



Understanding Stoichiometry Achievement: A Predictive Analysis of Motivation and Attitude in Resource Constrained Secondary Schools

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Abstract

Students' persistent difficulties and low achievement in stoichiometry have continued to raise concerns about the role of motivational and attitudinal factors in learning abstract chemistry concepts in under-resourced secondary school settings. This study employed a predictive correlational design to examine the relationship between motivation and attitude on students' achievement in stoichiometry in resource-constrained secondary schools. Regression analyses were used for data analysis. The findings indicated that motivation is a significant and moderate predictor of students' achievement in stoichiometry, explaining 33.0% of the variance, while attitude exhibited a low yet statistically significant predictive effect, accounting for 14.0% of the variance. In the joint regression analysis, motivation emerged as the dominant predictor of stoichiometry achievement ($\beta = .514$), while attitude made a smaller but statistically significant contribution ($\beta = .128$), indicating that motivation explains more of the variance when both variables are considered together. It is therefore recommended that chemistry teachers and curriculum designers prioritise strategies that enhance students' motivation and attitude to improve achievement in stoichiometry.

INTRODUCTION

Stoichiometry is a foundational concept in chemistry that serves as a bridge between qualitative chemical principles and quantitative problem solving. It is often applied in analytical Chemistry where the relationship between the number of moles of reactant and products is shown in a balanced equation. According to Gongden and Bash (2025), stoichiometry refers to “the relationships between the amounts of reactants and products before, during and after chemical reactions”. It is an essential aspect of Chemistry that helps students balance chemical equations, understand the relationships between molecules, and solve problems in titrimetry, chemical equilibrium, numerical problems in chemical reactions, the amount and concentration of substances, and the calculation of reactant and product proportions. All of which are essential to advancing chemistry across many industries and their real-world applications.

However, despite its importance, stoichiometry has been reported as one of the most difficult concepts in Chemistry among secondary school students. Mandina and Ochonogor (2018) and Mohafa et al. (2022) stated that students' poor achievement and lack of understanding of stoichiometry are prompted by their perception of the concept as difficult and abstract. The Chief examiners' report of the West African Examination Council (2017-2022) in Nigeria identified the following chemistry concepts as areas of difficulty and abstract to students: stoichiometry, organic Chemistry, chemical equilibrium, chemical kinetics, and chemical reactions. Specifically, the reports reveal that students' poor performance in stoichiometry is caused by their lack of mathematical skills in calculating moles, oxidation numbers, molar masses, and in balancing chemical equations, as well as their inability to determine percentage purity and empirical formulae. According to Stott (2022) and Mohafa et al. (2022), students' poor achievement in this concept is also not limited to Nigeria and West Africa; it also occurs in South Africa and Lesotho, where even teachers struggle with stoichiometry concepts and calculations. There is a low pass rate among South African

high school students in Physical Sciences, particularly in chemistry content such as stoichiometry (Department of Basic Education subject report, 2020; Mullis et al., 2016). Grade 12 students exhibit difficulties in calculating moles, applying mole ratios, and identifying reactants (Department of Basic Education Report, 2019).

These persistent difficulties in stoichiometry and other abstract chemistry concepts must be understood within the broader realities of resource-constrained secondary school contexts. A resource-constrained school is characterised by limited infrastructure, large class sizes, poorly equipped laboratories, unstable power supply, and a limited number of teachers. These features, which could affect effective Chemistry instruction, are also reported in many developed countries of the world, including Nigeria (World Bank, 2018; United Nations Educational, Scientific and Cultural Organisation, 2017), thereby making meaningful learning unattainable. Therefore, a resource-constrained environment prevents teachers from using effective instructional strategies that could be useful for difficult concepts such as stoichiometry. Psychological factors, such as students' motivation and attitudes, become particularly important because they can help students achieve despite poor infrastructure (World Bank, 2018).

