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Voices in the Classroom: Classroom Interaction Patterns of Biology Teachers

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Abstract

The study identified the various interaction patterns employed by biology teachers during classroom lessons. It identified the factors that influence interaction patterns in science classes while investigating if school type (private or public) influences interaction patterns in biology classes. The study adopted a descriptive survey research design. The targeted population for this study comprises senior secondary school students. The sample for this study comprises 150 biology students selected randomly from ten secondary schools. An adapted observation checklist was used for data collection based on Flanders' interaction analysis framework. Data collected were analyzed using descriptive statistics, frequency counts and percentages. The frequency of teacher-student and student-student interactions among Biology Teachers in the study area shows that teacher talk predominates at 62.9%. Within the teacher talk, direct talk was more prominent than indirect talk, with an average percentage of 40.7%. The study showed that 90% of the respondents indicated that teachers' personality traits, the time of the day, availability of teaching resources, and the teacher's level of experience affect the classroom interaction pattern. The study showed that school type has a significant influence on direct teacher talk and student talk, but no significant effect was found for indirect teacher talk, teacher talk overall, or silence.

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Introduction

Education is a process of acquiring knowledge, skills, values, and attitudes. It is an important factor in the development of any nation which helps individuals to contribute meaningfully to society and pursue personal or professional growth, with science education acting as a crucial means in equipping learners with the knowledge and skills needed for technology advancement.

Effective teaching and learning process in any subject goes beyond the transmission of knowledge from teachers to learners. Classroom interaction plays a crucial role in facilitating students' understanding, engagement, and motivation to learn biology (Alexander, 2020). The term "interaction" is made up of two morphemes, namely *inter* and *action.* It is a mutual or reciprocal action or influence. Interaction is the collaborative process of communication between two or more people to affect each other's experiences, thoughts, feelings and ideas (Dudley, 2019). Classroom interaction is the sum total of the activities taking place in the classroom between the teacher, the learner and the leaning materials during the teaching process. This helps to modify behavior, help students to socialize, develop desirable attitude and interest, and create an atmosphere to develop problem-solving skills (Nnorom & Erhabor, 2019).

According to Kouicem (2012), classroom interaction describes the form and content of behavior or social interaction in the classroom which is an essential part of teaching-learning process. It is considered a productive teaching technique, referring to the whole range of activities and experiences through which the teacher, curriculum materials, and learners interact (Abe & Bello, 2019).Classroom interaction is a crucial component for effective teaching and learning process as it not only benefits students but also gives the teacher feedback on whether the material explained is acceptable to students or not. It involves the verbal, non-verbal, social and instructional exchange that occurs within the classroom environment. Classroom interaction patterns play a vital role in the educational outcome of students, especially in subjects that require active engagement, such as biology. It is the interaction between the teacher and learners, and among the learners in the classroom (Amadi, *et al*., 2021).

Teacher-student, student-teacher and student-student approach are the major approaches to carry out classroom learning and interaction. The teacher-student relationship is focused on the teacher being the primary source of knowledge, and students are passive recipients of information (Obbo, 2022). This approach typically consists of lectures, direct teaching, and limited student participation. For this study, teacher-centered will be characterized by the teacher lecturing for the majority of the session with minimal student input (Wood et al., 2024). Student-teacher interaction is centered on active student participation, teamwork, and higher-order thinking. Student-centered interaction in this study will include students engaging in activities such as discussions, group work, and problem-solving exercises where the students will have greater control over directing their learning. The teacher will take the facilitator role of guiding the students throughout their learning but not directly teaching them.

The peer-to-peer or the student-student learning process is an educational process by which students are taught by and with their fellow students. It allows students to share, discuss, and work on assignments with one another, and

students take active roles in the learning process rather than passively receiving information. The process improves understanding, strengthens communication and establishes teamwork.

Student engagement in class depends not only on the teacher knowing the correct strategy but whether he or she can utilize it (Scott et al., 2014). It refers to the extent to which students participate in classroom activities, ask questions, and demonstrate interest in learning. It includes students' attention and involvement in group activities, responsiveness to the teacher's questions, and participation in discussions (Awal, 2010).One of the important aspect of science involving teaching and learning where classroom interaction is needed is biology. Biology is a core science subject which provides students with an understanding of life processes and their application. However, the effectiveness of teaching biology is dependent on the nature of classroom interactions between teachers and students. A proper orientation that a science related subject especially biology is not complete without a scientific interactions which are expected to foster a deeper understanding of concepts through experimental learning, should be made known to the teachers (Evan *et al*., 2016). This will help to improve learning outcomes.

