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Relationships between High School Teachers' Understanding and their Reported Practices of Inquiry-based Pedagogy in Science Classrooms in Nigeria

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This research examines the relationship between high school teachers' understanding and reported practices of inquiry-based pedagogy (IBP) in science classrooms in Nigeria. A sample of 11 science teachers from an education district in Lagos, Nigeria, was chosen for this case study. Data were collected using a semi-structured questionnaire, which combined closed Likert-scale items (analysed using descriptive statistics) with open-ended questions assessing understanding and reported practices of inquiry in science classrooms, supplemented by semi-structured interviews (analysed using content analysis) with sampled teachers. Teachers' understanding of inquiry-based pedagogy was categorised into four clusters: teacher asks questions, students respond; teacher sets questions, students engage in project activities; teacher sets the context, students generate questions; and teacher sets the context, students generate questions and conduct investigations. However, responses to Likert scale items within each of the four clusters revealed patterns of reported practices that were unrelated to teachers' understanding of IBP. Although teachers within the same cluster shared a similar understanding of IBP, their reported practices varied owing to factors such as time constraints, overcrowded classrooms, teachers' beliefs, insufficient provision and utilisation of technological resources, as well as ineffective professional development for inquiry teaching methods.

Keywords: *Inquiry-based practices; Science instruction; Teacher's understanding*

Introduction

Science education is a crucial subject leading to the rapid advancement of the technological revolution needed to meet every country's needs. Such a technological transformation is expected to complement the skills offered in twenty-first-century education. This allows the method and practice of teaching chemistry and physics to be characterised by an immersive and creative environment in which students, under the supervision of an educator, are involved in the construction of new knowledge (National Research Council (NRC), 2000a). In this regard, research establishes the significant benefits of inquiry teaching as an effective pedagogical approach that promotes the development of students' science process skills and training for valuable employment in the labour market (Laurillard, 2012). Inquiry within the context of this study is described as a teaching strategy that focuses on how students plan and carry out investigations, collect and analyse data, construct an argument and communicate results (Crawford, 2014). In science education, inquiry is expected to be taught in the context of issues in everyday life and "real-world" situations, with students gaining practical experience (Laurillard, 2012). Using inquiry-based pedagogy promotes students' acquisition, understanding and application of STEM concepts (Connell & Abramovich, 2018).

In Nigeria, the national policy on education advocates the use of inquiry activities in the teaching of science subjects at the senior secondary school level (Federal Republic of Nigeria, 2013).

Nevertheless, there is a growing concern regarding the level of acquisition of scientific inquiry skills among science students in Nigeria. This is evident in the West African Senior School Certificate Examination reports for Nigeria, which revealed that many students at the senior secondary school level struggle to answer conceptual questions that are related to practical aspects of science (see, for instance, West African Examination Council [WAEC], 2018). For example, in physics students struggle with accurately reading from laboratory instruments and scales; use incorrect construction, interpretation and application of graphs; apply inappropriate approximation of variable values used for graph plotting; and indicate poor mathematical manipulation, particularly with numbers expressed in standard forms. In chemistry, students are challenged by the basic understanding of simple chemistry principles such as applying a theoretical approach to practical issues, and showing good communication skills (WAEC, 2018).

One of the problems associated with the underperformance of Nigerian students in WAEC examinations could be linked to teachers' insufficient implementation of inquiry-based pedagogy (IBP) in science classrooms (Aina & Ayodele, 2018). Although the new senior secondary education curricula in Nigeria have emphasised the use of inquiry-based practices in teaching, it is unclear what teachers' IBP looks like in science classrooms and what factors influence such IBP practice. Research claims that many high school science teachers in Nigeria tend to lack knowledge of how to implement inquiry-based teaching in science, particularly in the context of practical work (Aina & Ayodele, 2018). Thus, this study explored the relationship between teachers' understanding and their reported practice of IBP in science classrooms in Nigeria. This study is motivated by the following research questions:

- What is the relationship between Nigerian science teachers' understanding of inquiry-based pedagogy and their reported practice of inquiry-based pedagogy in science classrooms?
- What barriers do these Nigerian science teachers perceive to inhibit their practice of inquiry-based pedagogy?

