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RELATIONSHIP BETWEEN STUDENTS' MISCONCEPTION AND ACADEMIC ACHIEVEMENT IN ORGANIC CHEMISTRY IN AWKA EDUCATION ZONE, ANAMBRA STATE

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ABSTRACT

Organic Chemistry, with its complex molecular structures and intricate reaction mechanisms, often leads students to form misconceptions as they grapple with new and challenging ideas. Hence, this study aimed to determine relationship between student's misconception and academic achievement in organic chemistry in Awka Education Zone. The study is guided by two research questions and two research hypotheses. The study adopted a correlational survey research design. The sample of the study consists of 370 senior secondary school 3 Chemistry students drawn from 14 public coeducational secondary schools using multi-stage sampling technique. Organic Chemistry Misconception Assessment Test (OCMAT) and students achievement scores for 2023/2024 session where used for data collection. The instrument OCMAT was validated by three experts from the Department of Science Education and Educational Foundations (Measurement and Evaluation unit), in Nnamdi Azikiwe University, Awka. The reliability of the instruments was determined using Cronbach's alpha, with coefficients of 0.78 for OCMAT, indicating satisfactory internal consistency. The data collected were analyzed using Pearson Correlation Coefficients, Simple Linear Regression and Fishers' Z-Test analysis were performed with Statistical Package for Social Sciences (SPSS, version 27). The findings of the study revealed low negative correlation between students' misconceptions and academic achievement. Despite the significant negative relationship between misconceptions and academic achievement, no significant gender-based difference was found. The findings emphasize the need for active learning strategies, utilization of technology and visualization tools and formative assessment, suggesting professional development for teachers and

curriculum revisions to address misconceptions to strategically address the issue of misconceptions in learning Organic Chemistry. Future research should explore longitudinal impacts and the effectiveness of various intervention strategies.

Keywords: Misconceptions, Organic Chemistry, Cognitive, Abstract, Constructivism, Academic Achievement

Introduction

Chemistry is a pure science field that studies matter's characteristics, makeup, and nature as well as the changes it goes through in various situations. Samuel and Ejiobi-Okeke (2021) defined Chemistry as a subject that is more interested with composition, structure, properties, behaviour of matter and also the chemical changes this matter undergoes during chemical reaction. In the context of Nigeria, chemistry is a compulsory subject for senior secondary school science students owing to its relevance (Omilani and Elebute, 2020). Its value is evident in its ability to relate to the practical needs of the majority through substantive content, practical application, and functional aspects. Ugwoke (2017) emphasized the significance of chemistry, arguing that it extends beyond the classroom or school environment, contrary to common belief. Chemistry is involved in numerous everyday activities outside of academic settings. Examples include cooking food, washing clothes with detergent or soap, boiling ground fresh tomatoes to evaporate the liquid, adding salt to perishable foods for preservation, and melting ice into liquid water for drinking, among others. The knowledge of Chemistry can help in development of appropriate technologies in some industries like, drug production industry, cement production industry, the plastic industry and many others (Samuel and Ejiobi-Okeke, 2021). Hence, Chemistry plays a crucial role in fields such as medicine, pharmacy and engineering, serving as a foundation for these professional courses. The study of Chemistry as a subject at the secondary school level aids students in developing elementary science skills, knowledge and attitude-based abilities required for problem solving in their environment. Therefore, a poor foundation in Chemistry at the secondary school level may endanger future achievement in the subject. Chemistry is also divided into multiple subfields, comprising organic, inorganic, physical, analytical, industrial, and nuclear, and is concerned with the properties and reactions of substances. Organic Chemistry is a prominent component within the science, technology, engineering, and mathematics field (STEM) according to the scientific community (American Chemical Society: Organic Chemistry, 2022).

Organic Chemistry is an important aspect of chemistry that focuses on the study of compounds containing carbon (Bruice, 2017). Essentially, it is the chemistry of carbon compounds, excluding carbon oxides, metal carbonyls, metallic carbonates, and related compounds. Organic compounds

are diverse classes of chemical compounds that contain one or more carbon atoms covalently bonded to atoms of other elements, typically hydrogen, oxygen, or nitrogen. Organic Chemistry involves studying the structure, properties, and reactions of carbon and its organic materials (Smith, 2020). It is a complex field that requires a comprehensive understanding of the properties and reactions of carbon-based compounds, since it involves the reactions and syntheses of wide variety of molecules including hydrocarbon and their derivatives. However, Organic Chemistry accounts for a considerable portion (20%) of the Chemistry syllables and examination (25%) in senior secondary school (Worokwu, 2016), which makes it a more important aspect of Chemistry.

