Self-Esteem and Quantitative Ability as Correlates of Students' Achievement in Stoichiometry in Chemistry in Egbeda, Oyo State

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Abstract

This study determined the connections between students' self-esteem, quantitative ability and their achievement in stoichiometry in chemistry in selected senior secondary schools in Egbeda, Oyo State. The study adopted the survey research design of the correlation type. Using simple random sampling technique, a total of 300 students were selected from a population of SSS II chemistry students in ten (10) government-owned secondary schools in Egbeda local government area, Oyo State. Three validated research instruments were used to collect data. They include Students' Self-esteem Questionnaire (r =0.85), Quantitative Ability Test (r=0.79) and Stoichiometry Achievement Test(r =0.76). Data were analyzed using descriptive statistics, Pearson Product Moment Correlation and Multiple Regression at the 0.05 level of significance. The findings of the study indicate that the level of students' self-esteem was high ($\bar{x}$ =2.63) at 2.50 threshold. The students' quantitative ability is low (32%). The relationship between self-esteem and students' achievement in chemistry (r = 0.05) was not significant, but a positive significant relationship was found between quantitative ability and students' achievement in stoichiometry (r=0.45). The two independent variables jointly significantly contributed to students' achievement in stoichiometry ($F_{(2,146)}$ =19.01; adj.R^2=0.20), accounting for 20.0% of the variance. Quantitative ability (β=0.45) is the only independent variable that made significant relative contribution to students' achievement in stoichiometry in chemistry. Based on these findings, it was recommended that students' quantitative ability should improved upon for maximum performance in stoichiometry and chemistry.

Keywords: Students' self–esteem, Quantitative ability, Achievement, Stoichiometry in Chemistry.

Introduction

Chemistry is a physical science that studies the properties, nature of atoms, their interactions and the changes they undergo. Chemistry is an incredibly fascinating field of study because it is so fundamental to our world. It plays a role in everyone's life and touches almost every aspect of human existences. Chemistry is one of the essential science subjects which not only equips learners with the fundamental scientific skills needed to understand physical phenomena but also prepares them to thrive maximally in science-related careers Therefore, it is offered in the Nigerian secondary school curriculum including the senior secondary schools in Egbeda Local Government Area in Oyo State. Some of the topics taught in senior secondary schools include atomic structure, IUPAC nomenclature, ionization, chemical kinetics, redox reaction, isomerism, quantum numbers, enthalpy, mole concepts, separation techniques, elements, mixtures and compounds among others. A credit pass in the senior secondary certificate examination is required to get admission into almost all basic and applied science discipline in tertiary institutions.

Research also shows that one of the challenges encountered by chemistry students can be attributed to poor problem-solving in stoichiometry (Opara, 2013; Udosoro, 2011; Badru, 2004). This is corroborated by the West Africa Examinations Council (WAEC) Chief Examiner's report which stated that students' have weaknesses in chemical arithmetic, poor mathematical skills and inability to determine mole ratio from stoichiometric equations (2007-2017). Stoichiometry is at the center of chemistry as it refers to the relationship between the measured quantities in a chemical reaction as well as the calculation which include the assumption of the law of conservation of matter and energy. Stoichiometry involves the mole concepts and the balancing of chemical equations analyzing the relationship between the number of reactants and products. Stoichiometry determining the amount of the substance in a reaction consists of mathematical procedures and understanding it requires problem-solving and high-level thinking skills (Vula and Berisha, 2022). The concept stipulates that the number of atoms or molecules involved in chemical reactions be converted into measured quantities expressible in convenient units. In order to use stoichiometry to do calculations about chemical reactions, it is essential to understand the relationships that exist between products and reactants and why they exist, which require understanding how to balance reaction (Hafsah, Rosnani, Zurida, Kamaruzaman, and Yin, 2014).