Literature

Inquiry-based Pedagogy

Maaß and Artigue (2013) refer to inquiry-based instruction as a multi-faceted procedure that not only involves asking questions but also allows students to pose questions, explore answers, construct new understandings, concepts and information, and then convey their knowledge to others to establish practical solutions. One of the objectives of the Nigerian secondary school science curriculum is to provide students with the essential scientific skills and attitudes required for the technological application of physics, as well as the application of scientific concepts and techniques in chemistry. This can be accomplished by fostering students' use of scientific inquiry practices outlined in the Next Generation Science Standard (NGSS) of the United States (NGSS Lead States, 2013). These practices include posing questions and identifying problems, creating and using models, preparing and conducting research, scrutinising and compiling data, using arithmetic and analytical thought, constructing theories and proposing solutions, engaging in evidence-based arguments, and collecting, assessing and communicating findings (NGSS Lead States, 2013). The practices stress the fact that teachers' and students' engagement in "scientific inquiry require coordination both of knowledge and skill simultaneously" (NRC, 2015, p.41). Therefore, teachers tend to integrate and support these science practices in classrooms via a lecture approach, experiments, hands-on activities and guided discussions that provide an opportunity for students to think and ask questions, as well as engage in groupwork and laboratory activities (Davis et al., 2019; Lembens & Abels, 2016). Teachers should be able to create a classroom situation that allows students to formulate their ideas and seek information by themselves and offer solutions.

Teachers' Understanding

For teachers to establish a culture of inquiry in a science classroom, their understanding of inquiry is essential. The understanding and inquiry practice of teachers is often affected by the kind of knowledge and exposure acquired in their initial teacher education programmes (Wang & Zhao, 2016).

Analysing the way inquiry is being interpreted today, it is challenging that most science teachers still understand inquiry more as a method than a tool for understanding the nature of science (Asay & Orgill, 2010). Similarly, the attitudes and beliefs of teachers about inquiry become central to their understanding and effective IBP practices (Ramnarain & Hlatswayo, 2018).

According to Ozel and Luft (2014), factors such as teachers' qualification, motivation and years of classroom teaching experience have been identified as major agents that contribute to teachers' perceptions and inquiry practice. Teachers' inadequate knowledge and skills in teaching inquiry could be one of the root causes of students' poor conceptual understanding and mathematical application abilities in science at the senior secondary certificate examination conducted in Nigeria. In this regard, Ssempala (2017) contends that teachers' understanding of IBP could have a profound effect on how they implement it in the classroom, thus having a profound effect on how students comprehend and develop scientific knowledge and skills.

Teachers' Levels of Inquiry Practice

The effective enactment and practice of IBP in science classrooms depend on the teacher's ability to incorporate the essential features of science practices into instructional activities to achieve the desired learning outcome (NGSS Lead States, 2013). The type and range of such activities should therefore support high levels of inquiry. In light of this, scholars have provided a continuum for determining the level of inquiry involved in an activity (Lembens & Abels, 2016; Ramnarain et al., 2016). The levels of inquiry are described as follows.

> Level 0—*confirmation inquiry*: the teacher will design a question and develop a procedure (method) that will guide students through an activity with known results. Students thus confirm a principle/idea based on the designed activity and use the existing principle to investigate a similar task.
>
> Level 1—*structured inquiry*: the teacher gives detailed instruction on the question and the procedure that students must follow in order to generate a solution to or explanation for the teacher's task using the evidence that they have collected.
>
> Level 2—*guided inquiry:* the teacher designs a question then students carry out an investigation autonomously in order to find an answer to the question, and the teacher then guides them in developing the desired science concept or principle.
>
> Level 3—*open inquiry*: students formulate their own questions and carry out investigations, devising their own methods with limited guidance, and report on their findings. In such a situation, the teacher encourages student interaction but intervenes only when absolutely necessary.