Many students encounter significant difficulties when studying Organic Chemistry, often perceiving it as a challenging, irrelevant, and unhelpful subject for their long-term career goals (Healy, 2019). This perception can lead to decreased motivation and engagement with the material, potentially impacting academic performance and future career choices in scientific fields. The extensive content presented in Organic Chemistry textbooks is a major contributing factor to these difficulties. Students frequently resort to rote memorization as a coping mechanism, rather than developing a deeper understanding of the underlying principles (King, Zhou, Fischer, Rodriguez and Warschauer, 2019). This approach can be counterproductive, as it fails to foster the critical thinking and problem-solving skills essential for success in advanced scientific studies and research. Despite these challenges, the scientific community widely acknowledges the crucial role of Organic Chemistry in understanding carbon-based compounds. This field of study provides the foundation for comprehending the structure, properties, and reactions of organic molecules, which are fundamental to life processes and numerous industrial applications. Students often experience high levels of anxiety when faced with Organic Chemistry coursework. This anxiety can be attributed to various factors, including the abstract nature of many concepts, such as curved arrow mechanisms used to represent electron movement in chemical reactions (Crandell, Lockhart and Cooper, 2020). The struggle to connect prior knowledge from general chemistry to these new, more complex ideas can create a significant cognitive barrier for many learners. To truly master Organic Chemistry, students must develop a comprehensive understanding of both its fundamental principles and their practical applications in scientific research and industrial contexts.

Sequel to the foregoing, it is noteworthy that the understanding of Organic Chemistry concepts in senior secondary education is crucial for several reasons. For instance, Organic Chemistry, focuses on the structure, properties, reactions, and synthesis of carbon-containing compounds, serves as the foundation for fundamental chemical principles and paves the way for advanced scientific comprehension (McMurry, 2016). The centrality of Organic Chemistry in

understanding the intricacies of living organisms and materials stems from the unique bonding properties of carbon. This versatile element serves as the foundation for an extraordinarily diverse array of molecular structures. Carbon's ability to form stable covalent bonds with itself and other elements, coupled with its capacity to create single, double, and triple bonds, enables the formation of complex three-dimensional architectures. These structures range from simple hydrocarbons to elaborate biomolecules such as proteins, nucleic acids, and carbohydrates. The resultant molecular diversity not only underlies the chemical basis of life but also gives rise to a multitude of synthetic materials with wide-ranging properties. This molecular complexity, rooted in carbon's bonding versatility, necessitates a deep understanding of Organic Chemistry to unravel the subtle interplay between structure and function in both natural and artificial systems. As students' progress through their secondary education, a grasp of Organic Chemistry concepts becomes essential for success in higher-level science courses and fields such as biochemistry, medicine, and environmental science.

The molecular intricacies explored in Organic Chemistry provide the foundation for understanding biological processes, drug design, and the structure-function relationships in living organisms. Moreover, Organic Chemistry principles extend beyond the realm of science, influencing various industries such as pharmaceuticals, agriculture, and materials science (Bruice, 2017). An understanding of Organic Chemistry empowers students to critically evaluate and contribute to advancements in these fields, fostering scientific literacy and an appreciation for the applications of Chemistry in real-world scenarios. In spite of these gains, the challenges faced by students in learning Organic Chemistry are multifaceted. One prominent obstacle is the abstract nature of many concepts of Organic Chemistry. As a result, students often struggle with visualizing molecular structures and understanding the spatial relationships between atoms, which are critical aspects of organic chemistry (McMurry, 2016). They enter classrooms with pre-existing knowledge and ideas about scientific concepts, some of which may differ from generally accepted scientific viewpoints due to reliance on sensory information rather than objective evidence (David, 2017). Organic chemistry, with its intricate concepts and abstract principles, often becomes a breeding ground for misconceptions, as students struggle to fully grasp the complexities of molecular structures and reactions