Erhabor (2019) explained learning outcome as the knowledge, skills, and attitude that students acquire and this is as a result of participating in instructional activities in classes. A proper participation will improve students' academic performance which can be measured through their grades in exams, class assignment, and practical assessment. Academic performance is used as a key indicator of the effectiveness of classroom interaction pattern in promoting student learning and mastery of concepts. Freeman et al. (2014) compared traditional lecturing to active learning strategies in undergraduate STEM courses, and the findings revealed that active learning approaches significantly reduced failure rates and improved student performance on assessment. The study underscores the effectiveness of interactive engagement techniques in enhancing educational outcomes. The more the individual student can participate in the learning process, the more such an individual will be able to contribute and take initiative, making learning take place. In other words, the more students are free to ask questions, make decisions about learning process, participate in discussion, and initiate conversations the more they contribute and benefit from the learning process.

Goetz et al. (2021) explained that while some teachers have been able to adopt and adapt with an effective students-teacher interaction where the focus is on students (learning and tasks done collaboratively by students, students provided with sufficient time to listen and consider the ideas of others and strategies aimed at fostering active participation and engagement), some have allowed the teacher-students interaction type to dominate where the focus is on teaching (lecture focused, limited opportunities for student participation) limiting opportunities for meaningful interactions between teacher and students, lack of motivation, negative attitude to subjects and overall poor academic performance of students. Biology being a science subject need more of an interactive approach than route learning but the reverse had been the case and this implies that the percent at which students are allowed to engage in science classes are small compared to teachers which can be attributed to the large content to be covered and many other factors (Akinyemi et al., 2015).

How effective a classroom interaction pattern will be can also be linked to school type. Different school settings, such as public, private, urban, rural, traditional, and progressive institution shape classroom interactions. The

public school, also known as the government schools are free or less expensive and open to all students while the private schools are privately funded schools that charge tuition fees and often selective admissions. Stockard et al. (2018) explained that the public schools are more teacher-led instruction with a focus on the instructor having control in the classroom due to the large number of students, which might limit opportunities for individualized student engagement. The private schools, however, typically utilize more student-led approaches that enhance effective classroom engagement and overall academic achievement (Darling-Hammond et al., 2020).

Although different methods of interaction have been tried all over the world, a gap in research on only the interaction practices utilized by biology teachers in secondary schools has been found. This study attempts to bridge this gap by analyzing and investigating classroom interactive patterns among secondary school biology teachers through the study of teaching strategies, levels of communication, student engagement level, and providing insight into effective pedagogy and making recommendations that enhance learner engagement and learning achievement in biology. Despite interactive teaching approach's importance, the majority of Biology instructors fail to implement these strategies effectively due to factors such as instructor-centered instruction practices, limited use of inquiry-based learning, and communication styles, all contributing to ineffective patterns of interaction. Moreover, disparity in classroom dynamics, such as large class sizes, insufficient teaching resources, and varying student's attitude may further hinder effective communication and engagement between teachers and students. This lack of interactive engagement could result in lower student motivation, reduced comprehension of complex biological terms and poor academic performance.

Also, school type has also been discovered to be a major factor that influences classroom interaction pattern. It was discovered that performance was low and several factors have been discovered that resulted in such low performance mainly in public school type. It is also widely established that the conventional teaching method is the most common method applied in the context of classroom interaction patterns. Hence, we must research explicitly on the classroom interaction so that more insight could be gained on the problems of teachers in the teaching and learning process. This study aims to bridge this gap by examining and questioning the pattern of classroom interaction of biology teachers of secondary schools by researching on teaching approaches, communication, level of student participation, as well as giving insights on good teaching practices and generating a recommendations that can enhance the students' involvement and learning outcome in biology. The findings will contribute to the literature base in science education, enhance science education practice, identify ways of enhancing students' engagement and participation, and inform teacher preparation programs for enhanced teaching strategies.