It is believed that the extent to which teachers enact inquiry depends largely on the standards outlined in the curriculum and the school context (Mkimbili et al., 2017).

Barriers Inhibiting Teachers' Implementation of Inquiry-based Pedagogy

Despite widespread advocacy of using IBP to enhance students' learning, contextual factors that do not favour the enactment of IBP by teachers continue to cause divergence (Ramnarain & Hlatswayo, 2018). Researchers discuss these contextual issues from technical, social, cultural and political perspectives (Anderson, 2002; Wang & Zhayo, 2016). In some countries including South Africa, the successful implementation of IBP appears to be fraught with difficulties like the lack of laboratory amenities and instructional materials, an insufficient amount of time to finish the curriculum and large class sizes, each creating uncertainty in the willingness of teachers to implement inquiry (Ramnarain & Hlatswayo, 2018). Also, the implementation of IBP is constrained by teachers' partial understanding of scientific knowledge and beliefs about the conceptions of inquiry, and their feelings of self-efficacy (Osborne, 2014; Wang & Zhayo, 2016).

Although the use of digital technologies and tools appears to provide potential affordances for more effective and efficient practice of inquiry-based pedagogy in science classrooms, technical issues such as limited/unavailable internet services and access to technology could also impose constraints on teachers' inquiry practice (Williams et al., 2017). Considering the challenges that teachers face when implementing IBP, research claims that continuous professional development focused on inquiry is critical to help teachers improve their pedagogical content knowledge, personal characteristics and beliefs about inquiry-based science pedagogy (NRC, 2000b).

Theoretical Underpinnings

This study is based on constructivist theory, which provides a practical orientation as to how teachers encourage students to engage in activities that can enhance their scientific thinking and practices (Hyslop-Margison & Strobel, 2007). Constructivism is essentially a philosophy of how people learn based on experience and empirical research (Harasim, 2017). This implies that learning takes place when individuals construct new knowledge as a result of sharing their experience through interaction with other people (Vygotsky, 1978). In such a classroom situation, inquiry demands a significant shift in the teacher's role from that of delivering content to being a facilitator of knowledge construction. This also influences the position of students from being passive recipients to being active constructors in the learning process and gives them a level of control as to what they are learning (Dewey, 1938). Thus, inquiry may not be used only to acquire knowledge and particular dispositions but also to discover the skills needed to succeed in life. However, research claims that the way teachers understand inquiry has a significant impact on how IBP is implemented in science classrooms and that individual participants construct an understanding of inquiry (Keys & Bryan, 2001). Hence, understanding teachers' knowledge of inquiry becomes extremely important in the practice of IBP in Nigerian science classrooms.

Within the constructivist paradigm, Vygotsky's sociocultural theory posits that social interaction forms a basic part of cognition development (Vygotsky, 1978). The sociocultural theory validates the objectives that students learn best when they are asked questions, allowed to investigate problems and proffer solutions, discuss their discoveries and reflect on the new knowledge gained during the inquiry process. This reflects Dewey's convictions on inquiry, which says that students have to engage in activities that enhance critical thinking rather than memorising (Kidman & Casinader, 2017). Thus, IBP as viewed in this study enables the development of fundamental abilities and cognitive skill sets that prepare students for a work-integrated environment (NGSS Lead States, 2013), as well as improving teachers' and students' critical thinking and investigation practices.

