in chemistry, research revealed that gender has an influence. For example, in their studies, Okereke and Onwukwe (2011), and Ezeudu and Obi (2013), observed that male students performed better than their female counterparts in chemistry and mathematics. However, the study of Oludepe (2012), maintained that gender has no significant on students achievements in Science and Integrated Science.

Statement of the problem

Chemistry is replete with abstract concepts and are so important that, without proper understanding of such concepts further studies in chemistry cannot be easily understood (Onuigbo, 2015). Despite all effort by teachers to arouse students interest in organic chemistry, students still find it very difficult in naming and drawing structures more especially the structural isomerism in alkane. For students to learn isomerism, their conception must be in line with the IUPAC nomenclature of organic compounds. Students' inability to gain this correctly hinders their understanding of isomerism in alkane. These and other related problems therefore, triggered the interest of the researchers to investigate the gender differences and the pre-service chemistry teachers' levels of understanding of structural isomerism in alkane.

Significance of the study

The study was designed to determine the students' performance in organic chemistry particularly in the area of structural isomerism in alkane.

Research question

The specific research questions which guided this study were:-

1. What is the level of performance of 100 level students in the chemistry concept test CCT?
2. What is the level of performance of 200 level students in the chemistry concept test CCT?
3. Which level has a greater average performance in the CCT?
4. Which gender out-performs the other in the CCT?
 - a. At 100 level.
 - b. At 200 level.
 - c. General.

Research hypotheses

Following the significance of the study, the following null hypotheses were generated and tested.

Ho₁: there is no significant difference in the mean performance of male and female pre-service chemistry teachers in the CCT.

Ho₂: there is no significant difference in the mean performance of male and female 100 level pre-service chemistry teachers in the CCT.

Ho₃: there is no significant difference in the mean performance of male and female 200 level pre-service chemistry teachers in the CCT.

Ho₄: there is no significant difference between the mean performance of 100 level and 200 level pre-service chemistry teachers in the CCT.

Ho₅: there is no significant difference between the mean performance of 100 level male and 200 level male pre-service chemistry teachers in the CCT.

Ho₆: there is no significant difference between the mean performance of 100 level female and 200 level female pre-service chemistry teachers in the CCT.

Methodology

The study adopted a descriptive survey design. This design was employed because the subjects of the study were observed in a completely natural and unchanged environment. This type of design usually yields rich data that leads to important recommendation.

Population and Sample of the study

The population of the study consisted of the entire pre-service chemistry teachers of Aminu Saleh College of Education Azare in Bauchi State Nigeria. The college is one of the leading colleges and its choice was due to the Colleges' adequate teaching staff, availability of well equipped chemistry laboratory, computer laboratory, and internet facilities that could aid science teaching and learning. Coupled with that most of the students in the College are computer literate, these enable them to use online and offline software in learning.

The sample for the study comprised of one hundred (100) pre-service chemistry teachers, randomly selected from the entire population of 100 and 200 levels, 50 students from each

level. 100 and 200 levels students were used because they were currently in the College. Pre-NCE and 300 level students were not used because pre- NCE students were not taking organic chemistry this semester and 300 levels were on teaching practice.

Sampling procedure

The list of the 100 and 200 levels was collected from the Department of chemistry Examination Officer. Two students were called and asked to pick fifty (50) numbers each from 100 and 200 levels respectively. Later the researchers marched the numbers picked with the student's names. There after the students were identified and the test was administered on them, supervised by the researchers.

Instrument for data collection

The instrument used for the data collection was the Chemistry concept test (CCT), which was structured short ten-item (10), objectives test constructed by the researchers. The CCT questions were on drawing, naming and identifying isomers in alkanes. The marking scheme was prepared awarding mark (one point) each to every correct response. Thus, a candidate that correctly answered all the ten questions ended up with a maximum of 10points. The CCT was validated for content and construct validity. This involved subjecting the instrument to analysis by experienced chemistry teachers from chemistry department of the college.

Method of data analysis

Simple frequency count, average and percentages were used to determine the performance of each subject/participant in the test. While t-test was used to compare the mean performance of the grouping involved in the study.

Results and Discussion

Table 1: Distribution of respondents by gender and level.

Level	Male	Female	Total
180	39	16	53
200	34	12	46

Missing	01	-	01
	72	28	100

Table 1 above shows the distribution of the students respondents by their gender and level of study. Of the One Hundred (100) randomly selected respondents, Seventy Two (72) representing 72% were male, while the remaining twenty eight (28%) were female students. Similarly, fifty-three (53) of the identified respondents were from 100 level of Chemistry Department of the College, this constituted 53% of the total respondents, while the forty six (46) about forty-six percent (46%) of the total respondents were from 200 level of the some Departments of the College. One respondent (1%) could not be identified into any of the two levels as such indication was not shown of the candidate's response – script. It was, however, possible to be identifying the candidate concerned as a male respondent.

Table 2: Distribution of Respondents Correct Responses by Items Levels and Genders.

