STUDENT INTERACTION PATTERNS AS PRECURSORS OF ACQUIRING CHEMISTRY PROCESS SKILLS DURING QUANTITATIVE PRACTICAL LAB ACTIVITIES

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ABSTRACT

Quantitative analysis is one of the most important secondary school chemistry topics where students can acquire chemistry process skills (CPS) through a series of laboratory activities. Research agrees that student interaction patterns (SIP), like interactions with other students, the teacher, and interfaces, improve online learning effectiveness, but their effectiveness in the acquisition of CPS in face-to-face chemistry labs is not clear. This study examined which interaction patterns students use most to gain CPS in a quantitative analysis chemistry lab. SIP and CPS during lab activities were observed in 197 chemistry students in randomly selected intact classrooms. The observation of students on these variables was evaluated using a 21-item laboratory interaction evaluation scale with a cronbach alpha of 0.84 and Chemistry students process skills observation checklists (CSPSOC). The study found that students interact most with each other in the lab, followed by with teachers, and least with interfaces (apparatus, reagent, and manuals). The relationship between the student-interface interaction pattern and basic CPS ($r = .25$; $p < .01$) and integrated CPS ($r = .19$; $p < .01$) was significant. The student-teacher interaction pattern predicted the student CPS the most ($\beta = .61$; $p < .01$) and accounted for 36% of the variance. In addition, the combination of student-student and indirect interaction patterns predicted CPS ($\beta = .18$; $p < .01$) and accounted for 39% of the variance. The paper discusses the implications for understanding interactions in a face-to-face laboratory from a cognitive, social, and teaching perspective. *[African Journal of Chemical Education—AJCE 13(3), July 2023]*

INTRODUCTION

Practical lab activities are an extremely important component when implementing the science curriculum, as they help students gain 21st-century abilities [1], [2], [24, 27, 31]. For example, Chemistry, which is a required course for all 100-level Science, Technology, Engineering, and Mathematics (STEM) majors, uses lab activities to help students apply chemical concepts learned in theory to tackle real-world challenges [2]. Students are often required to experiment with reagents and equipment in a quantitative practical classroom in order to develop their understanding of acid, base, and salt and maintain their enthusiasm for science. However, it has been noted that in most public schools in Nigeria, practical work, especially in overcrowded classrooms, has been limited to teacher demonstrations, limited supplies of resources, recipe-type activities, and ineffective instructional methods used by teachers [21].

Over time, the problem of overcrowded classrooms and a lack of resources and supplies has primarily been solved by introducing virtual laboratories to complement face-to-face practical lessons and even encourage science students to participate in lab activities. However, these virtual labs involve the physical isolation of students and equipment, thereby reducing the student's acquisition of psychomotor skills in science. Wei et al. [40] noted that the virtual laboratory's failure to allow students to physically control equipment, materials, and apparatus in real time may undermine students' chemistry process skills (CPS). This could have led to differences between the students' attitudes and the scientific attitudes needed by the industry [30], and the lab activities have often been shown to be ineffective [37].

As a result, in order to bridge the gap between students' attitudes toward chemistry and the scientific attitude required by industry, process skills should be encouraged as early as high school chemistry lab activities. Thus, CPS-enhancing therapies [5, 10, 33] have also been developed for students to improve these skills, but studies have revealed that students were only exposed to the basic chemistry process skills, while integrated skills remained unacquired [3, 4], [5,] and [17]. The result of the non-acquisition of an integrated CPS may have a detrimental influence on students' learning results in chemistry and other science subjects. Researchers discovered that students who performed well in four of the seven CPS tests still performed poorly in stoichiometry-related chemistry tests [3], [19], [21] [43]. The skills for an integrated process can be acquired by improving the patterns of interaction that students engage in the laboratory because man is a social being that incorporates relationships between human behaviors and the environment. More importantly, research has shown that different patterns of interaction help students succeed in online programs.

Therefore, the present study was carried out to test the effect of the research-proven student-student, student-teacher, and student-interface (apparatus, reagents, and manual) interaction patterns to improve chemistry process skills in the face-to-face laboratory classroom. The study presents ways to help students acquire integrated chemistry process skills and will assist teachers in planning and implementing interactive student laboratory activities. One research question and two hypotheses were addressed to achieve these goals.