Methodology

A case study was conducted using a convergent mixed-method approach (Creswell & Plano Clark, 2018) to explore the relationships between teachers' understanding and practice of inquiry in Nigerian science classrooms. The convergent mixed method approach involves the collection of quantitative and qualitative data on a single-phase project at the same time, analysing the two databases separately and then merging them to combine the results. The convergent design used in this study was based on a semi-structured questionnaire which combined closed items with open-ended items, and a semi-structured interview to obtain different but complementary data on teachers' understanding and practice of inquiry-based pedagogy (Creswell & Plano Clark, 2018). The quantitative objective of the study was to assess the extent to which teachers practice inquiry in their classrooms, while the qualitative objective was to explore their understanding of inquiry-based pedagogy as well as factors that might affect their implementation of inquiry-based pedagogy.

The questionnaire was constructed based on a review of the research literature, which referenced inquiry-based skills and knowledge that teachers should promote in their classrooms. Central to the development of the questionnaire items was the explication of science practices as presented in the NGSS Lead State (2013). According to the NGSS, engaging students in scientific inquiry requires "asking questions and defining problems, developing and using models, planning and carrying out investigation, analysing and interpreting data, using mathematical and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, as well as obtaining, evaluating and communicating information" (NGSS Lead State 2013, p. 384).

The first component of the questionnaire asked for teacher background information (i.e. name, age, gender, highest qualification, grade level taught, subjects taught, years of teaching experience). The second component consisted of open-ended qualitative responses about: (i) their understanding of inquiry-based learning; (ii) how they have been using inquiry-based approaches in their classroom; and (iii) problems regarding the implementation of inquiry-based learning if any. The third questionnaire component consisted of 20 scaled closed-ended questions (see Figure 1) aimed at self-reporting by the participants on the extent to which they encourage students to engage in inquiry skills in their classrooms. Participants were required to choose options from a five-point Likert scale. This was coded as 1 = never, 2 = once a year, 3 = once a month, 4 = once a week and 5 = daily. The semi-structured questionnaire was first drafted and piloted with three science teachers who do not form part of the study. The questionnaire was later designed using Google forms and the link was sent through email to 63 high school science (physics and chemistry) teachers in non-fee-paying schools in an education district in a suburb of Lagos, Nigeria, with informed consent. However, only 11 senior secondary school (SSS 1–3, i.e. Grade 10–12) teachers responded to the questionnaire. Data obtained from the scaled questions were analysed using descriptive statistics. Reliability analysis was carried out on the teachers' inquiry practice scale comprising 20 items. Cronbach's alpha value showed the questionnaire to reach acceptable reliability and internal consistency at $\alpha = 0.965$. Most of the items appeared to be worthy of retention, resulting in a decrease in the alpha if deleted. A mean (average) calculation was performed (mean = 3.73) to identify general trends in participants' responses for each item, and the standard deviation for the scale item was calculated to determine the degree of consistency among respondents (SD = 1.37).

The interview was conducted alongside the questionnaire and carried out digitally via WhatsApp. The interview guide contained questions that explored how teachers developed their understandings about inquiry-based learning, what a typical inquiry lesson looked like in their classroom, the scientific practices that teachers engage their students in during inquiry lessons and teachers' views on the effectiveness of using inquiry practices as an approach to teaching science content. Responses from the open-ended items and interviews were transcribed, coded and analysed using content analysis (Erlingsson & Brysiewicz, 2017). The codes were later sorted into subcategories based on how various codes are related. The emergent subcategories were used to organise and group codes into meaningful categories. In order to identify instances where there is an alignment between teachers' understanding of IBP and their reported inquiry practice, data from the interview and open-ended questions were used to validate result from the Likert scale items. Table 1 provides details of participants' biographical information.