Misconception is the misunderstanding of an idea or view that deviates from the generally accepted scientific concept. There are different definitions to the meaning of misconceptions. Misconceptions are defined as wrong ideas or views of a person's concept that is different from the scientific concepts formulated by experts in their field (Khandagale and Shinde, 2021). According to Kulgemeyer and Wittwer (2023), misconceptions are ideas or beliefs that students have formed about the physical

world before receiving instruction. These misconceptions may or may not align with scientific ways of thinking. For instance, many students incorrectly perceive chemistry, especially organic chemistry, as a difficult subject that only involves working with corrosive, toxic, and harmful substances, while forgetting that substances such as ethanol (C_2H_5OH), acetic acid (CH_3COOH), glucose ($C_6H_{12}O_6$) and amino acids (building blocks of proteins) are all organic compounds that play vital roles in everyday life and biological processes. Misconceptions, influenced by personal beliefs, perceptions, emotions, preconceived notions, and cultural factors, affect learners' acceptance of scientific explanations. Perera, Sarisavinarinawatie, and Shahril (2015) opined that students often struggle to grasp correct concepts despite teachers' efforts. Fear of punishment leads some students to memorize content without understanding it, masking their misconceptions. Tetzlaff (2017) found that students good at rote memorization often fail application-based problems, exposing gaps in their understanding. Misconceptions arise from various sources, including personal experiences, peer interactions, media, language, textbooks, and social factors (Widiyatmoko and Shimizu, 2018; Diah and Afadil, 2018). These factors create inconsistent frameworks that lead to fragmented understanding of scientific principles. In organic chemistry, misconceptions in fundamental topics like acid/base chemistry are particularly problematic as they underpin more complex concepts (Greenwood, 2017).

Misconceptions often arise from a combination of factors including cognitive biases, incomplete or misleading information, and educational deficiencies. Cognitive biases, such as confirmation bias, lead individuals to favor information that confirms their pre-existing beliefs while ignoring contradictory evidence. Incomplete or misleading information can stem from media sources, social networks, or even textbooks that oversimplify or inaccurately represent facts. Educational deficiencies, where foundational knowledge is weak or misunderstood, also play a significant role, as individuals may lack the critical thinking skills necessary to evaluate information accurately (Smith, 2020). These elements together create fertile ground for the development and persistence of misconceptions. Understanding the root causes of misconceptions is crucial, as these misunderstandings can significantly hinder academic achievement by creating gaps in knowledge and fostering erroneous beliefs.

Academic achievement refers to the performance outcome that indicates how well an individual has attained particular goals within an educational setting. According to Okonkwo and Samuel (2023) academic achievement is defined as the extent of success made by an individual or students in a learning task. In Chemistry, academic achievement involves a student's capacity to comprehend and recall facts, communicating this knowledge effectively, making it a significant predictor of overall performance in the subject. Despite the importance of Chemistry as the central science that forms the basic foundation for

many science disciplines and in improving the quality of life, the performance of students in Chemistry in senior secondary schools have not been excellent in external examinations, such as West African Senior School Certificate Examination (WASSCE). The analysis of students' performance at the Senior School Certificate Examination (SSCE) in Chemistry conducted by West African Examination Council (WAEC) showed that the achievement of Chemistry candidates in grade C6 – A1 from 2017 to 2022 revealed that in 2017, students' achievement was 64.48%, 2018-50.42%, 2019-61.98%, 2020-59%, 2021-61.5% and 2022 - 55.34%. Between 2018, 2020 and 2022 (50.42%, 59% and 55.34%), the performance was not too good, between 2017, 2019 and 2021 (64.48%, 61.98% and 61.5%) there was improved performance. Onyi and Nwafor (2022) provided empirical evidence for the low and fluctuating achievement of students in chemistry. This is supported by the Chief Examiners Reports (2017 - 2022) of the West African Examination Council (WAEC), which showed a pattern of inconsistency and a pressing need for improvement in students' achievement in the subject.

