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ORIGINAL PAPER

Students' views on what aids their learning of school science in Lagos state, Nigeria

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Abstract

In Nigeria, school science education is believed to be impeded by multiple issues, in part resulting from limitations on funding, but there is a dearth of research that attends to the views of learners themselves. The aim of this study was to explore the views of secondary students in Lagos, Nigeria about the school science teaching they received. A multiple case study research design was employed and semi-structured individual ($n=26$) and group ($n=4$) interviews were undertaken with 14–17-year-old students from four non-fee-paying, mixed-sex public secondary schools. Sampling was purposive, so that the four schools were fairly typical of secondary schools in Lagos, while the interviewed students were preparing to study science at university and follow science career pathways and included both students who were engaged in terms of their participation in class and those who appeared withdrawn. Analysis was undertaken within a theoretical framework derived partly from Vygotsky's socio-cultural theory of teaching and learning and partly from Watkins' theories of learning. Students articulated how certain teaching methods, such as learning with and from others in group work, using familiar examples as applications of knowledge and undertaking practical work, were felt to aid their learning of science. These views align with the sorts of approaches to teaching and learning advocated by both Vygotsky and Watkins. It was concluded that there exists quite a gap between what the students said were effective ways of their being taught science and what were often their experiences. Some of the differences are to do with funding shortages but others are to do with pedagogy and terminal assessment.

Keywords Students' views · Nigeria · Secondary school science · Vygotsky · Chris Watkins

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Introduction

Calls for reforms in school science education point to the need to improve pedagogy so as to build a strong foundation for students, whether they go on to follow a career in science or use their science understanding, knowledge and skills to help them solve the everyday socio-scientific problems they face and to make decisions (Sarkar and Corrigan 2014; Tilsen et al. 2021). In Nigeria, the focus of this study, as in many other countries, the calls for reforms in science education are based on the premise that positive developments within today's societies are largely because of the contributions that science and technology can make in many fields, such as communications, agriculture, medicine and energy (Furió et al. 2002; Holbrook and Rannikmäe 2007).

There is a long history of science in Nigerian schools, with the subject first being introduced in some schools and for certain students during the second half of the nineteenth century (Ogunniyi 1986). The key consideration in the minds of Nigeria's leaders after gaining independence in 1960 was that without a science and technology base, economic development of the country could not be achieved. This required the establishment of national policies on science teaching and the development of a curriculum that would lead to the generation of scientific and technological products (Ogunniyi 1986). Nigerian leaders thus adopted this new reform to move away from the system instituted by the colonial dominators and that of the African traditional educational system (Jegede 1997). Science now became a part of the curriculum in all schools, for all students.

Kaptan and Timurlenk (2012) extended the arguments that had been developed in wealthy, industrialised countries for the learning of science to developing countries, asserting that large numbers of people do not understand science or its valuable potential with respect to economic and social development. In Nigeria, a developing country, science education in schools is generally held not to be as successful as it might be, in part because teaching and learning are impeded by multiple issues resulting from limitations on the funding of the educational system (Okedeyi et al. 2013). Poor funding has resulted in laboratory equipment shortages, poor classroom environments and, by Western standards, very large classes. Consequently, many students study science by memorising facts, which they find boring (Agbowuro et al. 2015).

Learning something new depends upon the experiences and knowledge one has and brings to the learning situation (Kruckeberg 2006). Learning is therefore a cultural activity, and it has long been argued that for African students, as with others, to make sense of science, it needs to be presented to them in a way that connects with their prior knowledge (Ogunniyi 1986). Teachers' considerations of learners' ideas of phenomena within their socio-cultural milieu before being introduced to the ideas of science align with Vygotksy's socio-cultural model of science learning (Seah et al. 2014). However, the issue of large classes and inadequate resources poses challenges for teachers in implementing interactive teaching strategies based on a socio-cultural approach (Hardman et al. 2008).

The research question for this study is 'What are the views of 14–17-year-old students in Lagos State, Nigeria about what aids their learning of school science?'. Knowing how students experience teaching and learning is of help to teachers (Reay 2006), especially in planning science lessons. Likewise, listening to students' voices can help practitioners and policy makers to understand the many challenges students face in school contexts (Robertson 2015). However, there appears to be a paucity of studies in Nigeria that have gathered data for this age range of students on what helps them in their science learning. Much of the available recent literature seems to focus on the teaching and learning of science in higher education (e.g. Olatunde-Aiyedun and Ogunode 2020) or, in schools, on e-learning (e.g. Akanbi 2020). However, Ojelade et al. (2020) did investigate the effects of audio-visual instructional materials on the teaching of science concepts in secondary schools in Abuja, Nigeria, finding that such materials could enhance the effectiveness of learning science.