Table 1. Respondents demographics

Teacher's psuedonym	Age	Gender	Qualification	Subject	Years of experience
A	38	Female	BSc	Chemistry	10
B	36	Male	BSc/BEd, MSc	Physics	10
C	36	Female	BSc, PGD	Physics	6
D	35	Female	BSc (Engineering)	Chemistry	8
E	46	Female	BSc/Ed	Physics	8
F	35	Female	BSc/Ed	Chemistry	6
G	35	Male	Msc/Ed	Chemistry	8
H	50	Male	BEd	Physics	25
I	29	Male	MEd	Physics	7
J	26	Female	BSc	Chemistry	10
K	36	Male	BSc	Physics	12

All participants can be presumed to have sufficient pedagogical content knowledge since they all have more than three years of teaching experience as required for their participation in the study. It should be noted, however, that the sample size used in this study is not large enough to generalise the findings to the entire population of science teachers in Nigeria.

Findings and Discussion

Teachers' Understanding of IBP

Teachers' understanding of IBP was assessed based on responses to two questions. The first question from the open-ended questionnaire asked, "What do you understand by inquiry-based pedagogy?", while the second question from the interview asked, "What scientific activities do you normally involve your students in during inquiry lessons?" Teachers' responses to these questions were sorted into four categories emerging from the data, i.e. asking questions; collaboration with peers; project-based learning; and conducting experiments, as shown in Table 2.

Table 2. Categories of teachers' understanding of inquiry-based pedagogy (IBP)

		Participating teachers										
Category	Subcategories	A	B	C	D	E	F	G	H	I	J	K
a. Asking questions	a. Teacher asking question and students providing answers to the question asked	X				X	X		X	X		
	b. Encouraging students to ask questions that can be explored and seek their own answers		X		X			X			X	X
2. Collaboration with peers	Allowing students to share ideas			X								
3. Project-based learning	Involving students in individual learning/ project activities						X	X	X		X	
4. Conducting experiments	a. Supporting students to conduct experiments		X									
	b. Planning and carrying out investigations		X	X				X				
	c. Analysing and interpreting data		X									

Findings from Table 2 indicate that teachers have different understandings of inquiry. All participants with the exception of teacher C associated IBP with asking questions (category 1). However, the idea of asking questions was viewed from two perspectives. One set of teachers (A, E, F, H and I) referred to the teacher asking questions and students providing answers to these questions (subcategory 1a). This is revealed in the following typical excerpts.

> Inquiry-based learning begins with [me] asking questions or problems that are closely related to everyday practices and development of students' curiosity, critical thinking, and problem-solving skills (Teacher I).

On the other hand, teachers B, D, G, J and K viewed IBP as the teacher providing relevant everyday contexts that encourage students to ask and explore their own questions and seek their own answers (subcategory 1b). This is evidenced in the following extract.

> Inquiry learning focuses on moving students beyond general curiosity into the realms of critical thinking and understanding. You must encourage students to ask questions and support them through the investigation process, understanding when to begin and how to structure an inquiry activity. However, it is important to note that the different forms of inquiry-based learning, which incorporates confirmation, structured, guided, and open approach becomes decreasingly structured to suit different classrooms. (Teacher B)

Some of the teachers' descriptions of IBP contained more than one aspect of inquiry practices and thus are classified in more than one category. For instance, teachers F, G, H and J also associated

IBP with engaging students in project activities or individual learning (category 3). This was illustrated by the description of classroom practice of Teacher F:

> What I usually do is to make sure that my students make an active contribution in the class while I (teacher) provide some kind of guidance for them by giving them questions that will arouse their (students) interest with which they will carry out research and share their findings. I just have to guide them so that it will be within the scope of learning … that is, the scheme of work.

In addition, the data show that teachers B, C and G also associated inquiry with conducting experiments (category 4). This was revealed when teacher B demonstrated that he had a sophisticated understanding of IBP because he was able to explain some aspect of IBP such as practical investigative work and levels of inquiry in his description (see the quote above). However, it was found that none of the teachers except for teacher C mentioned discussions with peers (category 2) in their description of IBP. This was revealed when teacher C said,

> Most times we do group work and what I do is that I engage them in simple steps that they have to follow when doing science lessons like perform experiment in groups, observe a phenomenon, and allow them to draw conclusion from their observation.