Stoichiometry is at the core of most concepts in chemistry which many students perceive as difficult ; such as mole concept, symbols, formulae and equations, chemical equations, quantitative analysis (Uzezi, Ezekiel, and Auwal, 2017, Kyado, Achor, and Adah, 2021). Perhaps due to the fact that it requires a number of individual skills such as problem solving strategy. Generally, a solid foundation in stoichiometry is necessary for understanding quantitative deductions in almost every aspect of chemistry. Despite the relevance of stoichiometry, studies have shown that learners find stoichiometric calculations difficult (Evas, Yaron, and Leinhardt, 2008).The difficulties encountered by chemistry students as they solve stoichiometric problems are lack of understanding of the mole concepts, inability to balance chemical equations, use of inconsistent stoichiometric

relationships, identifying the limiting reagent, determination of theoretical yields and identification of substances in excess. Generally, there are a myriad of factors which can affect a student's performance in chemistry. Such include the teacher factors, societal factors, infrastructural problems, language problem, curriculum-related variables, textbook-related variables and those associated with the student (Nweze and Uzochukwu, 2019). One of the student factors is Self Esteem.

It refers to one's sense of general competence and includes intellectual ability, school performance, self-regulatory capacities, self-confidence, efficacy, and agency. The increase of self-esteem increases academic achievement, and at the same time the increase of academic achievement increases self-esteem (Baumeister, Campbell, Krueger, and Vohs, 2003). Self-esteem enables students to handle setbacks with ease. Instead of being crippled by failure, resilient students get up quickly, learn from their mistakes, and try again. It is generally assumed that having high self-esteem is very important. (Erol and Orth, 2011) shows how important it was to study adolescents' levels of self-esteem; students with low self-esteem struggle with problems they face in school, either academically or socially.

A student's self-esteem involves a variety of beliefs about the self, such as appraisal of one's own appearance, beliefs, emotions and behaviors. Most secondary school students are within the adolescence bracket 12-20 years, and this been a period of storm and stress, levels of self-esteem will likely vary from time to time. Many adolescents struggle within themselves and the level of their academic attainments. Self–esteem and academic achievement seem to be most highly related between the years of about seven to fifteen (Malbi and Reasoner, 2000).Those who feel confident, generally achieve more, while those who lack confidence in themselves achieve less.

Topçu and Leana-Taşcılar (2018) observed that there were significant correlations between self-esteem, motivation and achievement. According to Aryana (2010) students with high self-esteem may academically achieve higher or more, since they tend to have more confident, while students with low self-esteem lack confidence in them and may achieve less academically. Low self-esteem students do not involve themselves with anything that may expose their weakness or incompetence to others, so because of that and to avoid been called one thing or the other among their peers in class, they do not show or have interest in academic activities.

Another important factor that may influences student's achievement in stoichiometry in chemistry is quantitative ability. Quantitative ability tests the ability of a candidate to handle numerical data and solve numerical problems. It tests the ability of students to analyse and understand the problem rather than cramming. Students' success in stoichiometry problem solving depends mainly on their understanding of the concept of mole and conceptual understanding of the problems. The challenge of enhancing students' performance in solving stoichiometry problems is a daunting tasks as many teacher resorts to just teaching how to solve stoichiometry problems algorithmically. Adigwe (2013), in his study examined relationship between mathematics skills and achievement in chemical Stoichiometry and discovered that the entering mathematics skills possessed by the students significantly influenced their achievement in chemical stoichiometry.

Research Questions

1. What is the level of students' self-esteem?
2. What is the level of students' quantitative ability?
3. What is the relationship between students' self-esteem, quantitative ability and achievement in Stoichiometry?
4. What is the joint contribution of students' self-esteem and quantitative ability to students' achievement in stoichiometry?
5. What are the relative contributions of students' self-esteem and quantitative ability to students' achievement in stoichiometry?

Methodology

This study adopted the survey design of correlational type. It investigated the predictive effect of students' self-esteem and quantitative ability on their achievement in stoichiometry in chemistry in senior secondary schools. The population comprised all senior secondary school (SSS II) students who offer Chemistry in Egbeda, Oyo State. This involved the chemistry students in government-owned secondary schools that are situated in Egbeda, Oyo State. The Oyo State Teaching Service Commission (TESCOM) Zone 3, comprises of three local government areas, which are Egbeda, OnaAra and Oluyole. Simple random sampling technique was used to select ten public senior secondary schools from Egbeda Local Government Area. Egbeda Local Government Area consists of twenty mini-metropolises of which each of them has at least a senior secondary school. In each of the 10 chosen schools, a class of SSII Chemistry students (with an average of 30 Chemistry students in a class) was sampled as respondents in the study. A total of three hundred (300) chemistry students in ten senior secondary schools of Egbeda LGA participated in the study. Three validated research instruments were used to collect data. They include Students' Self-esteem Questionnaire (r =0.85), Quantitative Ability Test (r=0.79) and Stoichiometry Achievement Test(r =0.76). Data were collected from the respondents in these schools. Data collected were analyzed using PPMC and multiple regression at 0.05 level of significance.