Beyond cognitive challenges, researchers increasingly emphasise the role of affective factors, especially motivation and attitude, in shaping students' academic achievement in chemistry. Motivation is the thrust that propels one towards achieving a goal. These can be biological, emotional, social, and cognitive forces that initiate, guide, and maintain goal-oriented behaviours (Cherry, 2026; Ryan & Deci, 2020). Operationally, motivation is a collection of biological and/or environmental elements that drive students' desire to succeed. It enhances a student's perseverance, success, and involvement in a course. Because of this, it is impossible to overlook the importance of motivation in education. A study by Ramirez (2024) found that motivation is a critical factor influencing students' academic achievement in chemistry when a context-based

instructional strategy is used. Ince (2023) emphasises that highly motivated students have a positive attitude towards learning chemistry, which leads to improved achievement. They observed that motivation enhances students' attention, engagement, interest, and effort, thereby promoting better comprehension of complex scientific concepts. Similarly, Self-determination theory proposes that for learning to take place, students' competence, autonomy and relatedness are supported (Deci & Ryan, 1985; Ryan & Deci, 2000). It explains that motivation enhances students' understanding and retention, develops a genuine interest in learning, and helps them become more resilient in facing academic challenges. However, there is ongoing controversy in the literature regarding the differential impact of motivation on student achievements. Njoki (2018) and Izuchi and Onyekuru (2017) reported, in separate studies, that students' motivational beliefs are significant predictors of academic achievement. However, Yoo and Marshall's (2022) findings contradict the aforementioned, as they found no significant relationship between motivation dimensions and students' academic achievement. Also, Othman et al. (2011) found that weak correlations exist between academic achievement and students' academic motivation. When instructional strategies and curriculum content are held constant, affective factors such as motivation and attitude have been acknowledged to influence students' achievement in Chemistry. For instance, within the context of stoichiometry, Gongden and Bash (2025) and Oyovwi and Otariho (2025) reported that hands-on and problem-based learning can significantly improve students' attitudes toward stoichiometry and their academic achievement.

Attitudes are an individual's complex blend of feelings, beliefs, and overall disposition towards a particular subject. Students' attitude, which can be positive or negative, according to Lipnevich et al. (2016), is an individual's evaluation towards learning objects, such as school subjects, beliefs, feelings, and predispositions to act in certain ways. In the context of Chemistry, a positive attitude manifests as students who are

genuinely interested in exploring the interactions of matter, its properties, uses, and applications in the natural world. It always promotes curiosity and connects daily activities to real-life problems. Students with a positive attitude, unlike those with a negative attitude, tend to engage with their peers and participate in practical activities with interest. Mao et al. (2021) assert that a positive attitude towards science predicts and enhances students' willingness to engage with challenging topics and to improve achievement and learning effort. However, there is controversy regarding the extent to which attitudes predict academic achievement. While several studies, including Mao et al. (2021) and Ince (2023), emphasise a strong correlation between positive attitudes and high achievement, Bureau et al. (2022) argue that this correlation is mediated or moderated by other factors like self-efficacy, motivation, classroom resources, and learning conditions. Hence, a positive attitude alone may not be sufficient to influence students' achievement unless supported by an adaptive and conducive learning environment. A systematic review and multilevel meta-analysis conducted by Vu et al. (2024) suggests that the relationship between attitudes and achievement is bidirectional rather than unidirectional, suggesting that causality may not be straightforward. This view introduces another layer of complexity, as it implies that students' initial attitudes and academic achievement may mutually influence each other over time.

Given these divergent findings, the correlation between motivation and attitudes on academic achievements in chemistry remains a topic of debate. Researchers agree that attitudes are a key factor, but there is no consensus on whether they directly predict achievement or interact with other variables. Consequently, further research is needed to clarify the nature and strength of this relationship, while accounting for the joint prediction of motivation and attitudes toward achievement in stoichiometry, a concept that has been shown to be difficult to establish with limited empirical evidence. Existing research on stoichiometry achievement has been conducted in relatively well-resourced educational environments or has adopted

experimental and quasi-experimental designs. There remains a notable gap in predictive studies that quantitatively examine how motivation and attitude jointly and independently explain variations in stoichiometry achievement among students in resource-constrained secondary schools. Moreover, the study, conducted in a resource-constrained context, adds another dimension to the argument and knowledge by underscoring the critical importance of psychological factors (motivation and attitude) in shaping students' academic achievement in settings characterised by limited educational resources. The study was guided by the following three null hypotheses:

1. Motivation does not significantly predict secondary school students' achievement in stoichiometry.
2. Attitude does not significantly predict secondary school students' achievement in stoichiometry.
3. Motivation and attitude do not jointly and significantly predict secondary school students' achievement in stoichiometry.