In summary, four clusters of teachers have been identified in terms of their understanding of IBP, i.e.

Cluster 1: teacher asks questions, students respond (teachers A, E, I).

Cluster 2: teacher sets questions, students engage in project activities (teachers F, H).

Cluster 3: teacher sets context, students generate questions (teachers D, K).

Cluster 4: teacher sets context, students generate questions, and do investigations (teachers B, C, G, J). However, in case of teacher C, IBP is associated only with students engaging in investigations.

The analysis above implies that all the teachers have an incomplete understanding of IBP as noted by Leon (2015), which may result in their inability to enact inquiry practices effectively and appropriately in the classroom, supporting Ssempala (2017).

The Relationship Between Teachers' Understanding and their Reported Practice of IBP

The relationship between teachers' understanding of IBP and their reported use of IBP in science classrooms was explored using patterns in teachers' responses to the Likert scale items within each of the four clusters. The frequencies of the use of various IBP practices reported by the sample of teachers are summarised in Figure 1.

The result of participants' responses show that cluster 1 teachers (IBP is teacher asks questions, students respond) primarily reported frequently using practices in items 1, 2, 3, 5 and 14 with their students. Whereas item 3 (ask and/or answer questions) and item 14 (generate and compare solutions) align with this understanding of IBP, the other practices (the development of ideas for ways of confronting the problem posed; the use of brainstorming and the refinement of models for understanding concepts) contradict these teachers' understanding of IBP.

On the other hand, teachers in cluster 2 (IBP is teacher sets questions, students engage in project activities) indicated that they frequently use items 3, 7, 8, 14, 16 and 18. Thus, cluster 2 teachers' understanding of IBP corresponded to their responses to item 3 (ask/answer questions leading to engagement in other practices) and to item 7, in which they stated that students frequently create or design joint products/ideas using contributions from peers or classroom activities, by generating and comparing solutions to (given) problems (item 14) and arguing using their evidence (item 16), then analysing competing perspectives (item 18). The data suggest that teachers in cluster 2 enact their understanding of IBP in their classroom teaching.

Although items 2, 3, 5, 7–10, 13, 17, 18 and 20 were identified as the common inquiry practices frequently used by teachers in cluster 3, their responses to the Likert scale items do not correspond to their understanding of IBP as teacher setting context and/or students generating questions which aligns more specifically with item 1.