Theoretical framework underlying science teaching and learning

In this study, the theoretical framework is derived partly from Lev Vygotsky's socio-cultural theory of teaching and learning and partly from Chris Watkins' theories of learning, which incorporate some of Vygotsky's thinking. These theories were chosen for their suitability as they complement one another in helping answer the research question and are used as lenses to explore students' views on teaching approaches that could aid their learning of science.

Vygotsky's socio-cultural theory of teaching and learning

Lev Vygotsky believed that a person tries to construct knowledge in attempting to make sense of a concept, and during this mental process, the role of the social and cultural milieu of the person cannot be underrated (Vygotsky 1986; Howe 1996; Stears 2009). Using students' prior ideas acquired through their previous experiences of scientific phenomena has been emphasised as necessary in science education as a way of aiding the students' understanding of scientific concepts (Stears 2009). The unveiling of scientific ideas takes place through the social interaction between students, their teacher(s) and the cultural context. Teacher attempts at the mere transmission of scientific knowledge will not enable students' prior ideas of phenomena to be explored, and this will not help students to understand the new ideas being introduced (Cobern 1996). To enable students to learn science effectively calls for the adoption of student-centred teaching methods to engage students actively in class (Okedeyi et al. 2013; Aksela 2019).

Vygtosky, in his quest to understand the development of scientific concepts in a child's mind, proposed that there is an element of contention between the everyday concepts the child experiences and that which is taught in school (Vygotsky 1986). In his study of the development of concept formation, Vygotsky concluded that the child's spontaneous concepts work their way 'upwards' towards abstractness and clear the way for scientific concepts, which work their way 'downwards' towards being concrete (Vygotsky 1986). When the child is unable to link these two levels of concepts, there will not be comprehension or development of scientific knowledge. Therefore, if students are to be enabled to develop scientific knowledge, they must be aided to bring forward and apply what they experience within their everyday environments to make sense of the concepts taught in class. Conversely, students can utilise the developed scientific conceptual knowledge and ways of thinking to explain the world around them. According to Omorogbe and Ewansiha (2013), when this takes place, it shows that effective learning of science has taken place.

To give an example of spontaneous and non-spontaneous scientific concepts in a Nigerian context, students might have experienced the everyday phenomenon of heat transfer, for instance when they cook at home and use napkins to hold a hot pot by the handle to avoid hurting themselves. However, the scientific term 'conduction' and the associated scientific concept might be foreign to them; being able to discuss their everyday experience of this phenomenon among themselves and with their teacher should aid their understanding of the scientific concept. Students can go home, where they experience this phenomenon, and can begin to align their everyday experience with the scientific understanding of the phenomenon, using scientific language to explain this process of heat transfer. This process signifies a back-and-forth movement in students' minds between spontaneous and non-spontaneous concepts (Vygotsky 1986). However, are students within Nigeria's secondary school science classrooms able to make such links by reflecting on and discussing their spontaneous concepts? Cobern (1996) alluded to the possibility of students in developing countries not making sense of scientific concepts that are foreign to them, and this could be due to the method of instruction adopted within the science classroom.

Watkins' theories of learning

In his book *Classrooms as Learning Communities*, Watkins defined learning as a key process that humans go through to seek a product, in this case, knowledge (Watkins 2005). On the learners' part, Watkins et al. (2001) maintained that there is a connection between students' conceptions of learning and how they learn. Watkins et al. suggested that students' conceptions of learning relate to their beliefs about success, what motivates them to learn and their response to difficult tasks. According to Watkins et al. (2001), students who have a 'learning orientation' as their motivational theory have the following attributes: they believe that effort leads to success; believe in their ability to improve and learn; prefer challenging tasks, which gives them satisfaction when they succeed in such tasks; and self-instruct when engaged in tasks. On the other hand, students who have a 'performance orientation' believe that ability leads to success, and they are concerned about being judged on their ability to perform. In addition, they derive satisfaction from doing better than others; their emphasis is on standards, competition and public evaluation, and they evaluate themselves negatively when faced with a difficult task (Watkins et al. 2001).

According to Watkins (2006), when students' focus is on learning, performance is enhanced, and when it is on performance, performance is depressed. Watkins et al. (2002) assert that students' conceptions of learning depend on their experiences of styles of teaching, their attitudes towards learning and the assessment system in place. A synergy between students' and teachers' conceptions of learning as fluid and dynamic leads to outcomes such as knowledge; skills; actions; positive feelings and emotions, such as success and satisfaction; creative ideas and strategies about learning; affiliation to learning; having a sense of oneself as a learner; having knowledge of others and interacting with them; and having a sense of membership of a community (Watkins et al. 2002).