METHOD

The study was quantitative, using a predictive correlational design. This design, according to Creswell (2012), helps determine the extent to which an independent variable predicts a dependent variable by manipulating one or more variables. Specifically, this study used regression analysis to determine how motivation and attitude can singly and jointly predict students' achievement in stoichiometry.

The researcher selected students offering Chemistry in public schools in resource-constrained areas of the Aguata Education Zone, Anambra State, Nigeria. The students are in their first term (September to December) of senior secondary II (SSII) in the 2025/2026 academic session. A sample of 280 students was selected using multistage sampling procedures. Firstly, purposive sampling was used to select five resource-constrained schools from the Zone, as they have similar characteristics when compared to others. These schools were characterised by

the following features: inadequate resources, large class sizes, unstable power supply, and poor laboratory facilities. Then, a proportionate stratified random sampling was used to determine the number to be selected from each sampled school, while a simple random sampling was used to select eligible students from the schools. The students comprised 142 females and 138 males aged 14 to 18 years. An age mean of 16.31 and a standard deviation of 1.41 were established.

The following three instruments were used for data collection. They include the Stoichiometry Students Motivation Scale (SSMS), the Stoichiometry Students Attitude Scale (SSAS), and the Stoichiometry Achievement Test (SAT). Face and content validity were done by three experts, one each in Chemistry education, Psychology education, and Measurement and evaluation, who assessed the language, relevance, clarity and appropriateness of the items of the instruments. The Stoichiometry Students Motivation Scale (SSMS) was adapted from Glynn et al (2011). It consisted of 25 positively worded items on a four-point Likert scale: Strongly Agree (SA) = 4, Agree (A) = 3, Disagree (D) = 2, Strongly Disagree (SD) = 1. It was selected among other scales for its acceptable construct validity and reliability and has been used in the Nigerian secondary school context (Ezeanyagu et al., 2023). Moreover, the study conducted a contextual and cultural adaptation of SSMS, guided by Cruchinho et al. (2024), with three experts. Back translation was done by two language experts, after which the researcher organised the items for pilot testing. In addition, the validity of the original instrument was conducted using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), which revealed strong constructs and items, yielding fit indices of ($\chi^2/df = 2.77$, SRMR = 0.04, GFI = 0.93, CFI = 0.91, RMSEA = 0.07). The reliability indices of the adapted instrument, using Cronbach's alpha, ranged from 0.81 to 0.92; in the present study, 0.88 was established for the SSMS. Items such as "I like to do better than other students on science tests" and "understanding science will benefit me in my career" were reworded to "I like to perform better than other students in stoichiometry tests" and "understanding

stoichiometry will be beneficial to my future career” respectively. The highest possible score is 100, while the lowest score is 25. The Stoichiometry Students Attitude Scale (SSAS) was adapted from Kolawole and Kojigili (2015), which contained 22 items on a four-point Likert scale: Strongly Agree (SA)=4, Agree (A)=3, Disagree (D)=2, Strongly Disagree (SD)=1. Reverse scoring was ensured in negatively worded items. This scale was chosen among others because it was administered in Nigeria, and factor analysis confirmed its validity. The reliability of the original scale, as measured by Cronbach's alpha, was 0.937, while that of the present study was 0.86. Because the original instrument was developed for students' attitudes towards Mathematics, the items were reworded to align with the context of stoichiometry in chemistry. For example, “I enjoy learning stoichiometry,” and “I feel confident when solving stoichiometry problems” were used in the present study. The highest possible score is 88, while the lowest score is 22. Because SSAS had unequal total scores relative to other instruments, their scores were converted to 100% to enhance standardisation and effective correlation with the study variable. To measure students' achievement in stoichiometry, the researchers developed the SAT. The test comprised 50 multiple-choice questions with four options (A-D), covering key topics such as the mole concept (40%), balanced equations (24%), reactants and percentage composition (36%), as specified in the SSII chemistry curriculum. A table of specifications based on a modified Bloom's taxonomy was used to ensure content validity and appropriate cognitive coverage across remembering (32%), understanding (28%), applying (24%), analysing (6%), evaluating (6%), and creating (4%) levels. Each correct answer was assigned 2 marks, and each incorrect answer 0 marks. Consequently, 100% was the highest score, while 0% was the lowest. The internal consistency of the SAT was assessed using Kuder-Richardson (KR-20), yielding a reliability index of 0.89.