S/N	ITEMS	100 Level (53)			200 Level (46)		
		M	F	TOTAL	M	F	TOTAL
1	Homologues	30	14	44	31	10	41
		56%	26.41%	83.91%	67.4%	21.70%	89.10%
2	Carbon and Hydrogen Atoms	30	12	32	30	09	39
		56.60%	22.60%	79.20%	65.20%	19.57%	84.10%
3	$C_nH_{2n} + 2$	31	14	45	26	08	34
		58.50%	26.42%	84.92%	56.50%	17.48%	73.90%
4	Isomerism	16	06	22	29	07	36
		30.20%	11.30%	41.50%	65%	15.22%	78.22%
5	Isomers	07	04	11	15	05	20
		13.21%	7.55%	20.76%	32.61%	10.87%	43.48%
6	Two Isomers of (C_4H_2O)	14	06	20	10	01	11
		26.52%	11.32%	37.84%	21.74%	2.17%	23.91%
7	Structural Formula ($CH_3CH_2CH_2CH_3$)	16	07	23	30	02	32
		30.14%	13.21%	43.40%	65.22%	4.35%	69.57%
8	Pentane (C_5H_{12})	21	07	28	26	09	35
		59.60%	13.21%	52.81%	56.52%	19.57%	76.10%
9	Isomers Possible in (C_5H_{12})	05	00	05	20	10	30
		9.43%	0.0%	9.43%	43.48%	21.74%	65.22%
10	JUPAC Name of ($CH_3CH_2CHCH_3CH_3$)	15	03	18	16	04	20
		28.30%	5.66%	33.96%	34.78%	8.70%	48.47%

From the table 2 above, responses to item 1 recalled eighty five (85) total correct responses. Whereas male respondents correct responses those of female were twenty four percent (24%). For 100 level, a total of 44 corrects responses were recorded. Out of the forty four (44) 100 level respondents, 30 were male while 14 were female. These constitute 56.60% and 26.40 percentages male and female respectively. Whereas, thirty one (31) of the 200 level male respondents scored the same item correct, while only ten (10) female had it correct. That is to say that forty one percent (41%) of the total respondents who were 200 level got the item 1 correct. In this case, 67.4% of male 200 level and 21.70% female 200 level got the item correct.

Item 2 received seventy one (71) total correct responses. Male and Female respondent correct responses stand as sixty (60) and twenty one (21) respectively. For 100 level a total 32 correct responses were recorded. Out of the 32 correct responses, 30 were male while 12 were female. These values stand as

56.60% and 22.60% respectively. The total correct responses at 100 level remain 79.20%. The 200 level correct response with regard to male and female and total stands as 65.20%, 19.37% and 34.77%.

Items 3, 4 and 5 received total correct responses at 100 level as 45, 22 and 11 respectively and at 200 level the total correct responses were 34, 36 and 20 respectively. The total correct responses of the three items at 100 and 200 level stands as 84.92%, 41.50%, 20.67% and 73.90%, 78.22%, 43.48%, respectively. The male and females of 100 level received 31, 16, 07 and 14, 06 04 correct responses on the said items and the percentage correct responses were 58.50%, 30.20%, 13.21% and 26.42%, 11.30%, 7.55% respectively. 200 levels male and female respondents received correct responses on the items as 26, 29, 15 and 08, 07, 05 respectively. The percentage correct responses were 56.50%, 63.00%, 32.61% and 17.40%, 15.22%, 10.87% respectively.

Items 6 and 7 received 20, 11 and 23, 32 correct responses in total. Whereas male and female correct responses respectively stand as for 100 level 14, 06 and for 200 level 10, 01, which corresponds to 26.52%, 11.32% and 21.74%, 2.17% percentage respectively.

Items, 8, 9 and 10 received 28, 35, 05, 30, 18, 20 total correct responses. Whereas male respondent's correct responses were about 47, 25, 19, while those of the female were 16, 10, 07 correct responses for 100 level, a total of 28, 05 and 18 were correct responses were responded. Out of these numbers, 21, 05, 15 were male while 07, 00 and 03 were female. These constitute 39.60%, 9.43%, 28.30% and 13.21%, 0.00%, 5.66% respectively.

Whereas, 26, 20, 16 200 level respondents were scored correctly, however the female scored 09, 10, 04 correct responses respectively. In this case, 56.52, 43.48 and 34.78% of the male 200 level respondents and 19.57%, 21.74% and 8.70% female 200 level respondents got the items correct.

Analysis of the breakdown of the general responses of the respondents in CAT test items as revealed by table 2, shows that majority of the respondents do understand the meaning of Homologues series, Alkanes, general formula for alkanes, isomerism and formula for pentane (C_5H_{12}). However, the respondents have difficulties in stating how many isomers has the molecular formula C_4H_{10} , C_5H_{12} and in writing the structural formula of C_4H_{10} and naming the IUPAC name of $CH_3CH_2CHCH_3CH_3$. From the finding therefore, it is clear that the respondents have a good understanding of the concept isomerism in alkane. But lack the knowledge of structural formula in alkane. This is due to the fact that the entire question on the CAT that deal with structural isomers in the alkane, their responses were below 50% correct.