Watkins described three views of learning found in classrooms today: learning as being taught; learning as individual sense-making; and learning as building knowledge through doing things with others (2005, pp. 15–17). Learning as 'being taught' is likely to pervade sites of traditional teaching, where the teacher transmits content to the students, and they are assumed to learn by being told this information and memorising it. In other words, this approach to teaching is curriculum-driven. Furthermore, this view of learning as being taught does not necessitate interactions among learners (Kaptan and Timurlenk 2012), and students may find it challenging to discuss and express their thoughts when they believe that learning means being taught. Therefore, learners are less likely to develop understanding of scientific concepts (Osborne and Freyberg 1985; Kruckeberg 2006), and are more likely to consider themselves as passive recipients of knowledge (Watkins 2005; DiBiase and McDonald 2015; Duve et al. 2021).

The process whereby learners make sense of their experiences, relate them to past experiences and take learning forward into the future is the second view of learning presented by Watkins (2005). This view is related to constructivism as described by Piaget (Mercer and Howe 2012). In this case, the learner is involved in their own knowledge construction, and the teacher is not seen as transmitting knowledge but as helping the learner to construct it. Teachers' approach to learning in this sense puts the focus on learners, and tasks given to them are assumed to promote their thinking and processing. The learners have active roles to play during the process of learning; they plan and reflect on their style of learning and how they will engage themselves during the process of making sense of knowledge both now and in the future. Also, learners are encouraged to help themselves understand concepts by using experiences within and outside the classroom as resources for learning.

The third view of learning brings in a social facet to knowledge construction and places importance on the context where this takes place. According to Watkins (2005), human behaviour is 'fundamentally social' and therefore discourse among interactors plays a key role during the social construction of knowledge. Watkins connected this view of learning to the co-construction approach to learning, which focuses on the classroom as a community of learners where tasks involve the creation of knowledge by all learners in mutual interaction (Watkins 2005). Students as participants learn from each other, as they also help one another to learn. Furthermore, students are more likely to be motivated towards learning when it is assumed to be social, and they take responsibility for their choices and their outcomes. They reflect on what they are learning, and they act as researchers in building increasingly complex constructions of knowledge for mutual benefit.

In summary, Vygotsky emphasised the need, if a student is to learn, for them to construct their knowledge. What the skilful science teacher does is to enable a school student to do this while also coming to understand key scientific concepts, as held by scientists. Watkins stressed that students learn best if they have a 'learning orientation' rather than a 'performance orientation', the irony being that if a student's focus is on performance, their performance as well as their understanding is typically lower than when the student does not focus on how well they are doing (their performance) but simply on what they are learning. In his third view of learning, Watkins emphasised the social nature of learning, as had Vygotsky before him.

This study therefore uses both Vygotsky's socio-cultural perspective and Watkins' third view of learning because these complement one another, give weight to the central role of social interaction for learning to take place, and approach learning from within a tradition that values the active construction of knowledge by learners (cf. Lemke 2001). This perspective therefore considers the learning approaches that students bring to their study, which helps determine how such interaction aids in the construction of scientific knowledge (Chin and Brown 2002).

Research context and methods

Context and participants

The research described in this paper is part of a multiple case study conducted in four senior secondary schools in Lagos State, Nigeria, to understand the science teaching and learning within that context. Lagos State is the most populated state in Nigeria with a population of over 20 million people and is expected to take the lead regarding the number of students enrolled into schools (Gbenu and Lawal 2017). The high population in Lagos State is partly a result of the inflow of people from other states in Nigeria driven by business and economic growth (www.lagosstate.gov.ng, 2021).

The focus in this study is on non-fee-paying public secondary schools, where there are large class sizes (typically, about 70 students in a class) and inadequate equipment (Mohammed 2013). Secondary schools are of two types: Junior Secondary schools (with students typically aged from about 11 to 15); and Senior Secondary schools (with students typically aged from about 14 to 18). There are six educational districts in Lagos and three of these were selected for the main study, due to their accessibility. Four mixed-sex Senior Secondary schools were selected from across the three districts in the more populated areas. Each of these schools had between 818 and 920 students. These schools were chosen because they were fairly typical of Senior Secondary schools in Lagos State. In particular, they had students from a diversity of linguistic backgrounds, most of the students had working class parents or guardians (rather than being socially advantaged), classes were large (by the standards of science classrooms in economically advantaged countries) and the science laboratories were not well equipped (again, by the standards of science classrooms in economically advantaged countries); the examination results were slightly below average for Senior Secondary schools in Lagos State.