Statistics indicate that students' performance in Chemistry has been relatively moderate over the years. Specifically, the WAEC Chief Examiners' reports from 2017 to 2022, highlighted that few students attempted organic chemistry questions, and their performance was not excellent compared to other aspects of Chemistry. Common weaknesses include poor understanding of organic compound structures, inaccurate nomenclature, and properties. Even those who answered Organic Chemistry questions often failed to draw correct structures or provide accurate IUPAC names. This perception is not merely anecdotal, empirical evidence supports the widespread struggle with this subject. According to a WAEC report, many students either avoided Organic Chemistry questions altogether or answered them poorly in examinations (Donkoh, 2017). This avoidance behavior and poor performance highlight the severity of the issue. The extensive content in textbooks frequently leads to rote memorization rather than deep understanding. However, the problems extend beyond just content volume. Sibomana (2021) identifies multiple factors contributing to poor achievement in chemistry, including school-related issues, individual student factors, teaching methods, and misconceptions about Chemistry. This multi-faceted nature of the problem underscores the complexity of addressing Organic Chemistry education. While exploring students' conceptual understanding in organic chemistry, researchers have also investigated potential variations in academic achievement across different demographic factors, including gender.

Gender refers to the characteristics of women, men, girls and boys that are socially constructed. World Health Organization (2016) defined gender as socially constructed characteristics and norms associated with being a woman, man, girl, or boy, varying across societies and evolving over time. Historically,

stereotypes have perpetuated the belief that males inherently excel in subjects like mathematics and science, while females are more suited to humanities or social sciences. Recent studies in developing countries have also shown marked improvement in female academic performance (Ullah and Ullah, 2019) and this is against the backdrop of persistent challenges with access to education, and under-representation in STEM programmes at the secondary and undergraduate levels. Further, the results from these studies challenge the notion that males perform better and are fit for science and mathematics subjects than females (Workman and Heyder, 2020). Moreover, disparities in encouragement and mentorship within academic settings often disadvantage female students in fields traditionally dominated by males. Societal expectations and stereotypes linked to gender roles in science can impact confidence, interest, and engagement levels, potentially influencing academic performance and escalation of misconceptions about variations in self-efficacy, confidence, learning styles, and educational disparities could contribute to the intricate connection between gender and academic achievement in fields like Organic Chemistry.

Despite extensive research on misconceptions, there remains a gap in understanding how these misconceptions specifically correlate with academic achievement in Organic Chemistry, particularly with gender as a moderating factor. This study, therefore, seeks to determine the relationship between students' misconceptions and their academic achievement in Organic Chemistry within Awka Education Zone. Specifically, the study sought to achieve the following objectives:

1. The relationship between students' misconceptions and academic achievement in Organic Chemistry in Awka Education Zone.
2. The relationship between students' misconception and academic achievement based on gender in Awka Education Zone.

Research Questions

Two research questions were raised to guide the study.

1. What is the relationship between students' misconceptions and students' academic achievement in Organic Chemistry in Awka Education Zone?
2. What is the relationship between students' misconception and academic achievement based on gender in Awka Education Zone?

Null Hypotheses

The following null hypotheses were tested at .05 level of significance.

1. There is no significant relationship between students' misconceptions and their academic achievement in Organic chemistry.
2. There is no significant relationship between students' misconceptions and their academic achievement based on gender.

Research Method

Correlation survey research design was adopted for this study. The choice of correlational survey design is because the study examined the relationship between two or more variables in order to explain or predict the result. The population of the study comprised of 5005 (2290 males and 2715 females) chemistry senior secondary three (S.S.3) students of 64 (out of which we have 51 co-educational schools and 13 single sex schools) public secondary schools in the five Local Government Areas of Awka Education Zone. The sample size for this study consisted of 370 SS3 chemistry students drawn from 14 out of 51 co-educational public secondary schools in Awka Education Zone. The sample size was determined using Taro Yamane formula. The sample for this study was obtained using multi-stage sampling procedures. The instruments that were used for data collection are: Organic Chemistry Misconception Assessment Test (OCMAT) and Students Academic Achievement Scores in Chemistry. Organic Chemistry Misconception Assessment Test was used to collect data on students' misconceptions in Organic Chemistry, while students first term achievement scores was used to collect data on their academic achievement this is because Organic Chemistry course contents is taught in first term. The scoring rubric for the misconception test was classified under three categories. These categories are: Understand (U), Misconception (Mi) and Do not understand (DU). The Organic Chemistry Misconception Assessment Test (OCMAT) was subjected to face and content validation. This was done by three experts, who were given the title, the purpose of the study, research questions, and hypotheses together with copies of the instrument to guide them. One expert from Measurement and Evaluation unit of Educational Foundation and other two experts from Science Education Departments, both from the Faculty of Education, Nnamdi Azikiwe University, Awka. Cronbach's Alpha method was used to determine the internal consistency of the OCMAT the value obtained was 0.78. Out of the 370 misconception tests administered, 348 were validly completed and returned for analysis. The data collected were analysed using Pearson Product Moment Correlation Coefficient (PPMC), Simple Linear Regression (SLR) and Fisher Z-Test. The choice of statistical tool was due to the fact the study was correlational in nature.