Purpose of Study

The specific objectives are to:

i. identify the various interaction pattern employed by biology teachers during classroom lessons, focusing on the frequency and types of interactions among Biology teachers in Ile-Ife.
ii. identify the factors that influence interaction patterns in science classes among Biology Teacher in Ile-

Ife, and

iii. investigate if school type (private or public) influences interaction pattern in biology classes.

Research Questions

The following research questions and hypothesis are generated to guide the conduct of this study:

i. What are the dominant classroom interaction patterns used by biology teachers in secondary schools in the study area?

ii. What factors contribute to the interaction pattern in science classes?

Research Hypothesis

There is no significant influence of school type (private and public) of classroom interaction pattern of biology students in senior secondary school.

Theoretical Framework

The study adopts Flanders Interaction Analysis System (FIAS). This is systematic observation techniques used to analyze and categorize teacher-student interactions in the classroom. This is developed by Ned A. Flanders in the 1970s, FIAS provides a framework for observing, recording, and analyzing the verbal and non-verbal interactions between teachers and students. The FIAS system consists of 10 categories that describe teacher and student behavior In undergoing FIAS, the observer stays in the best position to hear and see the participant and decides which category best represents the communication events just concluded at the end of every 3 seconds. Thus, the time involved in coding one tally for every 3 seconds is 20 tallies in one minute, 100 tallies in 5 minutes and 1200 tallies in one hour. The FIAS is an effective instrument to measure the social and emotional climate in the classroom, provide feedback to the students-teachers, used to compare the behavior of teachers at different age levels, gender, and subjects. It helps to provide systematic and objective framework for classroom interaction, helps teachers to be more aware of their interaction pattern, and facilitates the identification of effective teaching strategies.

It consists of the following characteristics as scientific techniques, systematic recording, analysis of classroom behavior, representative of classroom behavior, observation techniques for classroom behavior, and measuring instruments for classroom teaching. Evaluation device, feedback device, supplementary device, and useful for theory techniques. To improve the quality of teaching and learning for all learners within the education system, teachers' classroom interactions need to from time to time and students' performance, according to Adu et al. (2010) can simply be viewed as an outcome of all academic tasks or rigors of a person, which could be poorly or successfully stated. Performance cannot be improved in students if they are discouraged. Teachers are expected to meaningfully contribute to students' academic performance. The weighty performance of a student is sometimes attributed to higher teachers' efficiency.

The National Policy on Education (2004) stated that secondary education would be in two stages, Junior and Senior, each stage being of three years duration. Whatever type of secondary school that is in place, the prime function of education officials is to provide a condition within which boys and girls develop socially, mentally, and intellectually. This can be achieved through the learners' association with knowledge, information and environment. This agrees with the purpose for secondary education as contained in the National Policy on Education (NPE) (1977, 1981, 1998, & 2004) inter-alia:- provide an increasing number of primary school pupils with the opportunity for education of a higher quality irrespective of sex, social, religious or ethnic background; Equip students to live effectively in our modern age of science and technology (NPE, 2004).

Method

This study adopted a descriptive survey research design to investigate the classroom interaction patterns of biology teachers in Ile-Ife. The target population of the study comprised of all SSS1-SS3 science students and Biology Teachers of senior secondary schools in Ile-Ife, Osun State. A sample for the study was conducted on a representative of 220 biology students who were randomly selected from 10 secondary schools. The 10 secondary schools comprise of 5 private schools and 5 public schools. The classes' observation will range from SS1 – SS3 science classes. Simple random sampling techniques will be used for this research.

In carrying out this research, the Biology Classroom Interaction Pattern Observation Checklist (BCIPOC) was the instrument used for the data collection for this study. The checklist is designed to observe and record the classroom interaction patterns between biology teachers and students in selected schools in Ile-Ife. It focuses on the verbal and non-verbal behaviors that reflect teacher-student interaction, student participation, and instructional methods. The checklist consists of 10 items representing key interaction behaviors based on classroom best practices and Flanders' interaction analysis framework. The 10 items include: teacher acknowledging student's feelings, teacher praising/encouraging student's behavior or response, teacher accepts or uses student's ideas, teacher asks question to stimulate discussion, teacher presents information in a lecture format, teachers provides instructions for an activity, teacher criticize student's behavior/response, student initiate a conversation or asks questions, student responds to teacher's questions, and a stage of silence in the classroom. The verbal behavior comprises teacher talk (7 categories), student talk (2 categories) and silence or confusion (1 categories). The first 7 categories has been bifurcated into the indirect and direct talk.