Research Questions

1. What interaction pattern is prevalent among secondary school students during chemistry quantitative analysis lessons in the laboratory?

Research Hypotheses

- $H_0$1: There is no significant relationship between the student's interaction patterns and basic and integrated chemistry process skills.
- $H_0$2: There is no significant predictive ability of the interaction patterns in the development of students' science process skills.

LITERATURE REVIEW

The Concept of Chemistry Process Skills (CPS)

Chemistry Process Skills (CPS) are the cognitive and psychomotor skills used in problem solving and the tools and abilities needed to apply scientific concepts to laboratory and practical work. It involves learning to do, define, refine, and resolve activities in the laboratory. [42, 32]. These skills encourage children's active participation in the learning process and include tools for information gathering, problem solving, decision-making, and adaptation [19] [26] [43]. Chemistry process skills are often grouped into two categories: basic and integrated skills.

The basic skills include observation, communication, classification, measurement, predicting, and inference, while the integrated skills are formulating hypotheses, naming, and controlling variables, experimenting, transforming, and interpreting data. According to research, junior high and secondary students performed poorly on the science process scale [19]. According to studies, while basic process skills are easily acquired by students, integrated skills are consistently reported as low [19] [26] 43].

Different methods to improve students' processing skills have been suggested, like the Bouabdaulah [9] study, which emphasized that prospective chemistry teachers may need to introduce concept maps to teach practical chemistry topics to address students’ skill acquisition problems. Furthermore, a study investigated the effect of a modified laboratory learning environment (MLLE) on secondary school students' biology process skills [33]. It was found that the process skills of the students improved when they were taught in a modified laboratory learning environment. It was also found that the biology process skills of low achievers improved significantly and had a significant effect on students’ retention [33]. Most of these studies have provided novel instructional approaches to help students acquire the basic and integrated skills they need to succeed in a scientific world but only a few have recognized the potential inherent in the interactions that take place among students, teachers, and the apparatus and reagents used to carry out these activities. Thus, the interaction patterns of students can influence the acquisition of basic and integrated CPS in laboratories. Any method of teaching will only be effective if students interact with their environments because they are social beings. This includes interacting with other students, teachers, and the equipment, apparatus, and materials in a laboratory setting.

Interaction Patterns that Take Place in the Face-to-Face Laboratory

Interactions are communication or direct involvement with someone or something that can occur between individuals that are essential elements in any social discourse, particularly for students in both formal and online learning environments. While much research on laboratories has focused on the products of learning and skills developed and used by students, an important aspect of laboratory learning is understanding the interactions in which students engage when carrying out laboratory activities. Indeed, interactions in laboratories between students and their environment have a direct impact on learners' performance and their learning outcomes according to the theory of distributed cognition [12] [25]. Other students, instructors, equipment, computers, and laboratory manuals can all be found in science laboratories [11]. Accordingly, the main interactions between the learner and the environment in science laboratories can be classified into four categories.

1. Student–student (S–S) interactions, which refer to interactions among students within or between groups;

2. Student–Teacher (S–T) interactions, which refer to interactions between students and the teacher;
3. student–interface (S–I) interactions, which refer to students manipulating equipment such as glassware, using chemicals, consulting the laboratory manual, or accessing the Internet in the laboratories; and
4. Indirect or vicarious interactions (I–I), in which students learn by watching or listening to what other people do.

The first two forms of interactions (S–S and S–T) are interpersonal and include two-way communication, whereas S–I and I–I are one-way in face-to-face laboratories because students only get information from materials and do not receive immediate answers.

A study showed that learner-instructor and learner-learner interactions, when used synchronously or asynchronously, were perceived as effective discussion modes and played an important role in the success of students [13]. Another study determined the perceptions of graduate students in distance education classes as regards student-to-student interaction. It was found that while some students desired student-to-student interaction, many of the respondents did not particularly like or want student-to-student interaction. It was also showed in a study that student-student relationships play a significant role as they can relate to and retain whatever they learn from their peers more than any other relationship [36]. In a study carried out by [17], it was revealed that the influence of interactions on student academic performance is significant. The predictor variable was also discovered to have significant contributions to the dependent variable. It has also been documented the type and number of interactions observed between students and graduate teacher assistants versus undergraduate teacher assistants [27].