The research's emphasis is on Senior Secondary education because the goal at this level, as stated in the National Policy of Education, is to prepare students for useful living in society and for higher studies in tertiary institutions (Gbenu and Lawal 2017). Because this study is about science learning, 26 students aged 14–17 who were preparing to study science at university and follow science career pathways were selected. These students were purposively sampled after consultation with their teachers with regard to the students' levels of participation in class, so that the sample included both female and male students, and both students who were engaged and those who appeared withdrawn.

Research methods: data collection and analysis

To understand how students experience teaching and learning of science within a context facing issues resulting from low funding of public schools, a qualitative approach was employed to allow for deeper attention to be given to the views of students. Data were collected by audio recording semi-structured individual and group interviews, which used open-ended questions. The students were asked questions that related to the main research question, 'What aids your learning of science in school?'. Suitable times to interview students were arranged before the interview took place, so that none of the participants missed out on any lesson: students were interviewed during their lunch breaks. All 26 students were interviewed individuals (mean duration 12 min) and 23 of them also participated in group interviews (mean duration 32 min: three groups each with six students and one group with five). All interviews were transcribed for subsequent analysis. Ethical approval was granted by the authors' university.

As most secondary public schools in Lagos face the same sorts of issues as the four research schools faced, it is likely that the results from this research have relevance to other secondary public schools within Lagos. To enhance reliability, interviews were listened to repeatedly and transcriptions were cross-checked to ensure that interpretations made aligned with the participants' responses. Common Nigerian names were used as pseudonyms for the interviewees, and these indicate gender.

Transcripts were repeatedly re-read by the first author for the purposes of coding. Thematic analysis (Bryman 2012) was employed and an inductive approach was used in that initially themes were allowed to emerge from the data and discussed repeatedly among the three authors; subsequently, the themes generated from the data were interpreted and explained from the theoretical perspectives of Watkins and Vygotsky. NVivo was used to assist with analysis: codes were developed and similar codes were organised into themes. In all, four themes were identified as we moved from codes to themes but two of them—'Value of science' and 'Teachers' views of teaching strategies'—are not relevant to this article. While no formal measures of inter-coding reliability were calculated, instances of coding were discussed among the three authors.

Results

The findings are presented under two themes: 'Students' preparation for lessons'; and 'Students' perceptions of teaching methods that aid learning'. The theme 'Students' preparation for lessons' contains no sub-themes, whereas the theme

'Students' perceptions of teaching methods that aid learning' contains three sub-themes: 'Group work', 'Using familiar examples' and 'Performing practical work'. The findings below are presented using this structure of themes and sub-themes.

Students' preparation for lessons

The narratives of students in this study of what aids their learning of science indicated that students saw the need to prepare for science lessons by reading ahead of and after lessons, and they felt the need to be determined to learn science. Reading ahead means that concepts are revisited in class rather than experienced anew. This could aid students' understanding of the topic when taught in class and enhance their performance in examinations. Students appeared to place importance on reading to aid their understanding of concepts:

> Because in some cases, there are some topics that you need to read, read, read and read before you understand even though the teacher explains. You need to read on your own. (Interview with Kike, School W)

It seems that students felt that teachers saw it as the responsibility of students to read after they are taught science in order to revisit the topic and reinforce and expand their understanding. Students' views about reading seem to resonate with the view of learning as 'individual sense-making' (Watkins 2005).

In conjunction with performing a considerable amount of reading to facilitate the learning of science, students cited having extra lessons after school. When asked to advise a person who wanted to learn science well, one student commented as follows:

> I will also advise the person to go for extra lessons to learn more and not rely only on what he or she is taught in school. This will help to improve a person's performance. (Interview with Titilayo, School W)

This student does not want to depend solely on what she is taught in school, which reinforces the suggestion that lessons at school are felt by students not to be sufficient to enable their understanding of science. Extra lessons within the context of this study would mean paying for private tutoring. According to Titilayo, the support she received from home, such as having extra lessons, might have contributed to enhancing her performance in examinations.

Furthermore, students spoke about their need to exhibit determination in order to learn science. For instance, one of the students in school W stated

> I will tell the person to go ahead to study science if the person is determined. We know that it is only those that are determined that try to make it in science. Anyone that succeeds in a science class did so because of his or her ability and determination. (Interview with Valerie, School W)

According to Valerie, students must be determined to learn science. Determination could be related to self-efficacy, having a belief and confidence in one's ability to do something (Tsai et al. 2011). Valerie's use of the phrase 'make it' appears to mean that students will understand scientific concepts and succeed in examinations if they are determined. Relating the learning of science to being determined implies that science can be challenging for students to learn. This student's view also seems to rest in part on a performance orientation, where the belief is that students' ability as demonstrated in examination results implies success (Watkins et al. 2001).