Results

Research question 1: What is the level of students' self-esteem?

Table 1: Students' self-esteem

S/N	Statement	Mean	STD.D
1	I generally feel anxious in new social situations where I may not know what is expected of me.	2.64	1.16
2	I have difficulty in knowing whom to trust and when to trust.	2.41	1.15
3	I am afraid of making mistakes which others might see.	2.43	1.16
4	I find it difficult to hear criticism about myself.	2.04	0.86
5	I think others are very critical of what I say and do.	2.94	0.99
6	I am easily embarrassed.	2.71	1.08
7	I am very concerned about my appearance.	2.75	1.01
8	I often feel like I do not know the right thing to do or say.	3.07	0.90
9	I find it difficult to accept who I am.	2.75	0.98
10	I have really high standards for myself and others.	2.75	0.97
11	I feel uncomfortable around successful people.	3.29	0.89
12	I am anxious and fearful most of the time.	2.75	1.02
13	When someone mistreats me I think that I must have done something to deserve it.	2.38	0.91
14	I am very critical of myself and others.	2.21	1.03
15	I tend to magnify my mistakes and minimize my successes.	2.61	1.21
16	I often feel depressed about things 1 have said and done, or things I failed to say or do.	2.59	1.10
17	1 have avoided making changes in my life because I was fearful of making a mistake or failing.	2.51	0.87
18	I try to avoid conflict and confrontation.	2.01	1.03
19	I have been told that I am too sensitive	2.69	1.04
20	I am happy with myself as a person.	2.75	0.99
21	1 feel good about how much my friends like my ideas	2.86	1.08
Weighted mean = 2.63			
Criterion mean = 2.50			

Table 1 revealed weighted mean of 2.63, out of maximum obtainable score of 4.00, which is higher than the threshold mean of 2.50. This means that the students have moderately high self-esteem.

Research Question 2: What is the level of students' quantitative ability?

Table 2: Frequency table for students' quantitative ability

Score Level	Frequency	Percentage
0-10	204	67.8
11-20	76	32.2

The table 2 shows that a good fraction of the students scored below half the possible highest score in the quantitative ability test. 204 students (67.8%) obtained scores within 0-10marks while only 76 (32.2) of them scored marks between 11 and 20 marks. It can be inferred that the level of students' quantitative ability is low.

Research Question 3: What is the relationship between students' self-esteem, quantitative ability and achievement in Stoichiometry?

Table 3: Correlation Matrix showing the relationship between the independent variables and students' achievement in stoichiometry chemistry

Variables	Achievement	Self-esteem	Quantitative ability
Achievement	1		
Self-esteem	0.054 0.517	1	
Quantitative ability	0.452* 0.000	0.002 0.984	1
Mean	10.20	51.19	11.89
STD.D	4.11	4.84	3.35

* denotes significant at p<0.05 level of significant

Table 3 revealed that a positive, weak non-significant relationship existed between self-esteem (r = 0.05; p>0.05) and students' achievement in chemistry. This indicates that students' self-esteem is not related to their achievement in chemistry. The table further revealed that positive, moderate significant relationship existed between quantitative ability (r = 0.45; p<0.05) and students' achievement in chemistry. This implies that students' achievement in chemistry is significantly related to their quantitative ability. It could be inferred from the result that for the students' achievement in chemistry to improve, their quantitative ability needs to be considered in order to have corresponding improvement in students' achievement in chemistry.

Research question 4: What is the joint contribution of students' self-esteem and quantitative ability to students' achievement in stoichiometry?