It was found that students showed no significant differences in their interaction patterns in the laboratory. It also concluded that students generally feel more comfortable interacting with the UTA. Student-content, student-peer, and student-teacher patterns are documented in the literature and have been used to facilitate the academic performance of distance education students in various studies [23] [6]. One area that has been scarcely researched is student-interface interaction, which is defined in this study as the relationship that takes place between students and the equipment, laboratory manual, and tools (e.g., technological software) needed to perform the required task in the laboratory [41].

In addition, it has been observed that students are usually exposed to practicals at the tail end of writing external practical exams. This practice compels teachers to set up the practical apparatus themselves while students document the result obtained by the teacher. The adverse effect of this practice is that students graduate from secondary schools most of the time and cannot set up the apparatus or equipment needed to carry out simple titration activities. The implication will be that students will not be able to internalize and practice whatever they have been taught in theory. The learning environment in which students carry out laboratory activities should be distinguished as either a productive or non-productive environment. Therefore, it is apt to evaluate the interaction pattern that operates in the secondary school laboratory and investigate its predictive ability for the acquisition of students' CPS.

Theoretical Framework of the Study

Interaction is considered crucial to learning experiences from the sociocultural constructivist perspective (Vygotsky, 1962), which theorized that participation in the discursive practices of the community supports knowledge construction. The theory evolved into "Community of Inquiry" (COI), which recognizes that the presence and interaction of cognitive, social, and teaching presences support teacher practices for students’ success. The theory of COI has been recognized for its applicability to computer-mediated communication (CMC) in synchronous and asynchronous educational interactions. Meanwhile, its applicability to face-to-face practical laboratories is lacking in the literature. Garrison, Anderson, and Archer (2000) posited that educational setups are supported by the presence and interaction of elements of cognitive, social, and teaching presences. It is used in this paper to describe the interaction that takes place between the four students' interaction patterns and their enabling ability to develop their chemistry process skills.

Studies have emphasized the active participation of students in the learning process, where the construction of knowledge emerges due to the interactions of students with their environment (other students, teachers, educational materials, and so on). Research identified learner-content interaction, learner-instructor interaction, and learner-learner interaction as types of interaction patterns [25]. Student–student (S–S) interactions are the interactions that take place among students within or between groups. Student–Instructor (S–I) interactions, used in the study as "student-teacher," refer to interactions between students and the teacher; student–equipment (S–E) interactions refer to students manipulating equipment such as glassware, using chemicals, consulting the laboratory manual, or accessing the Internet in the laboratories; and indirect interactions (I–I), often referred to as "vicarious learning," refer to students' learning by observing others or listening to others' conversations. Several researchers have carried out studies on interactions that take place both online and in a physical environment.

METHODOLOGY

This study adopted a descriptive survey design where observations were made of all laboratory activities during practical sessions. These observations were gotten from a 5-minute video recording of verbal interactions between students, teachers, and the apparatus. Observation checklists and rating forms were completed based on the observations of these students in the 10 recordings of the 5-minute video.

Participants, Research Instruments and Procedure

The population of the study comprised all senior secondary school three (SSSIII) students in Ekiti State during 2019/2020 session. Sample for the study were 197 students (62.4% female, 37.6% male) randomly selected from three 16 local governments of Ekiti State. Ages ranged from 16 to 20 years (M = 17.5 years, SD = 8.3). A multistage sampling technique was employed in selecting the sample. Three Local Government Areas (LGAs) were selected through a simple random sampling technique. One secondary school was randomly selected from the three local government areas. Students in their intact classes participated in the study.

Two instruments were employed in collecting data for the study. The students interaction pattern rating scale (SIPRS) and the Chemistry students process skills observation checklists (CSPSOC).

Students-interaction pattern rating scale (SIPRS) is a modified instrument of the interaction questionnaire from the study of [41]. It consists of four dimensions namely student-student interaction, students-teacher interaction, student-interface interaction, and indirect-interaction. Students' interaction pattern rating scale consists of two sections; section A, consists of the bio-data information of the respondents and Section B consists of 19 questions which were rated as frequently (4), occasionally (3), rarely (2) and never (1). It was used to gather information on students' interaction pattern levels in the classroom. The instrument was re-validated and reliability coefficient was computed using Cronbach alpha and a reliability coefficient was calculated as r = 0.94, 0.66, 0.88, 0.84 for students-students, students-teacher, student interface and indirect observation interaction pattern (for the different sections of the instrument) respectively.