Indirect talk entails teachers accepting students' feelings, praise or encourage students, accepts or use ideas of students and ask question about content. The direct talks entail the teacher lecturing the students, giving direction and command, criticizing or justifying authority. We also have the pupil talk in response to teacher's question and the pupil talk initiated by them. The last is the silence or pause or confusion in which communication cannot be understood by the observer. The checklist is used during live classroom observation sessions of 30 minutes with a 1-minute time interval because of its long duration

The process of data collection commenced by visiting the selected secondary schools one after the other. The researcher with the permission of the management moved round the schools to administer pre-made Flanders

interaction analysis observation sheets to record the interaction sequences, using code (1-10) that represent the types of talk for the respondent. The researcher visited the classes physically (with permission) and systematically observe for about 30minutes per lesson. Every 1 minute, recording the most used interaction using the codes (e.g. 5 = teacher lecturing, 9 = student initiation) and the recording sequentially to build a data pattern. The first process is called the coding process, which leads to the decoding process that brings meaning and more insight to the data collection. The factors contributing to the interaction pattern matrix, which is a 15-item factors was ticked in the order strongly agree, agree, disagree, and strongly disagree was ticked alongside the Flanders interaction analysis checklist. Descriptive statistics (quantitative data analysis), such as percentages, were used to analyze the data.

Results

Research Question One: What are the dominant classroom interaction patterns used by biology teachers in secondary schools in Ile-Ife?

To answer this research question, the Flanders classroom interaction categorization system was used for the analysis of the study. The observations in class were done within a thirty-minute classroom period, and the scores were recorded according to Flanders' system of classification. Thereafter, the encoding and decoding of responses was done following the description as given by Flanders in the Appendix and the interaction-based Teacher interaction (direct and Indirect), Student interaction and the silent interaction were presented for each respondent and cumulated in frequency and percentages as shown in Table 1. The percentages for calculation for each respondent is presented below.

Table 1. Classroom Interaction Patterns in Different Schools

School Type	Teacher Talk Percentage (%)	Indirect Teacher Talk Percentage (%)	Direct Teacher Talk Percentage (%)	Student Talk Percentage (%)	Silence Percentage (%)	Indirect/Direct Teacher Talk Percentage(%)
Public	71	25.8	45.2	25.8	3.2	57
Public	74.2	22.5	51.6	16.1	9.7	43.8
Public	71	25.8	45.2	25.8	3.2	57.1
Public	64.5	19.4	45.2	29.0	6.5	28.6
Public	77.4	22.6	54.8	16.1	6.5	41.2
Average						
Public	***71.62***	***23.22***	***48.4***	***22.56***	***5.82***	***45.54***
Private	48.4	25.8	22.6	48.4	3.2	144
Private	54.8	6.4	41.9	38.7	6.5	30.8
Private	58.1	38.7	19.4	38.7	3.2	200
Private	77.4	25.8	51.6	19.4	3.2	50
Private	32.3	3.2	29.0	64.5	3.2	11.1
Average						
Private	***54.2***	***19.98***	***32.9***	***41.94***	***3.86***	***87.18***
Average						
Total	***62.91***	***21.6***	***40.7***	***32.25***	***4.84***	***66.36***

From Table 1, the result explained the classroom interaction patterns in public and private schools, focusing on the percentage of teacher talk, student talk, and silence. On average, public-school classrooms are heavily dominated by teacher talk, which accounts for approximately 71.62% of the total classroom time. This high percentage suggests that public school settings are largely teacher-centered, where the teacher plays the central role in directing and controlling the flow of lessons. In assessing the two forms of teacher interaction in the public schools, it was observed that the direct talk (48.4%) was more prominent than the indirect talk (23.22%) in the study area. It was observed that the student talk was observed 22.56% of the time while silence was the least interaction pattern as observed 5.82% of the time.