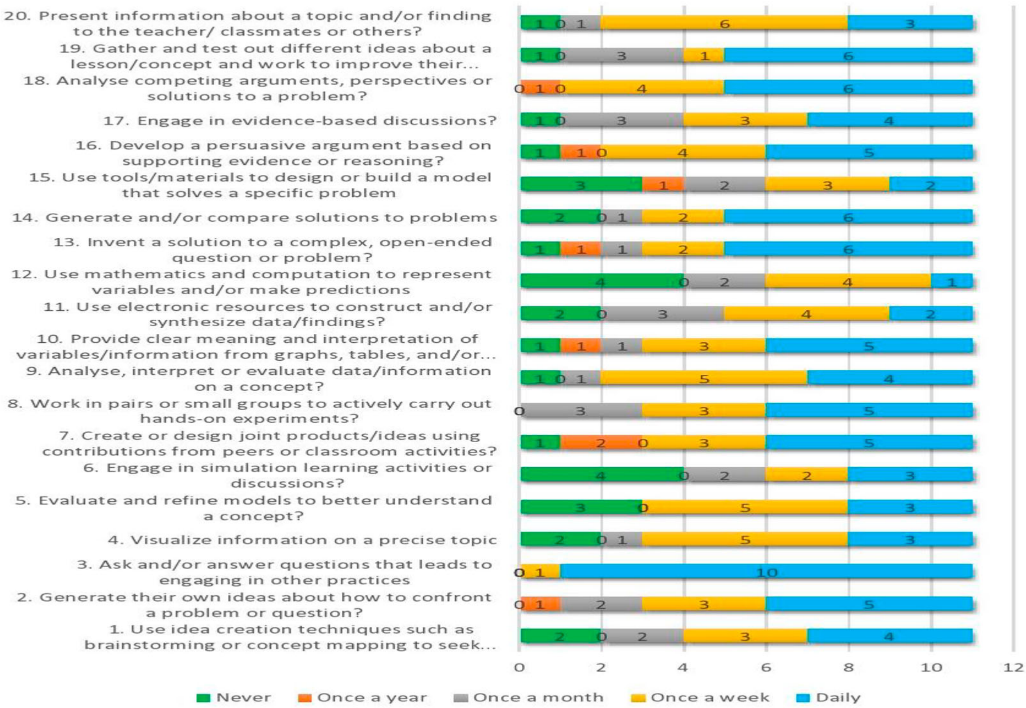

Figure 1. Participants' responses on the frequency of their use of inquiry practices.

In contrast, the responses of cluster 4 teachers to the Likert scale items 1, 3, 4, 8, 11, 15, 16, 18–20 shows that they engage their students in the indicated practices on a daily or weekly basis. Thus, cluster 4 teachers' responses to items 1 and 8, which state that teachers frequently encourage students to use idea creation techniques such as brainstorming or concept mapping to seek answers to their own questions and work in pairs or small groups to actively carry out hands-on experiments, aligned, in particular, with their understanding of IBP as teacher sets context and students generate questions and do investigations.

These results show that there is a weak alignment between teachers' understanding of IBP and their reported practices, thus implying that teachers' knowledge of IBP is not the main factor determining their classroom practice (Saad & BouJaoude, 2012).

In general, Figure 1 reveals that all the teachers with the exception of teacher C reported that they encourage students to ask and/or answer questions that lead to engaging in other practices on a daily basis, suggesting that many teachers think that IBP is the common question-and-answer strategy (item 3). Although this is an example of a non-IBP practice, not all lessons are fully IBP, and thus non-IBP practices may occur frequently in a science classroom. Nevertheless, teachers' responses to the Likert scale items indicate that non-IBP practices such as items 3 and 20 are frequently used in teachers' classrooms on a daily or weekly basis. Additionally, teachers in clusters 2–4 reported that they encourage students to actively participate in hands-on experiments, either in pairs or small groups (item 8) on a weekly or daily basis, thus implying that the majority of the teachers tend to associate IBP with small group discussions (category 2). Also, item 18 (analyse competing arguments, perspectives or solutions to a problem) was commonly reported as a daily practice among cluster 1, 3 and 4 teachers (B–E, G and J). However, analysis of teachers' responses to the Likert scale items reveals that most of these teachers engage students in activities that focus on basic inquiry abilities rather than the essential features of inquiry (Capps & Crawford, 2013).

What Barriers do these Nigerian Science Teachers Perceive to Inhibit their Practice of Inquiry-based Pedagogy?

Analysis of participants' responses to the interview and open-ended questions revealed large classroom size and time constraint to be a barrier that hinders teachers inquiry practice in science classrooms. For instance, this was noted when Teacher A said:

> Seriously, Inquiry-based learning is good because you see, it allows students to have prior knowledge of what is going to be treated in the class and you know it kind of encourages peer mentoring plus the fact that it helps to make my class interesting sometimes because the students become actively involved. But it is very time-consuming for a teacher like me who happens to be the only chemistry teacher in a school with a population of 473 (89 in SSS3, 159 in SSS2 and 225 in SSS1) science students. (Teacher A)

Overcrowded classrooms have commonly been cited in the literature as a potential threat to teachers' implementation of inquiry practices (Fitzgerald et al., 2019; Ramnarain & Hlatswayo, 2018). This finding is in line with Fitzgerald et al. (2019), who argued that carrying out effective inquiry practices like hands-on experiments and investigations is seemingly reduced in science classrooms with a larger population owing to the sense of unsafeness.