Science Process Skills Observation Checklists for Chemistry Students (SPSOCCS); The SPSOCCS is a rating scale used in the classroom to assess students' basic and integrated skills during quantitative analysis. The instrument was adapted from the study of Ugwu, (2009). Under each science process skill, the instrument statements of practical activities with which students were observed. Experts in the fields of chemistry, measurement and evaluation validated the instruments. They made the necessary changes to the items, and their feedback was incorporated into the instrument's final draft. After validation the final copy of the instrument was subjected to a reliability test using Cronbach's Alpha-statistics. The reliability co-efficient was calculated to be 0.80. This value indicates that the instrument was reliable and suitable to be use for the study.

The research was carried out in two stages during the third term of the 2019/2020 academic session. The study will last for about twelve weeks of third term of the selected schools i.e from May 5 to June 27, 2019. At the pre-data collection stage, the researcher will visit the selected secondary schools in Ekiti State to seek the permission of the school principals and solicited for support of the teachers and students' cooperation. The researcher went ahead to meet with the Chemistry teachers of SSII to be sure that the students have been engaging in practical activities. The researcher also employed research assistants who were trained for two weeks before the commencement of the field study. They were trained on how to observe the students on Chemistry Students Science Process Skill Rating Scale and administration of the students-interaction pattern questionnaire. The schools were visited during practical activities and students were observed and rated while the student's interaction scale was administered to the students during the period they were writing their lab report. The rated scale and questionnaire were collected and collated. The two scales were coded and sorted out for the missing data.

Data Analysis and Results

Checking for normalcy, missing data, extreme data, and outliers was performed during the initial data screening. The rating scale was dichotomized by combining the frequently and occasionally engaged interaction pattern values together and adding the seldom and never engaged interaction pattern values. Research question one was analyzed using descriptive statistics such as mean, frequency, and percentages. The hypotheses were respectively analyzed using Pearson Product Moment Correlation (PPMC) and hierarchical regression analysis.

RESULTS

Research Question 1: What interaction pattern is prevalent among secondary school students during chemistry quantitative analysis lessons in the laboratory?

Table 1: Descriptive Statistics of Mean, Standard Deviation and percentage of Students Interaction Pattern N =197

		Percentage Frequently/ ocassionally	Rarely/Never	Mean	Standard Deviation
	Student-Student Interaction				
1	The student was seen talking to another student to learn about the procedures/lab equipment.	182(92.4)	15(7.6%)	4.97	1.19

2	Student was discussing with other students about lab procedures/equipment	182(92.4)	15(7.6)	5.11	1.14
3	Student was observed to be communicating their titre values with other students	182(92.4)	15(7.6)	4.97	1.15
4	Student contacted with fellow students on how to analyse results while carrying out titration activities	183(92.9)	14(7.1)	4.99	1.15
5	Student was active in the small groups/teams he/she belonged	183(92.9)	14(7.1)	5.04	0.13
	Dimension Mean	25.04			2.52
	Students-Teachers Interaction				
6	The student interacted with the teacher on a clicker question and the instructor is answering student questions	174(88.3)	23(11.7)	4.95	1.29
7	There was evidence in teacher provided feedback on student work by commenting in his/her notes	173(87.8)	24(12.2)	4.76	1.24
8	Students was able to put forth effort and submitted practical note for teacher feedback before leaving the laboratory	172(87.3)	25.5(12.7)	4.53	1.15
	Students-Interface Interaction				
11	Students engage with the equipments/apparatus during acid – base titration	39(19.8)	158(80.2)	1.91	0.44
12	All the equipments were functional	28(14.2)	169(85.8)	1.63	0.35
13	The student followed procedures as stated in the laboratory manual	21(79)	176(89.3)	1.66	0.24
14	The student clamped the burette with the retort stand and pipetted the base	21(10.7)	176(89.3)	1.60	0.21

16	The student did not just leave the teacher with the setup, rather was seen to engage with lab procedures/equipment and basic concepts	50(25.4)	147(74.6)	1.80	0.14
	Dimension Mean	10.25			3.60
	Indirect Interaction (I-I)				
17	The student observed other students' experimental setup and behavior's when carrying out titration activities	160(81.2)	37(18.8)	3.52	0.46
18	The student listened to other student-student conversations to make the necessary corrections in his/her lab work	157(79.7)	40(20.3)	4.64	1.49
19	The student listened to other student-instructor conversations to adjust his/her lab activities	163(82.7)	34(17.3)	2.12	1.48
	Dimension Mean	14.60			4.21
	Grand Mean			25.09	5.52

