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Research Article

Patterns of Teacher-Student Interaction in Relation to Chemistry Achievement in Science Secondary Schools of Kano-Nigeria

Victor Tubosun Babalola[1], Awaisu Umar[2], Halima Sani Tafida[3]

[1]Department of Science Education, Yusuf Maitama Sule University, Kano, Nigeria
[2]Department of Social Science Education, Yusuf Maitama Sule University, Kano, Nigeria
[3]Department of Science Education, Sule Lamido University, Kafin Hausa, Nigeria

Abstract
The pattern of interaction is a live construct which explains the medium or mode of sharing knowledge of the subject matter and related issues in an academic environment. Recently, the pattern of interaction has been held responsible as one of the causes of poor achievement in chemistry and in sciences in general. Consequently, the present study investigates the teacher-student interaction modes such as ICT utilization, students' motivation, diagrams-enhanced discussion, mnemonics-enhanced tutorial, and instructional materials in relation to students' learning variables such as perception, interest, attitudes, laboratory attendance, and test scores for Chemistry Achievement in Science Secondary Schools of Kano-Nigeria. The research design used is correlational research design. A sample of 346 students was drawn through simple random sampling techniques from the study population of 3,071 students. Two instruments of data collection used in the study include; the questionnaire entitled; Teachers' Patterns of Interaction in Relation to Chemistry Achievement Questionnaire (TMIRCAQ), with a reliability coefficient of 0.88 and Chemistry Achievement Test with a reliability coefficient of 0.96. Method of data analysis used include; simple percentage, mean of the descriptive statistics and Spearman's Rank Order correlation statistics. The results show a significantly positive correlation between ICT utilization, students' motivation, mnemonics- tutorial, instructional Materials, and diagram based discussion patterns of interaction with chemistry achievement. The study recommends the use of ICT, diagram based discussion, mnemonics tutorials, instructional materials and students' motivation patterns of interactions for all teachers to improve students' achievement in chemistry.

Keywords: Chemistry Education, ICT Utilization, Interactive Patterns, Instructional Materials, Students' Motivation, Teaching and learning

Correspondence
Victor Tubosun Babalola
lolababa85@ymail.com

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1. INTRODUCTION

Chemistry is the central science subject taught at the senior secondary school level. It deals with the scientific study of elements that make up matter to the compounds composed of atoms, molecules and ions (Afyusisye & Gakuba, 2022). Chemistry also studies the compositions, structures, uses and reactions of substances in our environment (Ali, Babalola & Ibrahim, 2023). The study of chemistry does not only enhances diligence in the learners, but also patience, objectivity, critical thinking and respect for multidimensional opinions of different people. These habits when learnt may help solve daily problems and resolve many social issues including religious and interethnic intolerance bedeviling Nigeria and many other developing nations (Dasi, 2019). However, the teaching and learning of chemistry for scientific enterprise facilitated by skillful teachers is capable of preparing students for successful vocations and career trajectory needed for a credible lifestyle (Babalola, 2023b). Chemistry curriculum has also been designed to develop positive scientific world view in learners towards chemistry and science in general using innovative teaching methods such as context based approach and mnemonics instructional strategy (Babalola, 2022). However, despite the central roles that Chemistry has been playing in science disciplines and its relative increasing

importance to mankind, students' achievement in the subject has been reported a dismal failure (Saage, 2019). This is evident in Table 1, which shows that among the 4,507 students who sat for West African Examination Council (WAEC) between the years 2016 and 2019, only 2,100(46.56) passed the subject. This constitutes the 53.41% failure rate in chemistry among the science students in Kano State of Nigeria.

Table 1. WAEC Chemistry Achievement in Science Schools in Kano (2016-2019)

Years	No of Stud. Sat	No. Passed	No Failed	% Passed	% Failed
2016	983	483	500	49.1%	50.9%
2017	907	306	601	33.7%	66.3%
2018	1201	697	504	58.0%	42.0%
2019	1416	614	802	43.4%	56.6%
Total	4,507	2,100	2,407	46.59%	53.41%

Source: Kano State Science and Technical Schools Board (2024)

Many factors have been held responsible for the failure. This include the abstract nature of chemistry and excessive use of teacher-centered teaching method (Babalola, 2021), lack of students' motivation, abstract nature of chemistry, multiple representation in which students have to deal with learning macro, sub-micro, symbolic and process contents of chemistry and calculation nature of chemistry(Babalola, 2024). One of the most uncommonly mentioned factor among scholars as a cause of underachievement in chemistry is the poor pattern of teacher-students' interaction. For instance, Ogundare (2019), found in his study that teacher's talking was predominantly higher than student-talking during the teacher-students interaction in the classroom, making the teacher active participant while the students passive recipients. But the study was silent on the mode of teacher–students' interaction used, which is the gap, the present study seeks to fill in the body of the existing literature.