In contrast, private schools show a lower average of 54.2% teacher talk, indicating a somewhat more balanced approach that allows room for other forms of interaction. When examining student talk, the difference between public and private schools becomes even more apparent. In public schools, student talk occupies only about 22.56% of the classroom time, which suggests limited opportunities for students to actively participate, ask questions, or engage in meaningful dialogue. On the other hand, in private schools, student talk significantly increases to an average of 41.94%, demonstrating a more interactive classroom environment where students are more involved in the learning process.

Silence during classroom sessions is slightly higher in public schools, averaging 5.82%, compared to 3.86% in private schools. This suggests that there are slightly more non-interactive or inactive moments in public school classrooms, which may reflect either pauses in instruction, moments of disengagement, or periods of waiting. Another interesting aspect is the indirect-to-direct teacher talk ratio. In public schools, this ratio averages 45.54%, which indicates a moderate balance between teachers providing guidance (indirect talk) and giving direct instruction or commands. In private schools, however, this ratio is significantly higher, averaging 87.18%, suggesting that when teachers in private schools talk, they tend to use more indirect methods that may encourage student thinking, exploration, and contribution rather than simply issuing instructions. The total classroom interaction pattern reveals that public schools tend to emphasize teacher control and direct instruction, while private schools appear to foster more student involvement and interactive teaching practices. This difference may influence the learning experience and could have implications for student engagement, critical thinking, and classroom dynamics in both school types. Overall, the teacher talk was the predominant interaction pattern with a 62.9% followed by the student talk with 32.3%, direct talk was more prominent than indirect talk with an average percentage of 40.7% to 21.6% among the respondents as silence was the least interaction with 4.8%

Research Question Two: What factors contribute to the interaction pattern in biology classes?

To answer this research question, the questions in section B on the highlighted factors that contribute to the interaction patterns were analyzed. The mean score was used to determine the predominant factors that contribute to the interaction pattern as shown in Table 2. From Table 2, it was revealed that all the respondents agreed that the use of open-ended questions by teachers influences classroom interaction patterns in science classrooms. Similarly, all the respondents agreed that providing opportunities for students to ask questions and explore ideas also contributes significantly to interaction patterns. Additionally, 100% of the respondents agreed that a

conducive classroom environment, class size, and lesson type play vital roles in shaping classroom interactions.

Table 2. Factors Contributing to the Interaction Pattern in Science Classes

Factor	Strongly Agree f(%)	Agree f(%)	Disagree f(%)	Strongly Disagree f(%)	Mean
Use of open-ended questions by teachers	8(80.0)	2(20.0)	0(0.0)	0(0.0)	3.80
Opportunities for students to ask questions and explore ideas	9(90.0)	1(10.0)	0(0.0)	0(0.0)	3.90
Conducive classroom environment	10(100.0)	0(0.0)	0(0.0)	0(0.0)	4.0
Seating arrangement in the classroom	8(80.0)	2(20.0)	0(0.0)	0(0.0)	3.80
Variety of teaching methods to cater for different learning styles	6(60.0)	4(40.0)	0(0.0)	0(0.0)	3.60
Hand-on-activities included in lessons	6(60.0)	4(40.0)	0(0.0)	0(0.0)	3.60
Teacher's personality traits	9(90.0)	1(10.0)	0(0.0)	0(0.0)	3.90
Student's cultural background	6(60.0)	4(40.0)	0(0.0)	0(0.0)	3.60
Gender dynamics	4(40.0)	6(60.0)	0(0.0)	0(0.0)	3.40
Lesson type (practical/theory)	10(100.0)	0(0.0)	0(0.0)	0(0.0)	4.00
Time of the day (morning/afternoon)	9(90.0)	1(10.0)	0(0.0)	0(0.0)	3.90
Teaching resources (printed or digital)	9(90.0)	1(10.0)	0(0.0)	0(0.0)	3.90
Class size	10(100.0)	0(0.0)	0(0.0)	0(0.0)	4.00
Teacher's level of experience	9(90.0)	1(10.0)	0(0.0)	0(0.0)	3.90
Student's language proficiency	5(50.0)	5(50.0)	0(0.0)	0(0.0)	3.50

Furthermore, 90% of the respondents indicated that teachers' personality traits, the time of the day, the availability of teaching resources, and the teacher's level of experience affect classroom interaction patterns. About 60% of the respondents agreed that hands-on activities included in lessons and students' cultural backgrounds influence classroom interactions, while 50% believed that students' language proficiency has an effect. Only 40% of the respondents agreed that gender dynamics influence classroom interaction patterns.