Note: N=197 X < 2.5 low, X > 2.6 moderate X > 4.1 High

Table 1 shows that a larger percentage of the students about 182 (92.4%) engaged in student-student interaction pattern during titration activities. About 172 (87.3%) engaged in student-teacher interaction pattern, while fewer students were engaged with the interfaces and about 27(14.2%) and 157(79.7%) engaged in indirect interaction pattern. It could infer from the result that among the four-interaction pattern examined in the study, the most prevalent interaction pattern students engage in was the student-student interaction pattern, followed by student-teacher interaction pattern, the indirect interaction pattern, while the least interaction took place between student-apparatus/equipment pattern.

Hypothesis 1: There is no significant relationship between the interaction patterns and basic and integrated CPS.

Table 3: Correlations of the variables in the Study

Variables	SS	ST	SE	II	BasicPSkills	INTPSkills
SS	-					
ST	.717**	-				
SinT	.165*	.311**	-			
II	.451**	.510**	.253**	-		
BasicPSkills	.497**	.587**	.253**	.397**	-	
INTPSkills	.366**	.393**	.199**	.342**	.377**	-

SS-Student-Student Interaction, STI- Student-Teacher Interaction, SinT- Student-Interface Interaction, II- Indirect Interaction

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 3 showed that there was a positive relationship between Student-student interaction pattern and students basic (r = .49; p < .01) and integrated process skills (r = .37; p < .01). Student-teacher was related to basic process skills and integrated process skills (r = .39, p < .01). There was a moderate significant relationship between student-interface interaction pattern and basic (r = .19: p < .01) and integrated skills (r = .25: p < .01). Although, the relationship could be regarded as weak¸ a significant relationship was still established. The result showed that student-indirect interaction patterns have relationships with both basic (r = .39: p < .01) and integrated process skills (r = .34: p < .01)).

Hypotheses 2: There is no significant predictive ability of the interaction patterns in the development of students' CPS.

Table 3: Regression Analysis of the Predictor Variables on the Dependent Variable

Pattern		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R
		B	Std. Error	Beta			
1	Model 1						
	(Constant)	58.933	3.449		17.088	.000	
	ST	1.541	.145	.604	10.596	.000	.36
	Model 2						
	(Constant)	55.404	3.599		15.396	.000	
2	ST	1.296	.166	.508	7.807	.000	.39
	II	.629	.217	.188	2.892	.004	
	Model 3						
3	(Constant)	52.149	3.897		13.382	.000	
	ST	1.015	.213	.398	4.769	.000	
	II	.565	.218	.169	2.593	.010	.41
	SS	.425	.205	.167	2.078	.039	
	Model 4						
	(Constant)	50.433	3.846		13.112	.000	
	ST	.903	.211	.354	4.280	.000	.44
	II	.478	.215	.143	2.227	.027	
	SS	.496	.201	.195	2.468	.014	
	SE	.092	1.1566	.119	.112	.881	

The 2 variables of measure here are not properly defined, so, how were they captured or measured? (Interaction pattern and science process skills?) What statistic was used to produce table 3?

a. Dependent Variable: SPS
b. Predictors in the Pattern: (Constant), ST
c. Predictors in the Pattern: (Constant), ST, II
d. Predictors in the Pattern: (Constant), ST, II, SS
e. Predictors in the Pattern: (Constant), ST, II, SS, SE

Table 3 showed that in Student-teacher interaction pattern ($\beta = .61$; $p < .01$), predicted SPS, while another variable that has a predictive ability as regards the results in Table 3 is the indirect-interaction pattern ($\beta = .18$; $p < .01$). Student-student interaction pattern also predicted SPS ($\beta = .17$; $p < .01$), however, student-interface interaction pattern did not predict SPS.