In summary, students tended in part, in the language of Watkins (2005), to view learning 'as being taught', as they believe that their ability and determination aids their success. However, there were also instances of learning being viewed as 'individual sense-making', when they read before and after being taught, and as 'building knowledge through doing things with others' when they engage with extra lessons at home.

Students' perceptions of teaching methods that aid learning

Students expressed their views of how teaching methods, such as group work, using familiar examples as application of knowledge and doing practical work, appeared to aid their learning of science.

Group work

During data collection in one of the schools, two science teachers agreed with the researcher to put the science students in groups to have them interact during, and be more involved in, a few of the lessons. Students in this school after the intervention explained their views on working together in groups during those science lessons:

> Grouping is good because our teacher may teach us and some will not understand, but when she places us in groups it will be like a revision class and those who don't normally participate will do so. Even those that do not understand the topic will do so when the person from their group is explaining. (Interview with Christie, School W)

> I think it helps in a way but when you gather as a group like that, what I realise is that we children learn more from ourselves. (Interview with Bianca, School W)

Enabling students to explain concepts to each other, instead of relying solely on their teacher for explanations, was felt by students to help them understand the topic. This implies a need for students who fully grasp the relevant scientific concept to help those who are still trying to master these so that the latter can acquire the requisite knowledge and understanding. Students' opportunities to learn in this way are facilitated when they are allowed to discuss concepts. Christie's and Bianca's views of collaborating in groups resonate with Watkins' (2005) argument that students' sense of community increases as they become more involved in lessons, which further enhances intrinsic motivation. Another student's narrative corroborates Bianca's view of group work:

> I love the method a lot because when one student came out to teach it made the lesson lively. This is because you can easily ask the student questions

> and he will answer you in a way that you will get it easily, unlike the teacher. (Interview with Valerie, School W)

Valerie's quotation demonstrates that students' perceptions towards grouping methods can be positive and attest to their enthusiasm for involvement during the lessons. According to Valerie, having another student explain a concept instead of the teacher made the lesson more engaging. Furthermore, Valerie's quotation indicates that grouping enabled students to take ownership of their knowledge, especially when explaining concepts to their fellow students, and opportunities were created for them to freely ask questions of each other. Students' social interaction during the group discussion of concepts, which enabled them to share ideas and facilitated their learning, illustrates Vygotsky's notion of the zone of proximal development (Vygotksy, 1986), in that students are helped by the more knowledgeable ones to make sense of concepts.

Having students work in groups thus appears to improve students' participation, even within the context of a large class (of 70 or more students). According to one of the students

> The group method is actually a good one because as we are many in the class, when only the teacher is speaking, many of us do not listen. But the group method will make them contribute because they will not want their groups to fail or fall behind, so they will want to talk and contribute to make their group better. (Interview with Violet, School W)

This student's narrative suggests that a perception that it is teachers, rather than students, who mainly speak during lessons, which is consonant with the understanding of learning as 'being taught' (Watkins 2005). A lack of participation means students are less likely to be attentive during lessons, especially in large classes. As Violet stated, placing students in groups provides the opportunity for contribution during the lesson in a cooperative (although also competitive) way. With respect to participating in groups, another student stated:

> Even if our apparatus is not enough, they can group us table by table and they should put apparatus on each table; at least if not all the students can use it, we can see those using it on our table, do things ourselves, and everyone will contribute on the steps to take. (Interview with Lanre, School W)

Students are motivated to participate when they are placed into groups to teach each other and clarify the concepts they did not understand after 'being taught' by their teachers. Lanre commented on students' collaboration in groups during practical activities, especially when there is not enough apparatus to go round. Watkins and Vygotsky lay emphasis on the discussion of ideas through social interaction between students and teachers to aid students' conceptual understanding (Vygotsky 1986; Watkins 2005).

Furthermore, being able to participate during the lesson motivates students to engage in individual sense-making by reading and preparing ahead for lessons, as stated by Gregory:

> Group methods help in making us to go home and learn more about the topic. So, when the teacher explains the topic in class, it looks like something I have learnt before. (Interview with Gregory, School W)

According to Gregory, reading ahead for lessons and revisiting the concepts in classrooms can help students develop their understanding. Overall, use of student group work was felt by the students to be more effective at aiding their comprehension of concepts than relying only on traditional, didactic teaching, at least in part because it aided students' participation in lessons, which led to discussion of ideas and construction of concepts.