Overall, it was evident that all these highlighted factors contribute to the interaction patterns in science classes. Based on the mean scores, the most predominant factors influencing classroom interaction patterns were the conducive classroom environment and class size, each with a mean score of 4.0. These were followed by opportunities for students to ask questions and explore ideas, teachers' personality traits, time of the day (morning/afternoon), teaching resources (printed or digital), and the teacher's level of experience, all with mean scores of 3.90.The use of open-ended questions by teachers and seating arrangements in the classroom both had mean scores of 3.80. Variety in teaching methods, hands-on activities, and students' cultural backgrounds each had mean scores of 3.60. Gender dynamics emerged as the least influential factor, with a mean score of 3.40.

Hypothesis: There is no significant influence of school type (private and public) of classroom interaction pattern

of biology students in senior secondary school.

t-test analysis was used to test the significant influence of school type (private and public) of classroom interaction pattern of biology students in senior secondary school. The result is presented in Table 3.

Table 3. t-test for School Type and Interaction Pattern

Classroom Interaction	Mean	Standard deviation	df	t	p
Teacher Talk					
Private	71.62	4.62	8	2.289	0.051
Public	54.20	16.33			
Indirect Teacher Talk					
Private	23.22	23.22	8	0.477	.646
Public	20.00	20.00			
Direct Teacher Talk					
Private	48.40	4.53	8	2.426	0.041
Public	32.90	13.55			
Student Talk					
Private	22.56	6.04	8	-2.476	0.038
Public	41.90	16.43			
Silence					
Private	5.82	2.73	8	1.414	.195
Public	3.86	1.48			

The t-test results reveal important differences in classroom interaction patterns between private and public schools. For teacher talk, the analysis shows that the difference between the two school types is approaching significance, with $t(8) = 2.29$, $p = 0.051$. Although this result suggests a potential difference, the p-value slightly exceeds the conventional threshold of 0.05, indicating that the difference is not statistically significant. For indirect teacher talk, the result $t(8) = 0.48$, $p = 0.646$ shows no significant difference between private and public schools. This suggests that both school types have similar patterns in how teachers indirectly interact with students, such as through prompts or guided questioning.

In contrast, direct teacher talk shows a significant difference, with $t(8) = 2.43$, $p = 0.041$. This indicates that public schools use significantly more direct teacher talk compared to private schools. Direct teacher talk typically involves commands, instructions, and explanations delivered with minimal student input. A significant difference was also observed in student talk, with $t(8) = -2.48$, $p = 0.038$. The negative t-value indicates that student talk is significantly higher in private schools than in public schools, suggesting that private school classrooms provide more opportunities for student participation and dialogue. Finally, for silence, the result $t(8) = 1.41$, $p = 0.195$ indicates no significant difference between the two school types. This suggests that the amount of silent or non-interactive time in the classroom is relatively similar across both settings. The findings of the study shows that school type has a significant influence on direct teacher talk and student talk, but no significant effect was found

for indirect teacher talk, teacher talk overall, or silence. These findings suggest that private schools tend to promote more student-centered interaction, while public schools rely more on teacher-dominated instruction

Discussion

Teacher discussion was the most common kind of interaction in the classroom, according to the analysis of interaction patterns. This is consistent with previous research showing that many classrooms are teacher-centered, especially in areas where conventional teaching methods are still often used. The preponderance of teacher speaking suggests that the instructor was the main source of information and authority in the classroom, controlled the instructional plan, and mainly regulated the flow of communication.

According to Mercer and Howe (2012), conversely, student conversation was far less common, which may indicate that students had fewer chances to voice their opinions or actively participate in class discussions. This low degree of student involvement can be the result of teaching strategies that prioritize knowledge transfer over group knowledge creation or learner autonomy. Additionally, the results demonstrated that direct teacher communication was more prevalent than indirect teacher communication. Giving directions, explaining things, or posing closed questions that require succinct or honest answers are common examples of direct communication. This communication style frequently denies learners the chance to participate in extended discourse or critical thinking while reinforcing the teacher's authority. However, the less common use of indirect talk, like providing comments, encouraging student responses, or asking open-ended questions, indicates that there might not be as much support for more in-depth cognitive engagement and reflective thought. The least common pattern of contact was silence. This could be interpreted as class time being used effectively with little waste of time, or it could be interpreted as students not having enough waiting time to ponder questions, think about ideas, or create thought-evoking responses (Vygotsky, 1970). If strategically placed in questioning techniques, silence can be extremely useful in creating greater learning.