DISCUSSION

Understanding the interaction pattern that takes place in the classroom enables teachers to address the cognitive and psychomotor skills students lack. It also helps teachers ensure that both teachers and students achieve the objective with which they engage in laboratory activities. Experienced teachers describe, explain, and predict student interactions by drawing on their professional knowledge about the types of student interaction patterns that are associated with cognitive, affective, and psychomotive outcomes. In the present study, the results from analyzing student interaction patterns and observations both established that the student–student interaction pattern occurred most frequently, while student–teacher interaction occurred second most frequently, and both the student-interface and indirect-interaction patterns occurred less frequently. This result is consistent with ideas of socio-constructivism and community of inquiry (COI) theory, which postulate that meaningful learning for students is situated in social collaboration and interactions with other people, most frequently with colleagues or friends.

Similar studies indicate that students engage more with their colleagues [23], [36], and [6]. The result is also consistent with recent research by [40]. It was discovered that student-student interaction is the type of interaction that students view as being most relevant to their laboratory work [40]. One reason that may have necessitated the prevalence of student-student and student-teacher interaction in the laboratory is that students' notes are usually graded at the end of practical classes, and the grade will be used to judge students' performance.

Therefore, students in a rush to get grades ask their colleagues who are smarter for their notes to give dumb answers to the practical questions without necessarily carrying out the experiment. Moreover, Senocak and Tatar [36], in a study examining factors contributing to students' failure in the laboratory, observed that students scored highly on the item "worrying about being unable to complete experiments." Therefore, students tend to focus more on turning in their notes to earn good grades than performing the experimentation themselves. Though student-student interaction patterns in classes contribute to the development of teamwork and collaboration skills, these interaction patterns need to be guided by teachers to bring about the desired CPS in individual students. More activities that require students to work in groups or on sequential aspects of real-world projects should also be designed [34].

Students should be allowed to work collaboratively with other students and their teacher, but should be encouraged to participate in all the interactions that take place in the laboratory because they will retain more when they interact with the equipment and apparatus themselves. This differentiates between what students can perform by themselves and what they can perform with others in Vygotsky’s "zone of proximal development."

Moreover, the results from the study showed that all students' interaction patterns investigated had significant relationships with both the basic and integrated CPS. Studies have confirmed this finding, demonstrating that student-student interaction has a significant influence on student academic performance [36].Some other studies that have determined the levels of students' science process skills have reported that participants most of the time possess the basic skills of observation, measurement, communication, and recording but lack or rank low in the integrated skills of experimenting, manipulating variables, formulating models, identifying, and controlling variables. The present study showed that both basic and integrated skills were acquired and improved by engaging them in productive interaction patterns.

The third finding revealed that student-student, student-teacher, and student-indirect interaction patterns were important predictors of CPS and contributed up to 41% to students' process skill development. This discovery is in line with the findings of [23], who showed that students' levels of interaction influence their grades. It was also supported by [1] in a study that found that all three types of interaction investigated were significant predictors of academic performance among distance education students. Hence, the present study suggests that students' CPS will also require direct manipulation of interfaces (equipment, apparatus, reagents, and materials) by them when engaging in laboratory activities. As a result, it is critical for both teachers and students to recognize and connect the cognitive, social, and teaching presences to achieve the written and unwritten goals of the science curriculum.

CONCLUSION

In examining the interaction that takes place between students, teachers, equipment, and content, the findings from this study suggest that the interaction between student-student and student-teacher occurs frequently in laboratory classrooms, whereas student-equipment and interactive interaction need to be reemphasized. It also concluded that the studied student interaction patterns have the potential to develop students' chemical process skills in practical classrooms.

These findings could guide greater experimentation by educators in extending the range of student interactions that occur in face-to-face practical environments, especially in distant education studies. From the sociocultural constructivist perspective, the learner has the potential capacity for intellectual growth and could be able to do so, enhanced by scaffolding different interaction patterns.

RECOMMENDATIONS

It is therefore recommended that:

1. A new practice debugged of only one type of interaction, recitation book styles, should be adopted by teachers to enhance awareness of the influence of the three mutually interacting elements of cognitive, social, and teaching presences in the practical classroom.

2. Students should be encouraged to interact and participate in all possible interactions when carrying out laboratory activities to enhance the development of 21st century skills.
3. Teachers should ensure that the mode of interaction pattern adopted is unique to different activities in the sciences.
4. Laboratory technicians and subject teachers should be provided with suitable training seminars and programmes to create awareness of the different interactions that take place in the laboratory and methods that can be used to engage students actively in the laboratory.

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