Using familiar examples

According to Probyn (2001), students' understanding is aided when teachers explain concepts using examples that are familiar to students. Indeed, in this study, students expressed the view that learning science is aided when teachers explain concepts in this way. One of the students in the physics class in School Z offered an example to explain the concept of acceleration:

> Oscillation and acceleration are related to everyday things around us. For instance, a moving car can be used to explain acceleration. (Interview with Yemi, School Z)

Yemi linked an everyday example (a moving car) to the scientific concept of acceleration, which suggests that this student has been able to make sense of the concept. It is possible that Yemi repeated the example his teacher had used to explain the concept in the classroom; nevertheless, the example might have helped him to learn more about the concept, as he was able to relate it to a familiar object in his own environment. This seems to point to Watkins' second view of learning as individual sense-making where teachers aid students' understanding of concepts as well as pointing to his emphasis on drawing on the social world in learning (Watkins 2005). Furthermore, it relates to one of Vygotsky's propositions of using examples that are familiar to students to make sense of the science concepts taught in classrooms (Vygotsky 1986).

Other students also described the use of familiar examples to explain concepts:

> If those things (concepts) are around us, they can give them to us as examples. Like when we were looking at amoeba, she told us that it is an organism that can be found in a wet environment, and she demonstrated how they look for their food and can be found where we see dirty water. So now we know that where there is water on the ground, there would be some organisms there. (Interview with Florence, School Z)

Florence's narrative of teachers relating scientific concepts to examples that students see around them illustrates how such examples can help students to make sense of science. Citing how her teacher illustrated what an amoeba is and its behaviour and habitat, and the impact of this on her application of knowledge indicates the impact of such illustrations on Florence's learning. Being able to apply scientific knowledge to contexts outside the classroom could reinforce such knowledge, as stated by the following students:

> I would like them (teachers) to use examples I can see around me to explain. This will help me to understand science. (Interview with Dorcas, School Z)

> The best way is for my teacher to use what I see every day or do every day to explain science topics. This is because it will be a part of me. (Interview with Pero, School Z)

According to these students, using familiar examples to explain topics aids their understanding of scientific concepts and yet this strategy was, according to the students, not often used. The students' views resonate with Sadler and Zeidler's (2009) argument that concepts which relate to students' lives and focus on socio-scientific issues enable students to reason and socially engage, and motivate them to participate in class. Pero's use of the phrase 'it will be a part of me' suggests that students are able to make sense of and construct knowledge and that this then stays with them and becomes owned by them. Knowledge that becomes part of students' lives can then be applied in contexts outside the classrooms.

Performing practical work

One component of practical work in school science entails the 'doing of science' that mirrors the actual practice of scientists (Abrahams 2011). Students identified a correlation between performing practical work and developing an interest in science. For example, one of the students stated

> What actually motivated me to be in the science class is the practical, which I watch on the television and see how little children who do experiments find out things. (Interview with Goke, School X)

Seeing on the television how young children undertake experiments motivated this student to study science. Perhaps the practice of scientists is of interest to the student; this would align with Abrahams' (2011) argument that practical work motivates and makes students generate personal interest in science. Another student explained

> I was inspired to study science when I was in my previous school. Any time I saw the senior students they mostly did practical work like opening up some specimens and closing them back as if they are performing surgery and this surprises me. (Interview with Linda, School W)

The word 'surprises' indicates that what the student saw was novel and, for this reason, she became interested in knowing more about it; hence, her choice of science. In line with Linda's statement, being able to experience objects that they could manipulate may have been one of the reasons why students like to do practical work. For instance, one of the students stated

> I will prefer a method based on doing project more than theory. What I mean by the project is practical work than just theory, doing writing. I like practical

> work because dealing with something physically makes you have the experience rather than just theory, writing. (Interview with Alfred, School W)

As Alfred suggests, performing practical work enables students to experience real objects. The word 'experience' could be explained in terms of the phrase 'dealing with something physically' in Alfred's statement. This means being able to come into contact with and work with these tangible objects, which might be novel for these students and constitute an active form of learning that was not common in their classrooms. The word 'experience' also relates to Vygotksy's socio-cultural perspective of learning and Watkins' 'doing with others', whereby when students undertake practical work with others, they are enabled to achieve a greater complexity of knowledge (Howe 1996; Powell and Kalina 2009). The students mostly seemed to prefer undertaking practical work to listening to teachers' talk, which Alfred refers to as 'theory' in his narrative.