Overall, the results suggest a largely teacher-directed class environment with little space for reflective or dialogic learning and limited student involvement. The prevalence of direct compared to indirect communication suggests a transmissive mode of pedagogy that can threaten to undermine students' autonomous and critical thinking. These results point to the need for more student-instructional strategies that foster greater levels of engagement, active participation, and open communication. The results show that configurations of classroom interaction in science classrooms are largely determined by various factors, with some factors influencing more than others. With the highest mean score, the most significant of these were found to be a positive class environment and class size. This establishes the significance of a physically and socially organized, pleasant, and manageable setting in facilitating productive involvement. The learning context also has a significant role in shaping the way students take part and engage, as stated by Fraser (1998). Likewise, Blatchford et al. (2003) highlight that fewer class students facilitate increased involvement in the classroom, personal attention, and student-teacher interaction.

Issues like the time of day, staff availability of teaching aids, staff experience level, the ability of students to ask and explore, and the personality traits of teachers are followed. From these results, student-centred practices like

increasing curiosity and inquiry among students are essential in designing intensive engagement in scientific lectures. This concurs with Vygotsky's (1978) sociocultural theory, which posits the importance of interaction and communication in cognitive development. Furthermore, according to Stronge (2007), the effectiveness of a teacher is commonly determined by competency as well as disposition. For this reason, classroom dynamics are greatly influenced by the teacher's personal characteristics and professional experience.

It was also observed that interactions in the classroom were influenced by the time of day. According to research by Hargreaves (1994), energy levels and communication flow are affected because both teachers and students are generally more attentive and receptive in the morning than in the afternoon. By encouraging a variety of teaching pedagogies and visual engagement, the availability and utilization of instructional resources whether digital or printed also improves interaction (Mayer, 2009).

The influence of seating configurations and the usage of open-ended questions was moderately high. According to Chin and Osborne (2008), open-ended questions foster deeper thinking and motivate students to provide more details about their arguments, both of which are critical components of scientific literacy development. According to Wannara and Ruhl (2008), seating arrangements can either facilitate or hinder interaction based on whether they support eye contact, group discussions, or instructor accessibility. Even though they were somewhat less important, elements including students' cultural origins, hands-on activities, and a diversity of teaching styles all made an impact. It is well established that active learning methods such as practical experiments and differentiated teaching strategies promote participation, teamwork, and conceptual understanding (Prince, 2004). In her work on culturally responsive pedagogy, Gay (2000) highlights how students' cultural backgrounds also influence how they react to different teaching philosophies and interact with one another in the classroom.

Remarkably, the study found that gender dynamics had the least impact. Although some research indicates that gender may influence classroom involvement (Sadker & Zittleman, 2009), this conclusion might point to a change in classroom practices towards greater equity or a setting where gender is less of a barrier to engagement. The findings, taken together, highlight the complex interplay between physical, pedagogical, psychological, and social elements that influence how students and teachers engage in scientific classes. Classroom interactions can be more dynamic and productive when supportive surroundings, manageable class numbers, interactive teaching methods, and responsive teacher behaviors are prioritized.

The results indicate that school type significantly impacts both direct teacher talk and student discussion, whereas no significant impact was observed on indirect teacher talk, overall teacher talk, or quiet. This shows that the institutional context, public or private plays a vital role in establishing the patterns of classroom interaction, notably in how teachers and students engage with one another. The findings indicate that private schools are more inclined to promote student-centered engagement, as seen by increased levels of student discourse. Conversely, public schools often depend more on teacher-centered instruction, marked by a greater prevalence of direct instructor. This correlates with results by Bray (2007), who notes that private schools, frequently due to better resources, smaller class sizes, and greater autonomy, may embrace more progressive pedagogies that encourage student participation. Conversely, public schools, which may confront higher class sizes, fewer resources, and

greater bureaucratic monitoring, frequently embrace more structured, teacher-led systems (Udo & Udofia, 2014). The absence of a notable distinction in indirect instructor discourse among various school types is particularly intriguing. Indirect communication, such as prompting student responses or providing commendation, facilitates higher-order thinking and engagement (Alexander, 2008). The lack of significant influence from school type suggests that dialogic methods are either under-utilized in both educational environments or implemented inconsistently, irrespective of context.