1.1. Literature Review

A more comprehensive review of literature has also found that not only in Nigeria but globally, more factors have been suggested contributing to the pitiable performance of students in chemistry. These include; difficult perception of chemistry topics (Musengimana, Kampire, &Ntawiha, 2021), Chemical anxiety and lack of mindfulness (Babalola, 2023c), Lack of pre-requisite knowledge and poor conceptual understanding (Swoope, 2019) and bad pattern of teacher-student interaction (Ogbasi, & Madichie, 2020).

Nevertheless, the Self Determination Theory (SDT) has acknowledged the significance of teacher-student interactive patterns. It argues that individuals have three basic psychological needs which are the needs for relatedness, autonomy, and competence (Ryan & Deci, 2020). Specifically, relatedness refers to the human tendency in wanting "to feel connected to other people for care" which is a powerful motivation itself. Students who feel connected and supported by their teachers and ICT gadjets are more likely to learn better. Also students who are comfortable with their teachers may easily achieve more in classroom and in life (Koen 2018). Therefore, to achieve effective teacher-student interaction that can promote students' learning variables, teachers need awareness of the students' uniqueness such as learning styles, socio-economic background, academic backgrounds, academic ability and favourable patters of interaction.

In this study, the patterns of interaction considered include; ICT utilization, Students Motivation, diagrams-enhanced discussion, Mnemonics-enhanced Tutorial, and Instructional Materials. These mode of teachers' relating with students is one of the most important features in the context of learning, affecting students' development, school engagement and motivation to learn (Spilt, Koomen & Thijs, 2016; Roorda et al. 2019). In a similar perspective, all science teachers are counselor and their supportive counseling relationships with students ultimately promote a sense of school belonging and encourage students to participate cooperatively in classroom activities (Babalola, 2022).

One positive aspect of this perception is that good relationships between students and teachers are essential for development of students in school (Hughes & Chen, 2017). Therefore, both in and outside the classroom and laboratory setting interaction is a live construct for the investigation which enhances the coordination and minimizes the understanding gap between teacher and students (Sajjad, Siddique &Tufail, 2022). As earlier discussed, interaction pattern can be defined as a live construct which explain the medium or mode of sharing knowledge of the subject matter in an academic environment. The pattern/modes are

presented in Figure1. A healthy relationship with teachers enables students to work on their own and talk to teachers in time of difficulty as they know that teachers will recognize and respond promptly. Also, as soon as students enter the school setting, relationships with teachers provide for successful adjustment to the academic environment (Hughes & Chen, 2017).

Figure 1, explain teaching as a triadic process in chemistry classroom involving Teacher and students interacting or sharing chemistry concepts as the subject matter.

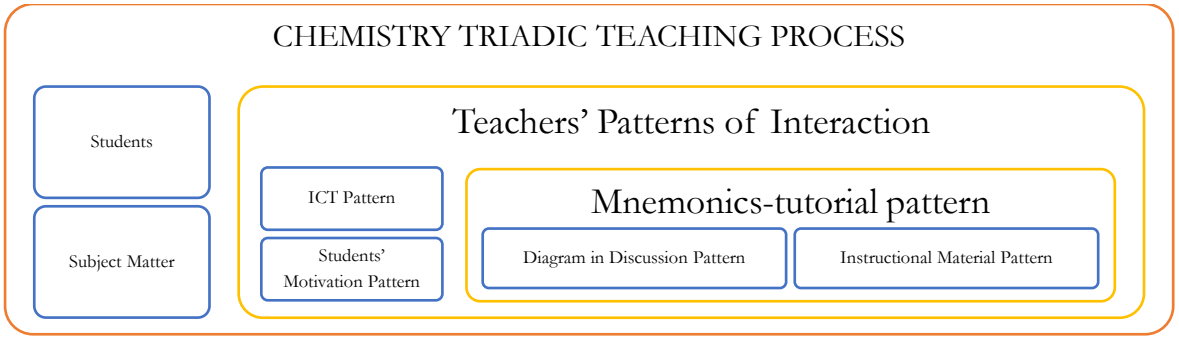

Figure 1. Patterns of Interaction Model in a Triadic Process of Teaching

This Figure 1, further revealed how important the teacher-students' interaction patters is as a medium of sharing chemistry knowledge contents in and outside the classroom environment.