To ensure 100% data collection, the researchers used the on-the-spot technique to hand out the instruments to the students. This was done after obtaining ethical clearance from the Research Ethics Committee of the

Department of Science Education at Nnamdi Azikiwe University in Awka, Anambra State, Nigeria (REC/DSE/NAU/25/0117). They also got approval from the school principals and cooperation from the Chemistry teachers. Because the participants were minors, the researchers also obtained parental consent after getting the students' consent. The students were also informed of their right to withdraw from the study, and their anonymity was ensured.

Linear and multiple regression analyses were used for data analysis, following the interpretation of correlational coefficients (r) by Evan (1996): $r \leq .39 \rightarrow$ Low; $r = .40$ to $.59 \rightarrow$ Moderate; $r \geq .60 \rightarrow$ Strong. The researchers tested the hypotheses at the .05 level of significance.

RESULT AND DISCUSSION

The regression assumptions of the data used in this study were tested prior to the analysis. Using Shapiro-Wilk, the normality test showed that the data were normally distributed [SSMS ($W = .997$, $p = .940 > .05$), SSAS ($W = .995$, $p = .511 > .05$), and SAT ($W = .996$, $p = .661 > .05$)]. The Durbin-Watson values of 1.955, 1.995, and 1.966 (See Table 2, 4 and 6), which are close to the benchmark value of 2 were obtained, indicating that the residuals are independent and no evidence of autocorrelation exists (Field, 2018). The data for the three research questions also showed no influential outliers, as confirmed by the maximum Cook's distances of 0.038, .055, and .042 which are below the acceptable value of 1.0 (Field, 2018; Hair et al., 2019). The test for multicollinearity was conducted using tolerance, VIF, and condition index. The tolerance of the independent variables exceeded the recommended value of 0.1 for SSMS (.771) and SSAS (.771); the variance inflation factors (VIF) values were below the critical value of 10 for SSMS (1.296) and SSAS (1.296). In addition, the condition index in the collinearity diagnostics was below the threshold of 15 (SSMS = 11.022, SSAS = 13.086). These values indicate that there is no issue of multicollinearity in this dataset (Field, 2018;

Hair et al., 2019). The scatterplot of standardised residuals against standardised predicted values (Fig. 1) has randomly distributed residuals around zero, with no discernible funnel-shaped pattern or systematic pattern; hence, the assumption of homoscedasticity was satisfied. For the linearity assumption test, the scatterplots indicate positive and linear relationships between; SSMA and SAT (Fig. 2), and SSMS and SAT (Fig. 3).

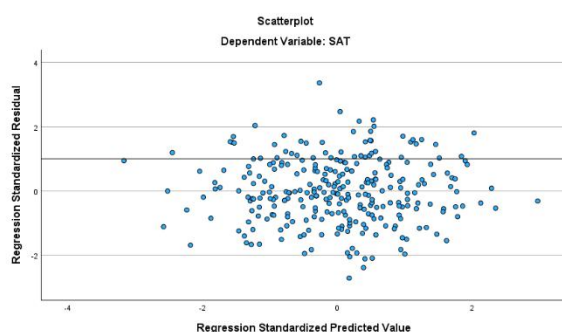


Figure 1. Scatterplot of standardised residuals versus standardised predicted values for the SAT.