Similarly, the absence of school-type effect on overall teacher talk and silence shows that while the quantity of teacher conversation remains equal, its quality and style vary by school type. Teachers in both public and private schools may engage in similar durations of discourse; however, the interaction modalities diverge, with private school educator's likely employing dialogue to promote student participation, while public school instructors predominantly utilize it for material delivery. These findings align with sociocultural learning theories, notably Vygotsky's (1978) perspective that learning is facilitated by social interaction. The educational environment shaped by institutional policies, cultural expectations, and resource availability can profoundly alter the form and function of classroom conversation. Mercer and Dawes (2014) contend that classrooms fostering exploratory dialogue and student expression are more effective in facilitating significant learning outcomes.

Overall, the findings underline the importance of school context in determining teaching style and classroom interaction patterns, with private schools displaying more qualities associated with constructivist and student-centered learning settings. This underscores significant implications for teacher training, policy, and the necessity to endorse dialogic teaching methodologies across all educational institutions to foster equitable and engaging learning experiences.

Conclusion

In conclusion, teacher discussion was the most common kind of interaction in the classroom, according to the analysis of interaction patterns. This is consistent with previous research showing that many classrooms are teacher-centered, especially in areas where conventional teaching methods are still often used. The preponderance of teacher speaking suggests that the instructor was the main source of information and authority in the classroom, controlled the instructional plan, and mainly regulated the flow of communication.

Direct teacher communication was more prevalent than indirect teacher communication. Giving directions, explaining things, or posing closed questions that need for succinct or truthful answers are common examples of direct communication. This communication style frequently denies pupils the chance to participate in extended discourse or critical thinking while reinforcing the teacher's authority. However, the less common use of indirect talk—like providing comments, encouraging student responses, or asking open-ended questions—indicates that there might not be as much support for more in-depth cognitive engagement and reflective thought.

Also, private schools are more inclined to promote student-centered engagement, seen by increased levels of student discourse due to better resources, smaller class sizes, and greater autonomy embracing more progressive

pedagogies that encourage student participation. Conversely, public schools are more likely to be based on teacher-led teaching, with a greater prevalence of direct instructor discourse because they may have to manage larger class sizes, fewer facilities, and more bureaucratic controls, and tend to embrace more formalized, teacher-led systems.

This study adds significantly to the existing body of knowledge on the various interaction pattern types used by teachers during a learning process. The findings will contribute to the new body of knowledge on science education, enhanced science education plans, seeking means to increase participation and motivation among pupils and direct teachers' training programs about instructional practices. Ultimately, this research makes a substantial contribution to the understanding of the subject matter by not only uncovering the root cause of students' poor performance in Biology as a subject but also offering practical insights that can inform policies, interventions, and cultural shifts within secondary schools. Regular professional development workshops should focus on interactive pedagogy, dialogic teaching, and constructivist approaches, emphasizing open-ended questioning, student-led discussions, and critical thinking. Teachers should evolve from knowledge dispensers to facilitators of learning, incorporating hands-on activities, discussions, and collaborative learning. Cooperative strategies, such as think-pair-share, jigsaw, round robin, and peer teaching, can be used to promote active engagement and student participation.

Students should be encouraged to participate actively in class discussions, ask questions, and engage in hands-on activities to enhance their curiosity and creativity. Open-ended projects and activities can develop critical thinking skills and personal skills. Schools should utilize available resources, such as textbooks, online materials, and community resources, and provide opportunities for teachers to develop their skills and knowledge in biology education.

Factors management and feedback are crucial for effective teaching and learning. Classroom environments should be conducive to effective teaching and learning, supported by professional development opportunities, materials, equipment, facilities, and resources. Socio-economic factors, such as poverty and lack of resources, can be addressed through scholarships or grants. Regular and constructive feedback is essential for students to understand their strengths and weaknesses, identify areas for improvement, and motivate them to learn and engage with provided materials.

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