As reported by Christiansen (2016), teachers have an important role to play in shaping the students' academic achievements in that teacher's mode of interaction is considered an important aspect for various reasons. Teachers who had a positive interaction with their students reported that their students had better attendance, participated and more attentive in the classroom. Effective teachers' interaction has also been discovered resulted in positive classroom environment which promotes the learning and growth of students positively (Zhang, 2019). Similarly, the involvement of faculty members and teachers in their student's academic growth resulted in tremendous increase in their academic and professional development (Cornelius-White, 2007). It has also been reported by Nugent (2019), that if educators take step and time to shape their patterns of interactions, they may encourage learners to acquire knowledge. Effective mode of teachers' interaction could be used as a tool to make instructors make learning environment a good place for learners to be, more active and well performed (Churchill et al., 2017). However, in the past decades, research on student-teacher interaction has focused on the ways and manner in which interactions affect students' peers, parent-students relationships, academic competence, and social-emotional adjustment (Pianta, Hamre, & Stuhlman, 2017). But the current study focuses on bridging the gaps in teacher-students' patterns of interaction in relation to students' learning variables for academic achievement in chemistry. To achieve this, five research questions and their corresponding null hypotheses were tested to guide the study.

2. METHODS

In Chemistry Education Research (CER), there are three methods otherwise approaches to research. These include; qualitative approach, quantitative approach and mixed method research approach. The qualitative research approach does not entertain the numerical evaluation of the research variables being investigated, while the quantitative paid premium attention to the numerical evaluation of the research variables. On the contrary, mixed method approach tends to combine the two aforementioned research approaches. Specifically, the present study adopts the quantitative approach methodology.

2.1. Research Design

Among other quantitative research approach such as quasi-experimental design, survey design, causal comparative design, the correlational research design has been selected for this study. Since the questionnaires were administered to students to seek their opinions and used to establish the relationship between the patterns of interaction and Chemistry achievement, the design may be called correlational survey research design.

2.2. Participants

A sample of three hundred and forty six (346) students participated in the study. This sample was drawn from the study population of 3,071 students using simple random sampling techniques. The study population were sourced from the five senior secondary Schools in the study area as recommended by the Cochran formula of sample size determination described in (Babalola, 2023a).

2.3. Research Instruments

Two research instruments are used for data collection. These include; a self-designed questionnaire entitled Teachers' Patterns of Interaction in Relation to Chemistry Achievement Questionnaire (TMIRCAQ). This questionnaire was designed in 4-point scale of Strongly Agree, Agree, Disagree and Strongly Disagree rating 4, 3, 2 and 1 respectively. The decision cut-off point=4+3+2+1=10/4=2.50 was compared with the grand mean to answer research questions. The reliability of the questionnaire was calculated as 0.88 using split-half method. The second instrument is Chemistry Achievement Test (CAT) with a reliability coefficient of 0.955 using a test-retest method and Pearson's Product Moment Correlation (PPMC). The instruments which made up of WAEC past questions of chemistry are validated by experts in Test and measurement and Science Education from Yusuf Maitama Sule University, Kano and Sule Lamido University, Kaffin-Hausa.

2.4. Procedures

The authors obtained permission from Kano State Science and technical school boards. The permission letter was taken to the Principals of the sampled schools who introduced the researchers to the students. The researchers introduced themselves to the students, solicited for their cooperation before administering the instruments to them personally.

2.5. Data Analysis

The data collected are analyzed using frequency count, simple percentage, mean and Spearman's Correlation statistics. The research questions are answered using simple percentage and mean of the descriptive statistics. The null hypotheses are also tested using spearman correlation coefficient at 0.05 significant level.

3. RESULTS

Research Question One: How does ICT mode of teacher's interaction relates with academic achievement in chemistry in science secondary schools, Kano?

This research question was answered using mean of the descriptive statistics as shown in Table 2.

Table 2. ICT Pattern of Interaction and students' Achievement in Chemistry

S/N	Items	SA (%)	A (%)	D (%)	SD (%)	Mean
1.	ICT pattern of teacher's interaction improves Chemistry test scores.	158 (45.7)	133 (38.4)	35 (10.1)	20 (5.8)	3.24
2.	ICT pattern of teachers' interaction improves students' interest towards Chemistry for academic performance.	139 (40.1)	140 (40.5)	45 (13.0)	22 (6.4)	3.14
3.	ICT pattern of teachers' interaction improves classroom and laboratory attendance for chemistry achievement.	157 (45.4)	117 (33.8)	42 (12.1)	30 (8.7)	3.18
4.	ICT pattern of teachers' interaction improves students' perception of chemistry for academic achievement.	144 (41.6)	135 (39.0)	33 (9.5)	34 (9.8)	3.12
5.	ICT mode of teachers' interaction improves students' attitudes towards practical chemistry for better scores.	138 (39.9)	140 (40.5)	46 (13.3)	22 (6.4)	3.14
	Grand Mean(Xcal)					3.164

Source: Field Survey, 2024

In Table 2, since the grand mean Xcal of 3.164 >2.50, it can be deduced that ICT mode of interaction improves students' academic achievement in chemistry among science secondary school students in Kano state Nigeria. However, the next Table 3, shows the significance or otherwise of the relationship between ICT mode of interaction and academic achievement in chemistry analysed using the Spearman's correlation.