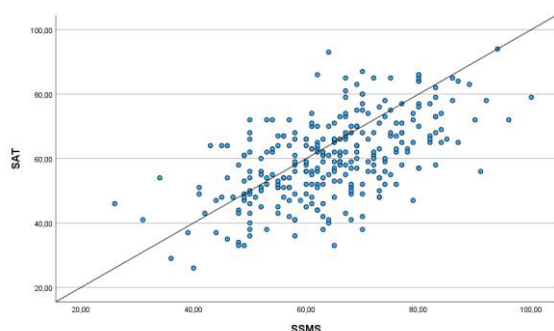


Figure 2. Scatterplot of the relationship between SSMS and SAT scores

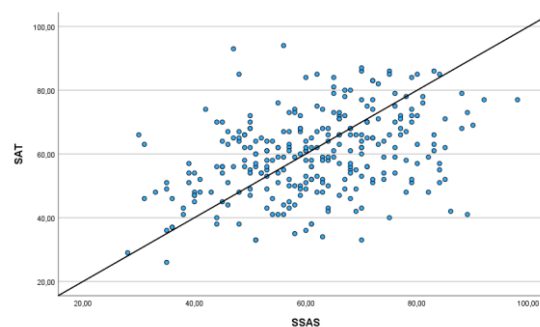


Figure 2. Scatterplot of the relationship between SSAS and SAT scores

The descriptive analysis of the study variables was done using mean and standard deviation, while the relationships among the study variables were determined using Pearson Product-Moment Correlation analysis, as shown in Table 1. Based on the midpoint of 50%, as the scores were all transformed to 100% prior to analysis. The students showed moderate and favourable values, with the highest mean motivation score ($M = 64.43$, $SD = 12.24$), followed by attitude ($M = 61.48$, $SD = 13.60$) and achievement ($M = 59.89$, $SD = 12.82$). The SD scores indicate greater variability among the attitude scores, followed by the achievement and motivation scores. Table 1 revealed significant positive relationships among motivation and attitude ($r = .478$, $p < .001$), motivation and achievement ($r = .575$, $p < .001$), and attitude and achievement ($r = .374$, $p < .001$).

The prediction of motivation on secondary school students' achievement in stoichiometry.

Table 2 reveals that motivation has a moderate positive relationship with students' stoichiometry achievement and accounts for 33.0% of the variance in achievement ($R = .575$; $R^2 = .330$). Moreover, the model showed that the prediction is statistically significant ($F = 137.202$, $p < .001$). Hence, motivation made moderate significant contribution to students' achievement in stoichiometry.

Table 1. Means, standard deviations, and correlations among study variables ($N = 280$)

Variable	M	SD	1	2	3
Motivation (SSMS)	64.43	12.24			

Attitude (SSAS)	61.48	13.60	.478**	
Achievement (SAT)	59.89	12.82	.575**	.374**

*M = Mean, SD = Standard deviation, ** = Correlation is significant at the 0.01 level (2-tailed).*

Table 2. Regression and ANOVA results for motivation predicting stoichiometry achievement

Model	R	R ²	Adj. R ²	Std. Error	Sum of Squares	df	F	Sig.	Durbin-Watson
1	0.575	0.330	0.328	10.50903	15152.566	1	137.202	<.001	1.955

Predictors: SSMS. Dependent variable: SAT. Decision: Moderate positive Relationship.

Table 3. Regression coefficients for motivation predicting stoichiometry achievement

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B
	B	Beta			Lower Bound Upper Bound
1 (Constant)	21.084		6.252	<.001	14.446 27.722
SSMS	.602	.575	11.713	<.001	.501 .704

a. Dependent Variable: SAT

The unstandardised coefficients, as shown in Table 3, also indicate that for every one-unit increase in motivation scores, students' stoichiometry score significantly increases by 0.602 units ($B = 0.602$, $\beta = 0.575$, $t = 11.713$, $p < .001$).

The prediction of attitude on secondary school students' achievement in stoichiometry.

In Table 4, Attitude shows a low positive relationship with students' stoichiometry achievement, accounting for 14.0% of the variance in achievement ($R = .374$; $R^2 = .140$). Additionally, the model showed that the prediction is statistically significant ($F = 45.108$, $p < .001$). Therefore, there exists a low but significant contribution of attitude on students' achievement in stoichiometry.

Table 4: Regression and ANOVA results for attitude predicting stoichiometry achievement

Model	R	R ²	Adj. R ²	Std. Error	Sum of Squares	df	F	Sig.	Durbin-Watson
1	0.374	0.140	0.137	11.91293	6401.586	1	45.108	<.001	1.995

Predictors: SSAS. Dependent variable: SAT. Decision: Low positive relationship.

Table 5. Regression coefficients for attitude predicting stoichiometry achievement

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B
	B	Beta			Lower Bound Upper Bound
1 (Constant)	38.244		11.585	<.001	31.746 44.742
SSAS	.352	.374	6.716	<.001	.249 .455

a. Dependent Variable: SAT

The unstandardised coefficients, as shown in Table 5, also indicate that for every one-unit increase in attitude scores, students' stoichiometry score significantly increases by 0.352 units ($B = 0.352$, $\beta = 0.374$, $t = 6.716$, $p < .001$). The Joint prediction of motivation and attitude on secondary school students' achievement in stoichiometry.