Students further related doing practical work to helping them learn scientific concepts they read about in textbooks, some of which they found difficult to comprehend:

> Yes; I would like to do practical work because, especially with chemistry and physics, I find them difficult, I am not able to understand. (Interview with Zara, School W)

> Yes, because practical work will help me in my reading. What we are reading in the textbook, we can see it when doing practical work and I'm able to understand it. (Interview with Thomas, School W)

> Yes; it helps us to learn more. Like for me, I don't have a chemistry textbook and if we do a practical on chlorine, that would help me to know more about it. It will help me to know more about other topics; it enhances learning. (Interview with Donald, School W)

The students Zara, Thomas and Donald expressed their positive view of performing practical activities to explain topics and aid their understanding. For instance, Zara refers to chemistry and physics as difficult and argues that conducting practical work helps relate scientific concepts to what she can see and touch, which aligns with the view of learning as individual sense-making related to the social environment (Watkins 2005). Of interest is Donald's statement that performing practical work enhanced his learning of a topic even though he does not have a textbook in which to read and learn more about the topic. Indeed, during data collection, several students in the four schools mentioned not having a textbook and felt that undertaking practical work could therefore help them learn science. Another student explained why practical work aids learning:

> If the teacher only explains, some people might not understand but if an experiment is carried out, we will learn it and know how it works. (Interview with Kehinde, School W)

The phrase 'learn it and know how it works' appears to represent a view of learning as making sense of knowledge in a social environment (Watkins 2005). Learning how something works indicates possessing a considerable sophistication of knowledge about that thing. According to Kehinde, students are able to make sense of scientific knowledge when they conduct practical work. Learning as 'making sense' as well as learning as 'building knowledge through doing with others' (Watkins' third view of learning) are crucial in learning science (Vygotksy, 1986; Wellington and Osborne 2001). However, the view of learning as 'being taught' is less likely to work for the learning of science (Kruckeberg 2006).

Related to the point about practical work aiding the understanding of scientific concepts is that it may help students retain scientific knowledge. For instance, one of the students stated that

> I prefer the practical method because during exams it will be very easy for you to remember what you have done during the practical. (Interview with Charles, School W)

Charles' statement also indicated the perceived importance of examinations to students. However, does 'remember[ing] what you have done during the practical' facilitate understanding? And are students able to apply the retained knowledge? Answers to these questions are suggested by the following student response:

> If I read, I will not be able to understand properly and I will just try to grasp and assimilate what I have read. But when the teacher demonstrates and explain, I will be able to capture and remember during exams the steps followed by the teacher and this will help me better. (Interview with Linda, School W)

Linda linked watching her teacher's demonstration of the concept with her own ability to follow what the teacher is doing, which she felt would enable her to remember the processes followed and consequently perform well in examinations. In line with Linda's view, other students stated the following:

> I prefer doing practical work because whatever you practise, even if they give you an oral test, your brain is going to give you the image of what you have seen and you can get everything right. (Interview with Oscar, School W)

> My teacher's practical work demonstrations will help me because I am the type of person who retains 70% of what I see and 30% of what I read and this will help me to remember things. (Interview with Valerie, School W)

Oscar's statement indicates a perceived link between the visualisation of concepts and performance in assessments. Similarly, Valerie referred to her teacher's demonstrations in class as helpful. Overall, it seems that students believe that both undertaking practical work themselves and seeing their teachers demonstrate it to them can aid their learning.

Discussion

The Nigerian secondary science curriculum is one that makes heavy demands on learners, not least because of large class sizes and limitations on the availability of laboratory equipment and other facilities. In this study, students' views on their learning of science are interpreted within a theoretical framework drawn from the work of Lev Vygotsky and the work of Chris Watkins. Listening to students' views about practices that aid their science learning can help reveal to teachers and others how science can be taught in meaningful ways, despite the various constraints schools face in Nigeria, which include large class sizes and a shortage of specialist science equipment.

Interviews with students were transcribed and a total of four themes identified: 'Students' preparation for lessons'; 'Students' perceptions of teaching methods that aid learning'; 'Value of science'; and 'Teachers' views of teaching strategies'. In this article, we focus on the first two of these themes, as the other two are not relevant for the research question posed here: 'What are the views of 14–17 year-old students in Lagos State, Nigeria about what aids their learning of school science?'. The theme 'Students' preparation for lessons' contains no sub-themes, whereas the theme 'Students' perceptions of teaching methods that aid learning' contains three sub-themes: 'Group work', 'Using familiar examples' and 'Performing practical work'.

In terms of 'Students' preparation for lessons', students felt that they needed to prepare for science lessons by reading ahead of their lessons, and they felt the need to be determined if they were to succeed in learning science. They also felt that they had to read after lessons and that they benefit from having additional lessons (though this requires their parents/guardians to be able and willing to pay for this).