Research Question 1:

What is the level of performance of 100 level students in the CCT?

Table 3: 100 level respondents' distribution by grade and gender.

Grade	Male	Female
A	08	01
B	04	03
C	09	04
D	07	02
E	09	06

The 100 level respondents passed the CCT in varying grades. Out of the 53 respondents, 32 (i.e. 71.70%) passed the CCT while 28.30% failed in the 71.70% that passed 30.20% (16 respondents) scored between A and B grades while 41.54% (22 respondents) scored C and D grades and 28.30% (15 respondents) failed the CCT (i.e. scored F grades). In this same group, male respondents amounting to 37 respondents (69.81% of the respondents) have 12 of them (32.43%) of male respondents scored between grades A and B, 16 of them (about 43.24%) scored between grades C and D with 9 (24.32%) failed the CCT. For females (28.30% of the total respondents) only 04 respondents (28.00%) scored between grades A and B. Another 39.50% (06 respondents) scored between grades C and D. While another 6 respondents (37.50%) failed the CCT. On the average male 200 level respondents involved in the CCT scored a mean of 4.81 while the female scored a mean 4.43. The entire group, on the other hand, scored a mean of 4.70.

Comparatively, male respondents out scored the female in the CCT as more male scored between A and B (32.43%) to 25% of female. Similarly in the grades C and D male out scored the female, i.e. 43.24% to 37.50% respectively. In the failed grade however, female out performed the male (37.50% to 24.37%) female/male respectively.

Research Question 2:

What is the level of performance of 200 level students in the CCT?

Table 4: 200 level respondents' distribution by grades and gender.

Grade	Male	Female
A	18	01
B	07	03
C	05	03
D	04	01
F	00	04

The table shows that 25 out of 34 while is 73.53% scored between grade A and B (i.e. between 60% and above) among the males whereas 4 out of 12 female respondents scored between A and B grades. That shows that only 33.33% of the female scored 60% and above Grades C and D recorded 09 males altogether where only 4 females fall into the categories. That is 26.47% of the male scored between 40 and 50% while 33.33% of females were in that category. No male failed the CCT, while 33.33% (04 respondents) failed. From the above, it may be assured that males

of the 200 level have better understanding of concepts involved in CCT than the female.

From average performance of each of the male female group, that of male respondents is greater than the female. Thus, it can be assured that male performed better than female respondents.

For the level respondents, the picture of their performance in the CCT shows that 29 of the 46 respondents scored between A and B grades (i.e. 6 and above over 10), while 13 scored between C and D grades (4 and above out of 10), While only 04 respondents score below 4 over 10 (i.e. failed). The performance is indicative of a high level in the CCT as 63.04% scored between A and B grades while 28.26% scored grade C and D. Only 8.7% of those respondents failed the CCT.

For 200 level 19 out of 46 respondents (about 41.30%) scored grade A 10 (21.74%) scored B, 8 (17.40%) scored C, 5 (10.87%) scored D and 4 (8.7%) scored F. This further shows that 91.30% of the students passed the CCT, while only 8.7% failed. The overall average performance of the level in the CCT is 6.13 (while ranged in the B grade of the CCT).

Table 5: t - test value of respondent's performance in the CCT.

Gender	N	Mean	Standard deviation	t – cal	t - crit
All Male	71	3.70	1.97		
Female	28	4.57	1.83	2.63	1.96
100 level Male	37	4.86	1.93		
Female	16	4.44	1.84	0.93	1.96
200 level Male	34	6.62	1.58		
Female	12	4.75	1.91	3.34	1.96
Students' levels					
100 level	53	4.74	1.89	- 3.70	1.96
200 level	46	6.13	1.85		
All male respondents					
100 level					
200 level	39	4.86	1.93		
	34	6.62	1.58	- 4.17	1.96
All female					
100 level	16	4.44	1.83	- 4.40	1.96
200 level	12	4.75	1.91		

* Significant at 0.05 level,

From table 5 above it can be observed that t - calculated (t - cal) for H₀₁ and H₀₃ were

greater than their respective t - critical. Thus, the two hypotheses are rejected. Whereas, the

t - cal. For H_{02} , H_{04} , H_{05} and H_{06} were respectively lower than their t - crit., hence their respective null hypotheses retained (not rejected). These simply that there is significant difference between the mean performance of male and female respondents in the CCT, irrespective of their levels. Also, the above implies that significant different exists in the mean performance of female respondents by level.

Summary of Finding:

The following are observed regarding the understanding of the respondents in the CCT in the study.

- ✓ The respondents understand the concepts of homologues series, hydrocarbon, isomerism, and possible isomers in a given organic formula.
- ✓ They have difficulties in the meaning isomers.
- ✓ Their performance in the CCT on IUPAC nomenclature was also not encouraging.

Recommendations:

Teachers of chemistry, especially organic, should endeavour to endear their students to the subject and concepts in organic chemistry more especially the female determine the level of their students understanding of the treated concepts before teaching.

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