Table 6 reveals that motivation and attitude jointly have a moderate relationship with students' stoichiometry achievement, accounting for 34.3% of the variance in achievement ($R = .586$; $R^2 = .343$). Moreover, the model showed that the prediction is statistically significant ($F = 72.340$, $p < .001$). Hence, there is a significant composite

contribution of students' motivation and attitude to their achievement in stoichiometry. Moreover, the multiple regression analysis, while acknowledging that both motivation and attitude are significant predictors of students' achievement in stoichiometry, the magnitude of the standardised beta coefficient reveals that motivation ($\beta = .514$; $p < .001$) is a better predictor of students' stoichiometry achievement than their attitude ($\beta = .128$; $p = .022$). These findings therefore suggest that, even though students' positive attitude towards stoichiometry is essential, motivation plays a far more influential role in predicting achievement in stoichiometry, particularly when multiple predictors operate simultaneously.

Table 6. Regression and ANOVA results for joint prediction of motivation and attitude on stoichiometry achievement

Model	R	R ²	Adj. R ²	Std. Error	Sum of Squares	df	F	$\beta(t)$	Sig.	Durbin-Watson
1	0.586	0.343	0.338	10.42799	15732.984	2	72.340	.514(9.263) .128(2.310)	<.001 .022	1.966

Predictors: SSAS, SSMS. Variable: SAT. Decision: Moderate Positive Relationship. β : Standardised Beta Coefficient

Table 7. Regression coefficients for joint prediction of motivation and attitude on stoichiometry achievement

Model	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error				Lower Bound	Upper Bound
1	(Constant)	17.797	3.636	4.894	<.001	10.638	24.955
	SSMS	.538	.058	.514	9.263	<.001	.424 .653
	SSAS	.121	.052	.128	2.310	.022	.018 .224

a. Dependent Variable: SAT

The unstandardised coefficient, as seen in Table 7, indicates that motivation makes the largest and most significant contribution, compared with attitude, to explaining achievement in stoichiometry. Thus, for every one-unit increase in motivation (holding attitude constant), students' achievement increases by 0.538

units, while that of attitude increases by 0.121 when motivation is controlled.

The study found a moderate positive relationship between motivation and secondary school students' academic achievement in stoichiometry, with 33.0% of the variation in stoichiometry achievement attributable to motivation. Further analysis

showed that motivation significantly predicts students' achievement in stoichiometry. This implies that motivation significantly contributed to secondary school students' academic achievement in stoichiometry. Motivation helps students develop a genuine interest in learning, enhances autonomous learning, and makes them goal-oriented in improving their academic achievement. Highly motivated students tend to develop a positive attitude toward learning, participate actively in class, spend more time studying, and complete assignments on time, thereby reducing anxiety and increasing confidence. According to the self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000), students develop personal satisfaction, a deeper understanding and improved retention when they are motivated. This is because motivated students are more resilient and ready to conquer any academic challenges to improve their learning outcomes. The findings of Ramirez (2024) align with those of the present study, which showed a significant association between students' motivation and achievement in stoichiometry and gas laws when taught using context-based instructional strategies. Similarly, Njoki (2018) and Izuchi and Onyekuru (2017) averred that there is a significant correlation between secondary school students' motivational beliefs and their academic achievement. A study by Koroka et al. (2023) also found a significant positive relationship between Biology teachers' self-motivation and students' achievement in the subject. A systematic review by Chestnut and Johnson (2025), while acknowledging that differences in students' affective variables, demographic, participation and achievement levels could affect their achievement in chemistry, reported that active learning environments and motivation are significant predictors of students' academic success. These findings suggest that motivated students are likely to overcome conceptual difficulties, engage in quantitative chemical reasoning and can persist in multi-step calculations. Therefore, in

resource-constrained secondary schools, teachers and educational stakeholders should develop interventions that improve students' self-belief, engagement and perceptions of stoichiometric to reduce the negative effects of resource constraints on achievement.