Table 3. ICT Interaction and Mean Achievement Scores in Chemistry

Statistics Variables			**IMT1**	**SCA**
Spearman's rho	ICT Mode of Teachers Interaction (IMTI)	Correlation Coefficient	1.000	.978
		Sig. (2-tailed)	.	.000
		N	346	346
	Students' Chemistry Achievement (SCA)	Correlation Coefficient	.978	1.000
		Sig. (2-tailed)	.000	.
		N	346	346

N=346; Grand Mean (X=3.164); (rho=0.978), P-Value=0.00, sig level=0.05

Since Table 3, shows a strong positive rho of 0.978, and P-value of 0.000(P<0.05) the null hypothesis; there is no significant relation between ICT pattern of interaction and Chemistry achievement is rejected.

Research Questions Two: How does students' motivation pattern/mode of teacher's interaction relates to students' academic achievement in chemistry?

This research question two was answered using mean of the descriptive statistics as shown in Table 4.

Table 4. Motivational Pattern of Interaction and Chemistry Achievement

S/N	**Items**	**SA (%)**	**A (%)**	**D (%)**	**SD (%)**	**Mean**
1	Motivation is a strategic way of boosting test scores in chemistry.	138 (39.9)	131 (37.9)	45 (13.0)	32 (9.2)	3.08
2	Clapping for students for contributing to classroom discussions improves students' perception of chemistry topics.	135 (39.0)	142 (41.0)	40 (11.6)	29 (8.4)	3.11
3	Discouraging laughing, when students answer questions improves students' interest towards chemistry learning.	159 (45.9)	137 (39.6)	30 (8.7)	20 (5.8)	3.26
4	Gifting outstanding students, promotes positive attitudes towards Chemistry.	143 (41.3)	132 (38.1)	46 (13.3)	25 (7.2)	3.14
5	Motivation improves students' laboratory practical engagement.	136 (39.3)	140 (40.5)	48 (13.9)	22 (6.4)	3.13
	Grand Mean(X)					3.14

Source: Field Survey, 2024

As shown in Table 4, since the grand mean Xcal of 3.164 is greater than 2.50, students' motivation patterns of teachers interaction improves academic achievement in chemistry. The null hypothesis on the significant relation or otherwise between Students Motivation and chemistry achievement is in Table 5.

Table 5. Motivation Pattern and mean Chemistry achievement Chemistry

Statistics Variables			SM	SCA
Spearman's rho	Students' Motivation (SM)	Correlation Coefficient	1.000	.814
		Sig. (2-tailed)	.	.000
		N	346	346
	Students' Chemistry Achievement (SCA)	Correlation Coefficient	.814	1.000
		Sig. (2-tailed)	.000	.
		N	346	346

N=346; Grand Mean (X=3.14); (rho=0.814), P-Value=0.00, sig level=0.05

As presented in Table 5, showing rho of 0.814, and p-value< 0.05, the null hypothesis which states that; "there is no significance relation between students' motivation and students' achievement in chemistry" is rejected.

Research Questions Three: How does mnemonics-enhanced tutorial mode of teacher-student interaction relates to academic achievement in chemistry?

This research question three was answered using mean of the descriptive statistics as shown in Table 6.

Table 6. Mnemonics-Tutorial Interaction and Chemistry Achievement

S/N	Items	SA (%)	A (%)	D (%)	SD (%)	Mean
1	The use of mnemonics-tutorial encourages studying in group for improve test scores.	129 (37.3)	131 (37.9)	45 (13.0)	41 (11.8)	3.01
2	The use of mnemonics-tutorial help slow learners to learn chemistry better.	130 (37.6)	144 (41.6)	40 (11.6)	32 (9.2)	3.08
3	The use of mnemonics-tutorial simplifies Chemistry teaching for better interest.	161 (46.5)	142 (41.0)	30 (8.7)	13 (3.8)	3.30
4	The use of Mnemonics-tutorial ease students' stress and promote positive attitudes towards Chemistry practical.	120 (34.7)	132 (38.1)	46 (13.3)	48 (13.9)	2.93
5	The use of mnemonics-tutorial improve students' retention for better test score.	135 (39.0)	139 (40.2)	48 (13.9)	24 (6.9)	3.11
	Grand Mean(X)					3.086

Source: Field Survey, 2024

As shown in Table 6, the grand mean Xcal of 3.086 is greater than 2.50. This is an indication that Mnemonics Tutorial mode of teacher-student interaction enhances chemistry achievement.

However, to investigate the significance or otherwise of the relation, the corresponding null Hypothesis (HO_3) which state that; there is no significant relation between Mnemonics-Tutorial pattern and students' achievement in chemistry in science secondary schools of Kano state is tested in Table 7.