Presentation of Results

Research Question 1: What is the relationship between students' misconceptions and students' academic achievement?

Table 1: Pearson r results on the relationship between students' misconception and academic achievement in Organic Chemistry

Sources of Variation	N	Misconception r	Academic Achievement r	Remark
Misconception	348	1.	- .160**	Low negative relationship
Academic Achievement		-.160**	1.	

Table 1, shows that Pearson correlation analysis was conducted to determine the relationship between students' misconceptions and their academic achievement in organic chemistry. The result revealed a low negative relationship between misconceptions and academic achievement, *r* (348) = -.160. This indicates that as students' misconceptions increase, their academic achievement tends to decrease, though the strength of the relationship is weak.

Research Question 3: What is the relationship between students' misconception and academic achievement based on gender?

Table 2: Pearson r results on the relationship between students' misconception and students' academic achievement in Organic Chemistry based on gender

Gender	Sources of Variation	N	Students' Misconception r	Academic Achievement r	Remark
Male	Students' Misconception	176	1	-.148**	Low negative relationship
	Academic Achievement	176	-.148**	1	
Female	Students' Misconception	172	1	-.059*	Very low negative relationship
	Academic Achievement	172	-.059*	1	

Table 2 shows the relationship between students' misconceptions and academic achievement, considering gender as a moderating variable. For male students, the analysis revealed a low negative relationship between misconceptions and academic achievement, *r* (176) = -.148. This suggests that as misconceptions increase, academic achievement decreases, although the relationship is weak. For female students**,** the analysis showed a very low negative relationship between misconceptions and academic achievement, *r* (172) = -.059. This indicates a minimal inverse relationship

between misconceptions and academic achievement among female students. Overall, result reveals that male students exhibit a slightly stronger negative relationship between misconceptions and academic achievement, compared to female students, who show a very weak negative relationship. This suggests that misconceptions have a somewhat greater impact on the academic achievement of male students than on female students, although the relationships are weak for both genders.

Hypothesis 1: There is no significant relationship between students' misconceptions and their academic achievement in Organic chemistry.

Table 3: Linear regression analysis on the relationship between misconception and academic achievement of students in Organic Chemistry

Variable	R	R^2	R^2 Change	B	Beta	% Var. Added	df	F	P-value	Decision
Misconception	0.160	0.026	0.026	-0.346	-0.160	2.6	346	9.099	0.003	Significant

Table 3 shows that a linear regression analysis was conducted to determine the extent to which students' misconceptions predict academic achievement. The results revealed that misconceptions significantly predict academic achievement, accounting for 2.6% of the variance in academic achievement, $R^2 = 0.026$, R^2 *change* = 0.026, $F(1, 346) = 9.099$, $p = .003$. The unstandardized coefficient (B) was -0.346, and the standardized beta coefficient (β) was -0.160, indicating that an increase in misconceptions is associated with a decrease in academic achievement. The relationship was statistically significant.

Hypothesis 2: There is no significant relationship between students' misconceptions and their academic achievement based on gender.