The issue of time constraint was peculiar to cluster 1 teachers, as it was also emphasised by teacher I, who stated that planning inquiry lessons takes an inordinate amount of time and prevents him from completing the actual teaching recommended in the syllabus. In addition, it was found that teachers' perceived challenges regarding time were also associated with their (teachers') beliefs about students' learning and motivation, which includes students' unwillingness to engage with in-class activities, low confidence in asking questions or explaining the knowledge they have already received, and inability to provide detailed answers to questions asked as indicated by teachers in clusters 3 and 4 (B, D, J). This viewpoint corroborates with previous findings which demonstrate that teachers' perceptions and beliefs about the importance of inquiry to students' behaviour, classroom teaching and management practices play a crucial role in the effective enactment of IBP in science classrooms (Ramnarain & Hlatswayo, 2018).

During the interview, four teachers from clusters 1 and 2 (A, E, F and I) expressed significant frustrations with the use of ICT resources to facilitate students' inquiry activities. This was noted when they stated that their schools lacked technology resources and that even schools with a room full of computers lacked internet access.

Although all the teachers mentioned that they had once attended a professional development programme on inquiry-based learning, eight of them stated that the training was not adequate to enhance their effective implementation of inquiry in the classroom. One of the participants said:

> I can remember going for a two-day in-service training programme … but the programme was not intensive as I had expected, and it was delivered in the traditional mode (like storytelling). So, we were given a module to take home and read during our free period and advised to follow the steps in the module. That was all to the training. (Teacher A)

In summary, the major impediment between teachers' understanding and implementation of inquiry as reported in this study appears to be caused by intrinsic and extrinsic factors such as lack of appropriate instructional materials and inappropriate professional development on inquiry teaching methods (Ramnarain, 2016).

Conclusion and Recommendations

This study investigated the relationship between high school teachers' understanding and their reported practices of inquiry-based pedagogy in Nigerian science classrooms. It was discovered that all of the teachers' descriptions of IBP were incomplete. Four clusters of teachers were identified based on their description of IBP. Teachers' understanding of IBP was interpreted as: teacher poses questions, students respond (cluster 1); teacher poses questions, students engage in project activities (cluster 2); teacher sets context, students generate questions (cluster 3); and teacher sets context, students generate questions, and conduct investigations (cluster 4). The findings of the study further revealed that frequently engaging students in the creation or design joint products/ideas using contributions from peers or classroom activities was reported as a common practice among cluster 2 teachers, while frequently encouraging students to use idea creation techniques such as brainstorming or concept mapping to seek answers to their own questions and work in pairs or small groups to actively carry out hands-on experiments was reported as a common practice among cluster 4 teachers, which partially relates to their understanding of IBP. While the responses of cluster 1 and 3 teachers to the Likert scaled items reflected a set of inquiry skills commonly reported to be practised in the classroom, none of their reported practices corresponds to their understanding of IBP. Thus the findings show a weak relationship between teachers' knowledge and reported classroom practice. This implies that teachers' knowledge of IBP does not always translate into classroom practice.

The relationship between teachers' understanding of IBP and their reported practices within each cluster were found to be inconsistent owing to a variety of factors, including unavailability of time, students' lack of confidence, large classroom size, inadequate provision and the use of technological resources. The findings also revealed that most of the teachers expressed concern about insufficient professional development on inquiry which is based on the traditional talk and chalk approach. Regardless of the methods that teachers reportedly use in enacting inquiry in their classrooms, it is recommended that educational stakeholders should actively promote the formation of communities of practice across schools to assist teachers in learning how to teach using IBP, or joint development of teaching materials for the use of IBP specifically in large and/or under-resourced science classrooms. This may contribute to the development of teachers' understanding and skills of implementing IBP, enabling Nigerian students to develop science practices and process skills that could help improve their science achievement.

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Competing interests

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