Table 7. Mnemonics-Tutorial Pattern and Chemistry Achievement

Statistics Variables			**MTM**	**SCA**
Spearman's rho	Mnemonics-Tutorial Mode (MTM)	Correlation Coefficient	1.000	.802
		Sig. (2-tailed)	.	.000
		N	346	346
	Students' Chemistry Achievement (SCA)	Correlation Coefficient	.802	1.000
		Sig. (2-tailed)	.000	.
		N	346	346

No. of stud. =346; Grand Mean (X=3.086); rho=0.802, P-Value=0.00

Since the rho is 0.802 and P-value< 0.05, the Null Hypothesis is rejected.

Research Questions Four: How does instructional materials mode of teacher's interaction relates with students' chemistry achievement in science secondary schools of Kano state, Nigeria?

This research question four was answered using mean of the descriptive statistics as shown in Table 8.

Table 8. Instructional Material Pattern and Chemistry Achievement

S/N	**Items**	**SA (%)**	**A (%)**	**D (%)**	**SD (%)**	**Mean**
1	Instructional material enhance teaching and learning for chemistry achievement.	137 (39.6)	133 (38.4)	65 (18.8)	11 (3.2)	3.12
2	Instructional materials improve students multiple representation of chemistry.	149 (43.1)	144 (41.6)	40 (11.6)	13 (3.7)	3.24
3	Instructional materials improve students Chemistry interest and attitudes.	131 (37.9)	140 (40.5)	50 (14.4)	25 (7.2)	3.09
4	Instructional materials improves students' classroom and laboratory attendance.	120 (34.7)	132 (38.1)	46 (13.3)	48 (13.9)	2.94
5	The use of instructional materials improve students' perception of chemistry topics.	155 (44.8)	147 (42.5)	30 (8.7)	14 (4.0)	3.28
	Grand Mean(X)					3.13

Source: Field Survey, 2024

As presented in Table 8, since the grand mean Xcal of 3.13 > 2.50, it is an indication that Instructional Material pattern of interaction enhances the teaching and learning process for academic achievement in chemistry. The significant of this relation is examine in the corresponding Hypothesis in Table 9;

Table 9. Instructional Material Pattern and Chemistry Achievement

Statistics Variables			**IMM**	**SCA**
Spearman's rho	Instructional Material Mode (IMM)	Correlation Coefficient	1.000	.978
		Sig. (2-tailed)	.	.000
		N	346	346
	Students' Chemistry Achievement (SCA)	Correlation Coefficient	.978	1.000
		Sig. (2-tailed)	.000	.
		N	346	346

Stu=346; Grand Mean (X=3.13); rho=0.978, P-Value=0.00, sig level=0.05.

As indicated in Table 9, since the rho of 0.978 and P-value of 0.00<0.05 are found in this hypothesis tested, the null hypothesis is rejected, there is a significant positive relation between Mnemonics-tutorial mode of teacher's interaction and students academic achievement in chemistry in science secondary schools Kano state.

Research Questions Five: How does diagram-enhanced discussion mode of teacher's interaction relates with students' academic achievement of chemistry in science colleges?

This research question was answered using mean of the descriptive statistics as shown in Table 10.

Table 10. Diagrams in Discussion Pattern and Chemistry Achievement

S/N	**Items**	**SA (%)**	**A (%)**	**D (%)**	**SD (%)**	**Mean**
1	The use of diagrams in discussion improves classroom participation.	139 (40.2)	141 (40.7)	35 (10.1)	31 (8.9)	3.12
2	Using diagrams in discussion simplify learning for better test score in chemistry	124 (35.8)	130 (37.6)	50 (14.4)	42 (12.1)	3.05
3	The use of diagrams in discussion patterns ease stress in chemistry practical labs.	128 (37.0)	137 (39.6)	50 (14.4)	31 (8.9)	3.05
4	Diagrams in discussion patterns improve students' perception of chemistry.	158 (45.7)	142 (41.0)	30 (8.7)	16 (4.6)	3.28
5	Diagrams in discussion patterns attracts students interest to learning Chemistry	135 (39.0)	133 (38.4)	48 (13.9)	30 (8.7)	3.08
	Grand Mean(X)					3.12

Source: Field Survey, 2024

A shown in the Table 10, since the grand mean Xcal of 3.12 was found to be greater than 2.50, it can be deduced that diagram-enhanced discussion mode of interaction improves the teaching and learning of chemistry and academic achievement in chemistry among the students. To establish the significance or otherwise of the relation, the corresponding null Hypothesis which states that; there is no significant relation of diagram-discussion pattern with chemistry achievement is tested in Table 11.

Table 11. Diagrams in Discussion Pattern and Chemistry Achievement

Statistics Variables			**DDM**	**SCA**
Spearman's rho	Diagram in Discussion Mode (DDM)	Correlation Coefficient	1.000	.852
		Sig. (2-tailed)	.	.000
		N	346	346
	Students Chemistry Achievement (SCA)	Correlation Coefficient	.852	1.000
		Sig. (2-tailed)	.000	.
		N	346	346

No. of students=346; Grand Mean (X=3.12); rho=0.852, P-Value=0.00, sig level=0.05.