Table 4: Fisher's Z-test analysis on the relationship between misconception and academic achievement of students in Organic Chemistry based on gender

Variable		Correlation (r)	N	Fisher's Z	Z-cal	P-value	Decision
Misconception	Male	-0.148	176	-0.1485	-0.828	0.407	NS
	Female	-0.059	172	-0.059			

Note: NS = Not Significant

Table 4 shows that Fisher's Z-test was used to compare the correlation between students' misconceptions and their academic achievement for male and female students. For male students, the correlation between misconceptions and academic achievement was $r = -0.148$, $N = 176$. For female

students, the correlation was r = -0.059, N = 172. The Fisher's Z-test result was Z-cal = -0.828, p = 0.407, indicating that the difference in the strength of the relationship between males and females was not statistically significant. Since $p > 0.05$, therefore, we fail to reject the null hypothesis. This means that there is no significant difference in the relationship between students' misconceptions and academic achievement based on gender.

Discussion

This study reveals that a low negative relationship exists between misconception and students' academic achievement in Organic Chemistry. On the other hand, there is a low negative relationship between misconception and academic achievement of students in Organic Chemistry based on gender. The findings of Awofodu, Saka, Olanrele and Ogunkomaya (2020) agreed with the findings of the present study as it revealed that a negative relationship exist between misconception and students' achievement in Biology. This aligns with the findings of Roy and Mohapatra (2022) which showed that more misconceptions were observed in boys than girls. Contrarily, the finding of Olojo, Akinwumi and Olofin (2022) showed that male students performed best in Chemistry, followed by Physics, and least well in Biology more than their female counterparts. In another study, the finding of Tambaya, Yunusa and Matazu (2016) showed that there were no significant differences in the academic achievement of male and female students in Biology, Chemistry and Physics. In another study by Topal (2018), finding showed that students' misconceptions about general science subjects were independent from their gender.

Result relating to the hypotheses raised shows that there is a significant low negative relationship between misconception and students' academic achievement in Organic Chemistry. This finding aligns with that of Fuentes (2021) which showed that there is a significant difference in students' level of misconception in relation to their science academic achievement, although, the present study focused on Organic Chemistry. Similarly, Brown and Green (2018) findings aligns with the present study, the study found that there is a significant negative correlation between misconception and academic achievement of students in chemistry.

On the other hand, the study found that there is no significant relationship between misconceptions and academic achievement of students based on gender. The study aligns with the study of Omwirhiren and Ubanwa (2016), which revealed that there is no significant difference between misconception and academic achievement based on gender. Contrarily to the findings of the study, Soeharto and Csap (2022) findings showed that there is a significant difference between misconception and academic achievement based on gender in science. Similarly, the findings of Onah and Anamezie (2022) showed that there is significant difference in the prediction of academic achievement with

gender. This suggests that while there is a negative relationship between misconceptions and academic achievement for both genders, the strength of this relationship is relatively weak and does not vary significantly between male and female students. These findings imply that misconceptions impact academic achievement similarly across genders, despite the slightly stronger correlation for males. This finding aligns with that of Ozmen (2019) indicating that misconceptions are a general barrier to learning across diverse student populations, but gender does not significantly moderate this relationship The lack of significant difference suggests that interventions aimed at reducing misconceptions should be applied uniformly across male and female students to improve academic outcomes.

Conclusion

In conclusion, this study highlights that while there is a negative relationship between students' misconceptions and their academic achievement in organic chemistry, this relationship does not significantly differ based on gender. Both male and female students experience a decline in academic performance as misconceptions increase, although the strength of the relationship is relatively weak for both groups. The findings suggest that misconceptions pose a common challenge across genders and that gender-specific interventions may not be necessary. Instead, addressing misconceptions at a broader level, with strategies that target all students, may be more effective in enhancing academic achievement in organic chemistry.

Recommendations

Based on the findings of the study, few recommendations were made

1. Educators should implement instructional methods, such as concept clarification sessions and interactive problem-solving activities that specifically address common misconceptions in organic chemistry for all students, regardless of gender. This can improve students' conceptual understanding and academic achievement.
2. Regular use of diagnostic assessments can help identify misconceptions early on in the learning process. Teachers can then provide tailored feedback and interventions to correct these misconceptions before they negatively impact academic performance.
3. Professional development programs for chemistry teachers should include strategies for identifying and addressing misconceptions in organic chemistry. Training should focus on creating gender-inclusive teaching practices that support all students in overcoming learning barriers associated with misconceptions.

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