In terms of 'Students' perceptions of teaching methods that aid learning', one finding was the students' preference for the inclusion of some group work. Putting students in groups to collaborate has been found in another Nigerian study to have a positive impact on students' learning in science (Ayodele and Fatoba 2017). In our study, students indicated that they believed that group work facilitated their being able to teach one another. This view of group work accords with Vygotsky's notion of the zone of proximal development, where a more knowledgeable person scaffolds learners to think logically as they interact, in order to construct more advanced concepts (Vygotsky 1986). Students also reported that reading scientific material either before or after science lessons was a major determinant of their success in science. This supports Okedeyi et al.'s (2013) claim that successful science teaching encourages students to read their notes. It also suggests that the teaching approach during lessons was not conducive to complex understanding on its own.

Allocating tasks to students in different groups for them to talk about and allowing students to share ideas they have formed in these groups with the rest of the class could promote students' joint construction of concepts. Within each group, students' talk can entail relating scientific concepts to their prior ideas; the teacher's role in such a lesson will include promoting discussions within groups. By allowing students to discuss in groups and relate concepts to their prior ideas, students are more likely to appreciate how the scientific concepts they are being taught relate to their everyday conceptions. This conforms to Vygotksy's emphasis on the importance of social culture within a learning context and Watkins' view of learning of constructing knowledge with others.

Teachers' giving of familiar examples of how science concepts taught in class relate to their personal lives is likely to stimulate students' interest to know more about these concepts. Additionally, teachers can extend this activity by allowing students to talk and share their ideas to make sense of the concepts. This kind of talk is exploratory (Mercer 1996; Hadjicosti et al. 2021), and teachers' use of formative questions can prompt students to think, talk and understand concepts. By allowing students to connect examples of phenomena around them to science concepts, students are more likely to become scientifically literate. Promoting exploratory talk in science classrooms aligns with Watkins' view of learning as constructing knowledge with others, and with Vygotksy's proposition of aiding students to use their familiar examples of phenomena, or their spontaneous concepts, to understand scientific concepts, that is, non-spontaneous concepts. To be scientifically literate is a widespread aim of science of education, but one that is rarely being met in Nigerian science classrooms.

Practical work is another teaching method that the students claimed aids their learning in science because it requires them to work together, using equipment to make sense of abstract concepts. These reported advantages of practical work are in alignment with the findings of other researchers (Abrahams and Millar 2008; Hodson 2014; Darlington 2015). Furthermore, the purported benefits of practical work can be interpreted within Vygotsky's socio-cultural perspective on learning and Watkins' view of learning as the co-construction of knowledge, in that students are able to collaborate and make sense of concepts experientially (Vygotsky 1986; Watkins 2005; Mercer 2008).

This research was designed to explore students' views on the learning of science in secondary schools in Lagos State, Nigeria. The study has highlighted students' views of teaching strategies that they believe teachers can adopt to facilitate their learning. The students felt that group discussion of their prior ideas of scientific concepts, undertaking practical work in groups, and the use by their teachers of familiar examples to explain concepts would all aid their learning of science concepts. These methods conform closely to a socio-cultural perspective on learning, such as that advocated by Vygotsky and by Watkins.

Understanding students' views of what they believe aids their learning can provide insights for researchers to enable them to identify specific areas for further investigation. In addition, there are implications for practitioners and for policy makers. There was quite a gap between what the students said were effective ways of their being taught science and what they said were often their experiences. Some of the differences are to do with funding shortages but others are to do with pedagogy and terminal assessment. While this study is obviously limited by its reliance solely on student interviews, so that the data are of students' perceptions, specifically perceptions that they have recalled and chosen to voice to a researcher, and its relatively narrow geographical focus, it suggests a need to review the current secondary science curricula that are employed in Nigeria (cf. Chima 2021). This would be timely as it is now some twenty years after the inception of the Universal Basic Education programme in Nigeria. There is also a need for work to be undertaken in partnership with practising secondary science teachers in Nigeria to see whether the suggestions reported here for a richer classroom pedagogy are feasible and would prove successful. Focussing on the issues discussed in this paper could help to provide a richer experience of science learning for students, and improve their understanding of science, potentially of benefit both to themselves as individuals and to the country as a whole.

Conclusion

This study explored the views of secondary students in Lagos, Nigeria about the school science teaching they received. Semi-structured individual and group interviews were undertaken with students aged 14–17. A theoretical framework for the study was employed that combined Vygotsky's socio-cultural theory of teaching and learning and Watkins' theories of learning. Thematic analysis of the data shows that students believe that certain teaching methods, including learning with and from others in group work, using familiar examples as applications of knowledge and undertaking practical work, aid their learning of science. These beliefs are in alignment with the approaches to teaching and learning advocated by both Vygotsky and Watkins. However, there exists quite a gap between what the students said were effective ways of their being taught science in school and how they perceived they were often taught. Some of these differences are to do with funding shortages but others are to do with the pedagogies that teachers prefer and with how student learning in science is assessed.

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Data availability The data consist of confidential interview transcripts.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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