As shown in Table 11, since the rho of 0.852 and P-value of 0.00<0.05 are found, the null hypothesis is rejected. That is, there is a significant positive relation between diagram-discussion mode of teacher-student interaction and students academic achievement in chemistry.

4. DISCUSSION

This study revealed that the use of ICT pattern of interaction improves students' learning variables for chemistry achievement in science secondary schools of Kano State, Nigeria. The results further indicated that; ICT utilization pattern of teacher-students' interaction enhances; Chemistry test scores (x=3.24>2.50 and 45.7% strongly agreed), students' interest and students' attitude towards Chemistry (x=3.14>2.50 and 40.1% strongly agreed), attendance and participation in chemistry classrooms (x=3.18>2.50 and 45.4% strongly agreed), students' perception of chemistry topics for better performance (x=3.12>2.50 and 41.6% strongly agreed) and chemistry laboratory attendance and practical test score(x=3.14>2.50 and 39.9% strongly agree). This finding agrees with Babalola, Ahmad & Sani (2024) who discover that AI ChatGPT has positive impact on students' learning variables for academic achievement in a conducive social environment. This may be because ICT utilization provides opportunity for collaboration and individual differences such as visual, audio and audio-visual learning styles.

Similarly, students' motivation mode of interaction enhances students learning variables for Chemistry achievement among students of science secondary schools. The results revealed that students' motivation is a strategic way of boosting students' academic performance (x=3.08>2.50 and 39.9%>9.2) and showed that students' motivation improved students' perception of chemistry topics (x=3.11>2.50 and 39% >8.4%), students' punctuality and classroom participation (x=3.26>2.50 and 45.9%> 5.8%), students' test score(x=3.14>2.50 and 41.3%>7.2%) and students' laboratory practical engagement(x=3.13>2.50 and 39.3%>6.4%). This finding agrees with that of Nugend (2019) who finds that, teachers who provided appropriate resources and assistance to students meet their students' needs beyond academic instructions. This results may be because students' motivation is a strategy which provides both intrinsic and extrinsic extra energy and encouragement for students in the academic environment.

Another study also revealed that, the use of Mnemonics-enhanced tutorial mode of teacher-students' interaction improves the teaching and learning of chemistry and other students' learning variables for academic achievement in science secondary schools of Kano State. As seen in Table 6, the results show that; mnemonics-tutorial encourages students to study in group and enhance test scores (x=3.01>2.50 and 37.3%>11.8%), help the slow-learners to learn chemistry better with keen interest and positive attitudes (x=3.08>2.50 and 37.6%>9.2%), simplifies Chemistry teaching and learning process with positive perception of chemistry topics (x=3.30>2.50 and 46.5%>3.8%), ease students' stress in chemistry practical laboratory and improve students' laboratory attendance and participation (x=2.93>2.50 and 34.7%>13.9%) and students' retention and test score(x=3.11>2.50 and 39.0%>6.9%). This finding agrees with that of Babalola (2023c) which reveal a significant effect of mnemonics-enhanced tutorial on students' academic achievement and mindfulness among university students. This finding may be because mnemonics gives students opportunity to retain knowledge content better by relating chemistry content with daily activity and other familiar things. Tutorials also give students opportunity to work in group, collaborate and share knowledge with peers.

This research shows further that the use of instructional materials pattern of teacher-student interaction in chemistry teaching improves students' perception, laboratory participation, interest, and attitudes towards learning and test scores for better chemistry achievement in science secondary schools of Kano State. The results in Table 8, shows that Instructional material patterns of teacher-student interaction improves; chemistry achievement (x=3.12>2.50 and 39.6%>3.2%), students multiple representation of chemistry concept and test scores(x=3.24>2.50 and 43.1%>3.7%), Chemistry test scores (x=3.09>2.50 and 37.9%>7.2%), help teacher to better demonstrate knowledge to students(x=2.94>2.50 and 34.7%>13.9%). It also improves students' perception of chemistry (x=3.28>2.50 and 44.8%>4.0%). This finding corroborates with Hanum (2020), whose result indicated that effective interaction in classroom does not only impact learning process by increase students' language and performance but also improved the teacher's teaching process in the classroom. This may be due to the fact that instructional materials provides support for teachers in the classroom and appeal to learners' senses such as eyes, ear and skin.