Table 4: Multiple Regression Analysis showing the joint contribution of independent variables to students' achievement in stoichiometry

Sources of Variance	Sum of Squares	Df	Mean Square	F	Significant
Regression	516.879	2	258.440	19.014*	0.000
Residual	1984.477	146	13.592		
Total	2501.356	148			
R = 0.455 R Square = 0.207 Adjusted R Square = 0.196 Std. Error of the Estimate = 3.68677					

* denotes significant at p<0.05 level of significance

Table 4 showed that the joint contribution students' self-esteem and quantitative ability to students' achievement in stoichiometry was significant ($F_{(2, 146)} = 19.01$; Adj $R^2 = 0.20$; p<0.05). This implies that when students' self-esteem and quantitative ability were taken together, they jointly contribute to students' achievement in stoichiometry. Table 3 showed a multiple regression coefficient (R = 0.46), this means that students' self-esteem and quantitative ability have a positive, moderate significant relationship with students' achievement in stoichiometry. Table 4 further revealed a multiple regression adjusted ($R^2 = 0.20$). This means that 20.0% variation in students' achievement in stoichiometry is accounted for by the joint contribution of the independent variables while the remaining 80.0% may be due to other factors and residuals not under investigation in this model.

Research question 5: What are the relative contributions of students' self-esteem and quantitative ability to students' achievement in stoichiometry?

Table 5: Multiple Regression Analysis showing relative contribution of independent variables to students' achievement in stoichiometry?

Model	**Unstandardized Coefficients**		**Standardized Coefficient**	**Rank**	**t**	**Sig.**
	Beta	**Std. Error**	**Beta (β)**			
(Constant)	1.312	3.393			0.387	0.700
Self-esteem	0.045	0.063	0.053		0.716	0.475
Quantitative ability	0.554	0.090	0.451	1st	6.124	0.000*

Table 5 showed that the relative contribution of students' self-esteem (β = 0.05; t = 0.72; p>0.05) to students' achievement in stoichiometry was not significant. However, that of quantitative ability was significant (β = 0.45; t = 6.12; p<0.05). This indicates that students' quantitative ability is the only independent variable that contributed to students' achievement in stoichiometry.

Discussions

The result of this finding indicates that students have moderate self-esteem. This is similar to the result obtained by Farid and Akhtar (2013). In this study, it appeared that students also answered the questions in conformity with social acceptance. This might be because the students hold a small degree of belief in their potentials, especially since they are

meant to be the 'revered science students'. Self-esteem is basically one's idea of themselves and is said to be affective in nature. This study also revealed that students' quantitative ability is generally low. It is not strange that many students have problems with numbers, calculations and solving problems. Perhaps, most of the students did not choose to do chemistry based on their capacities but based on some extrinsic factors. Students who have chosen to study chemistry are often not properly counseled and tested to ascertain their natural tendencies and abilities.

The positive, weak non-significant relationship which exists between self-esteem and students' achievement in chemistry may be due to the notion which some students hold about their abilities to tackle problems. This indicates that students' self-esteem is not related to their achievement in chemistry. This finding is contrary to that of Topçu and Leana-Taşcılar (2018) who observed in their study that there is a significant relationship between self-esteem and academic achievement, as well as that of Aryana (2010) who reported that students with high self-esteem may academically achieve higher or more.

Furthermore, students with high quantitative ability had the highest achievement in Stoichiometry test while those with low quantitative ability had the least achievement. The observed differences in the students' mean scores are statistically significant. Thus, students' quantitative ability has a significant and positive effect on students' achievement in stoichiometry in chemistry, due to its numerical nature. So this finding is similar to that of Adigwe (2013) who posited mathematics skills possessed by the students significantly influenced their achievement in chemical stoichiometry.

Conclusion

It is concluded that when students' self-esteem and quantitative ability are adequate, their achievement in stoichiometry is likely to be satisfactory. However, quantitative ability has more connections with students' achievement in stoichiometry in chemistry.

Recommendations

It is therefore, recommended that stakeholders in chemistry education should not relent in their efforts towards improving learning outcomes of secondary school students. Also, chemistry teachers should encourage students to improve their quantitative abilities and self-esteem by providing opportunities for practice and creating avenues for them to develop healthy beliefs in their capacities.

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