The findings of the study showed a low positive relationship between attitude and secondary school students' academic achievement in stoichiometry, with 14.0% of the variation in students' academic achievement accounted for by attitude. Moreover, further analysis showed that attitude significantly predicts secondary school students' achievement. This implies that attitude significantly contributed to secondary school students' academic achievement in stoichiometry. Attitude ensures that students are resilient learners who bounce back from academic challenges and setbacks. It also fosters confidence and motivates students to learn. Students with a positive attitude tend to reduce their anxiety toward stoichiometry, effectively apply problem-solving strategies, and improve their willingness to attempt complex calculations. It also improves their understanding of stoichiometry, thereby increasing cognitive effort and reasoning ability for effective calculations, particularly in schools with limited infrastructure and large class sizes. The findings of Gongden and Bash (2025) suggested a link between a strong attitude and students' achievement in stoichiometry, as significant improvements in both were observed when students were taught using a problem-based learning approach. This finding aligns with Kenni et al. (2024), who reported a significant positive correlation between students' attitudes and academic achievement in science subjects. Fareo (2019) agrees that the higher the students' positive attitude towards science, the more likely they are to achieve better academic results. Moreover, though the findings of Omilani and Ajayi (2023) reported that affective variables such as emotional intelligence and attitude are not significant predictors of students'

achievement in stoichiometry, they acknowledged that both together with cognitive variables (logical thinking ability, and mathematical ability) have a significant composite contribution to students' stoichiometry achievement.

The study's findings showed that there is a moderate positive joint relationship between motivation and attitude in secondary school students' stoichiometry achievement, with 34.3% of the variation in students' stoichiometry achievement attributable to these factors. The multiple regression model showed that, when combined with motivation, attitude explained 12.8% of the variance in students' achievement in stoichiometry, while motivation explained 51.4%, indicating that the predictive effect of attitude overlaps with that of motivation. Hence, making motivation the stronger and more influential predictor of students' achievement in stoichiometry. Moreover, further analysis showed a significant joint prediction of motivation and attitude for secondary school students' academic achievement in stoichiometry. This implies that both motivation and attitude contributed significantly to secondary school students' academic achievement in stoichiometry, with motivation exerting a stronger influence. Moreover, both motivation and attitude help enhance students' creativity, mindset, well-being, and persistence. A positively motivated student develops a good attitude, which encourages active participation in the classroom, reinforces confidence, improves reasoning during calculations, and is crucial for success in stoichiometric problem-solving. This finding is consistent with those of Kenni et al. (2024) and Fareo (2019), who found that both motivation and attitude are significant predictors of secondary school students' academic achievement. The factors that influence students' attitudes and motivation towards studying, in the words of Fareo (2019), include parental encouragement, access to books, peer interaction, effective assessment, and teachers' punctuality, which are often

lacking in resource-constrained areas. Moreover, Richardson et al. (2012) reported, in their systematic review and meta-analysis, that, in addition to cognitive ability, students' achievement can be explained by motivation and other affective constructs. Hence, the government should make the provision of academic resources and a good learning environment its priority to enhance students' academic outcomes. Also, the teacher should prepare Chemistry lesson plans, including stoichiometry, that improve students' motivation and attitude towards the subject.

CONCLUSION

The study investigated the predictive effect of motivation and attitude on secondary school students' achievement in stoichiometry. The study established that motivation and attitude significantly predict students' academic achievement in stoichiometry. Also, motivation and attitude showed a significant association with students' academic achievement in stoichiometry. This implies that an increase in students' motivation and attitude towards stoichiometry is associated with their higher achievement in the subject. Hence, the researchers encourage students to develop a positive attitude towards studying Chemistry. Although, the study is limited by its predictive correlational design, the major significance of the study's findings lies in their empirical confirmation that affective factors, specifically motivation and attitude, are strongly associated with learners' achievement in complex scientific concepts such as stoichiometry, thereby reinforcing the integration of the cognitive and affective domains in science education. Based on these findings, the researchers recommended that Chemistry teachers adopt a learner-centred pedagogy to enhance students' affective domains through a supportive learning environment, active participation, peer collaboration, and guided problem-solving. Teachers in resource-constrained secondary schools should be provided with training and

targeted professional development to equip them with the strategies needed to enhance students' motivation and attitudes. Locally improvised learning materials can also be created to teach chemistry concepts under constrained conditions. Moreover, informed policy and targeted interventions through school psychologists should be developed to promote not just Chemistry achievement but also achievement in other school subjects, particularly in under-resourced contexts and in future classrooms.

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