Another result of this research reveals that, relevant diagrams in chemistry discussion pattern of interaction improve students' learning variables such as perception, interest, attitudes and chemistry test scores for better performance in chemistry among students of science secondary schools in Kano State, Nigeria. The results further show that diagrams in discussion improves students' classroom participation (x=3.12>2.50 and 40.2%>8.9%), simplify learning for better test score (x=3.05>2.50 and 35.8%> 12.1%),

ease stress in chemistry practical laboratory (x=3.05>2.50 and 37.0%>8.9%), improve students' perception of chemistry topics (x=3.28>2.50 and 45.7%>4.6%) and attracts students' interest to Chemistry learning (x=3.08>2.50 and 39.0%>8.7%). This finding corroborates with that of Babalola (2021) which reveal a significant positive effect of diagrams on Chemistry achievement. This study also agree with that of Abudu & Muideen, (2019), whose findings showed that appropriate method of teaching improves chemistry and this will have an exponential effect towards reducing mass failure currently encountered in both internal and external examinations in Nigeria and particularly in chemistry subjects which requires more practical than theory. This finding may be because, diagrams and discussion provides students with opportunity to see how what is been discussed look like. It is a model which support three domains of learning including cognitive (Absorption of diagram at once rather than one after the other as in the case of written text), Psychomotor domain(using hand to draw diagrams of learning content) and affective domain (attractive diagrams connects with students' mind and feeling making the learning content difficult to forget.

5. CONCLUSION

This research was conducted to investigate the patterns of Teacher-students' Interaction in relation to students' learning variables such as perception of chemistry topics, interest and attitudes towards chemistry, laboratory engagement, classroom attendance and test scores for academic achievement in chemistry. The pattern/mode of teacher-students interaction examine include; ICT utilization, Students Motivation, Diagrams-enhanced discussion, Mnemonics-enhanced tutorial, and Instructional materials in relation to Chemistry Achievement using the correlation research design.

The findings reveal that, the use of ICT utilization, Students Motivation, diagrams-enhanced discussion, Mnemonics-enhanced tutorial, and Instructional Materials patterns of interaction positively and significantly relate to chemistry achievement. The study recommends that the teachers should put more efforts towards using ICT and students' motivation patterns of interaction for teaching Chemistry especially among Science secondary school students not only in Kano State but globally.

Also, School authorities should provide adequate instructional materials for teaching and learning of chemistry in science secondary schools. Likewise, Government should provide qualified Chemistry teachers who can use their wealth of experience to apply relevance instructional strategies such as diagram-enhanced discussion, mnemonics-enhanced tutorial in order to promote students' learning variables for academic performance in chemistry in science secondary schools, Kano and beyond.

This study is hereby significant to improve the teaching and learning of chemistry at the secondary school level. This study is an eye-opener to government at all levels (Local, State and Federal) to wake up to their responsibility of providing credible educational inputs such as qualified teachers who can use diverse mode of interaction including ICT and instructional materials for schools. Through this study, the Chemistry teachers' work in the classroom might become easier as the students' perception, attitudes and interest towards chemistry improves.

Nevertheless, this study used correlational survey design of the quantitative approach. This might be seen as a limitation to the study. Hence, a similar research may be conducted using a quasi-experimental research design to examine authenticity of the claim here.

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Data Availability Statement. All data related to this work can be obtained from the corresponding author.

Conflicts of Interest. The authors declare that there is no conflict of interest in this study whatsoever. Identity of the students who participated in the study are kept confidential and the students participated in the study willingly.

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REFERENCES

Abudu, M. G., & Muideen, H. A. (2019). A study of student perceptions of chemistry teachers' behaviour. *Journal of Research in Science Teaching*, *9*(1), 335-350.

Afyusisye, A., & Gakuba, E. (2022). The effect of the chemistry practicals on the academic performance of Ward Secondary School students in Momba District in Tanzania. *Journal of Mathematics and Science Teacher, 2*(2), em019. https://doi.org/10.29333/mathsciteacher/12397

Ahmad, R., Zaidi, B., & Mahmood, S., (2016). *Teaching: Making a difference*. John Wiley & Sons.

Ali, H., Babalola, V.T. & Ibrahim, R.H.(2023). Teachers' Perceived Effect of School-Based Planning on Chemistry Achievement in Kano Metropolis Secondary Schools, Nigeria. *International Journal of Innovative Research in Education Technology & Social Strategies*, *10*(1), 10-22. https://doi.org/10.48028/iiprds/ijiretss.v10.i1.02

Babalola, V. T. (2023). Effect of mnemonics enhanced tutorial on chemistry education students' achievement and mindfulness in a university. *Journal of Mathematics and Science Teacher*, *3*(1), em032. https://doi.org/10.29333/mathsciteacher/13073

Babalola, V.T. (2021). Effect of Diagrams on Chemistry Students' Academic Achievement in Kano Municipal Secondary Schools, Nigeria. *Global Journal of Arts Humanity and Social Sciences*, *1*(1), 1-8.

Babalola, V.T. (2022). Students' counseling and teachers' moral integrity management in science Education. *SOSEARCH*, *3*(1), 118-128. https://doi.org/10.26740/sosearch.v3n1.p1-11

Babalola, V.T. (2023a). Sample Size and Sampling Techniques in Chemistry Education Research: A Meta-Synthesis. *Science Set Journal of Physics*, *2*(4), 01-07. www.mkscienceset.com

Babalola, V.T. (2023b). Inclusive skill development for chemistry education programme. *UNESA Journal of Chemical Education*, *12*(2), 102-111. https://doi.org/10.26740/ujced.v12n2.p102-111

Babalola, V.T., Ahmad, S.S., & Sani, H.T. (2024). ChatGPT in Organic Chemistry Classrooms: Analyzing the Impacts of Social Environment on Students' Interest, Critical Thinking and Academic Achievement. *International Journal of Education and Teaching Zone, 3*(1), 1-2. https://doi.org/10.57092/ijetz.v3i1.155.

Christiansen, K. A. (2016). Intrinsic, extrinsic, and integrative orientations of French Canadian learners of English. *Canadian Modern Language Review, 57*, 424-444.

Churchill, K., Hill, R. & Boelter, C., (2017). Linking Black Middle School Students' Perceptions of Teachers' Expectations to Academic Engagement and Efficacy. *Negro Educational Review*, Spring 2018.

Cornelius-White, J. (2007). Learner-Centered Teacher-Students Relationships Are Effective: A Meta-Analysis. *Review of Educational Research, 77*, 113-143. https://doi.org/10.3102/003465430298563

Dasi, O.O. (2019). A survey of Personnel Resources for Chemistry Teaching in Ijebu-Ode Local Government Area of Ogun State. *JONED* Vol 3.

Francis, L.J. & Greer J. E. (1999). Measuring attitude towards science among secondary school students, the affecting domain. *Journal of Science and Technological Education, 17*(2), 219-226. https://doi.org/10.1080/0263514990170207.

Hughes, H. & Chen, U. (2017). Institutional Factors as Correlates of Effectiveness in Schools in South West Nigeria. Unpublished Ph.D Thesis, University of Ado-Ekiti, Ado-Ekiti, Nigeria.

Koen, R., (2018). *Cooperation and competition: Theory and research.* Interaction Book Company.

Musengimana, J. Kampire, E. & Ntawiha, P., (2021). Factors Affecting Secondary Schools Students' Attitudes toward Learning Chemistry: A Review of Literature. *Eurasia Journal of Mathematics, Science and Technology Education, 17*(1), 1-12. https://doi.org/10.29333/egmste/9379

Nugent, R. C. (2019). *Enhancing relationships between children and teachers*. American Psychological Association.

Ogbasi, S.O. & Madichie, J.C. (2020). Classroom interaction patterns as correlates of senior secondary school students' achievement in chemistry in Awka education zone. *South Eastern Journal of Research and Sustainable Development, 3*(1), 39-56. *https:*//sejrsd.org.ng/index.php/SEJRSD/article/view/86

Ogundare, G. O. (2019). Assessment of Classroom Interactions and Senior Secondary School Students' Learning Outcomes in Chemistry in Oyo State, Nigeria. The PhD Theses of the University of Ibadan. https://pgsdspace.ictp.it/xmlui/bitstream/handle/123456789/810/ogundare.pdf.

Pianta, L., Hamre, D. & Stuhlman, Z. (2017). Toward effective teaching of Music in Nigerian Schools. *Int. Jo. of Research in Edu.*, *3*(1), 157-163.

Roorda, S., Grill, F. & Horn, S. (2019). Teachers' motivation and students' achievement in middle school students. Pro Quest Dissertation and Theses. Unpublished

Ryan, A. & Deci, I. (2020). Chemistry teachers Understanding and Implementation of the senior secondary Chemistry Curriculum. *Nigeria Journal of Science and Educational Research, 4*(1), 151-158.

Saage, E. (2019): *Cooperative in the classroom*. Interaction Book Company.

Sajjad, Q., Siddique, M. & Tufail, 1. (2022). Teacher-Student interaction towards chemistry at secondary level. *Global Journal of Educational Studies*, *7*(2), 167-174. https://doi.org/10.31703/gesr.2022(VII-II).16

Snage, E. (2019). *Essentials of Research Methodology*. New Age Publishers Ltd.

Swoope, M.W. (2019). What Impacts the Student Outcome in General Chemistry? *Modern Chemistry and Application*, *8*(1), 1-3. https://typeset.io/papers/what-impacts-the-student-outcome-in-general-chemistry-4ur4m2jjgt.

Umar, A. & Babalola, V.T. (2023). Teaching Chemistry and English Language with Mnemonics as a Mindfulness Strategy for Students' Academic Struggles. *International Journal of Innovative Research in Education Technology & Social Strategies*, *10*(1), 40-51. https://doi.org/10.48028/iiprds/ijiretss.v10.i1.06

Zhang, J. H. (2019). The Current Situation and Effect of Teacher-Student Interaction in College Teaching. *Research in Education Development, 23*, 10-17. https://doi.org/10.14121/j.cnki.1008-3855.2019.23.004