# INCLUSION OF SCIENTIFIC ARGUMENTATION INSTRUCTIONAL STRATEGY IN THE CURRICULUM OF PHYSICS TEACHERS' EDUCATION IN NIGERIA

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## Abstract

*Science education literature in recent times was dominated by the call for a pedagogical shift from the teacher-centred approach to a more student-centred approach to learning. One such method that has gained the attention of science educators over the past two decades is the Scientific Argumentation Instructional Strategy (SAIS). The implication of this call is that Science Teacher Education Curriculum in Nigeria, with specific reference to physics education, needs to be re-examined for the inclusion of a pedagogical approach that emphasized the use of Scientific Argumentation Instructional Strategy. The paper has adopted a theoretical approach to argue for the inclusion of Scientific Argumentation Instructional Strategy in the Curriculum of science teachers in Nigeria. The historical perspective of teacher education in Nigeria was briefly x-rayed while the conceptual and operational interpretation of scientific argumentation was presented with a special focus on claims, justification and rebuttal which are considered as the critical components in SAIS. The paper presented useful arguments to advocate the inclusion of SAIS into teacher education curriculum towards de-emphasizing focus on teacher-centred learning. A step-wise approach towards the implementation of SAIS in the physics classroom was presented while a template of instructional plan on SAIS was also proposed for the use of the science teacher educators. It was however recommended that the science teacher education curriculum should be re-designed to emphasize, encourage and promote the use of scientific argumentation in science classrooms. The secondary school physics curriculum should also be expanded to contain both the scientific and socio-scientific topics to pave for the students' engagement in scientific argumentation*.

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## Introduction

Teacher Education simply connotes the education for teachers. It refers to the total of the educational experience that deals with the systematic training, planned preparation and professional development of eligible and willing students for teaching positions, especially in the pre-primary, primary and secondary levels of education (Onah, 2005; Asubiojo & Ajayi, 2017). Teachers form a very important component in any educational system. Ogundare (2009) asserted that the teaching profession is the largest in the world. Owing to the growing population of school-age children and the emergence of so many private schools in Nigeria, the demand for teachers, either professionally qualified or not has been on the increase. Therefore, teacher education must be structured to target the excellence of preparing teachers to cause changes in education for the good of the greatest number of people.

Teacher education is not only fundamental in the educational system of a country, it is also cardinal in the growth, development and reformation of the society at large. It is therefore premised on some philosophical considerations. According to Oriaifo (2008), the considerations include:

1. To acquire theoretical and practical knowledge of the relevant subject matter.
2. Learn the methodologies of teaching.
3. Develop desirable skills through formal, informal and non-formal processes.
4. Gain requisite positive habits for teaching, responsibility, initiative, correct living and desirable values.

The policy on education (FRN, 2004) succinctly declares that teacher education shall continue to be given major emphasis in all educational planning development. This policy affirms the nation's belief in the fact that no educational system may rise above the quality of its teacher. Hence, the need for continuous deliberations on the pedagogical content knowledge and other dynamics that surround the teaching-learning enterprise becomes highly inexhaustible. This discussion seeks to open a new horizon in the methodologies that are available for the teacher trainee and re-position the in-service teachers towards a better and effective instructional delivery in the classroom. It becomes highly imperative at this juncture, to briefly examine the historical account of the emergence of teacher education in Nigeria.

**Historical Development of Teacher Education in Nigeria**

Going by the historical narration on the development of teacher education in Nigeria, it was clear that so much effort has been invested in the production of quality and qualified manpower over the years to handle the teaching profession in the national interest. Teacher preparation in Nigeria began with the establishment of the first teacher education institute in 1859 by the Church Missionary Society (CMS) in Abeokuta before it was later moved to Lagos in 1867. The training of teachers in Nigeria has witnessed different phases of growth and development as outlined by Oriaifo (2008). The Monitorial System which began in England in 1811 was extensively explored by the missionary school before the advent of the Pupil-teacher and student-teacher system which was considered by Oraifo (2008) as the genesis of the professionalization of the teaching profession. The student-teacher approach was also described by Oraifo (2008) as an arrangement whereby the pupil-teacher continues his formal secondary education while at the same time engaged in teaching. This system was short-lived as it only lasted from the middle of the 1940s to the late 1950s. The next stage in the evolution of teacher education was the teacher training system. Oraifo (2008) identified five categories of primary school teachers in this system. These include the vernacular or grade four teachers, the grade three and grade two teachers, the grade one and the senior teachers. Besides the teacher education programme that was targeted at the preparation of primary school teachers, significant effort was also made towards the training of secondary school teachers through the establishment of Advanced Teachers Training Colleges (ATTC). The year 1932 to 1961 was quite revolutionary for the advancement of the teacher education system.

The establishment of Yaba Higher College and University College Ibadan added a greater impetus to the gain attained in the country's quest for producing professionally trained teachers. The recommendation of the Ashby Commission for the establishment of Grade 1 Teachers' College and the intervention of UNESCO in 1962 was also significant in the progress attained. The ATTC later paved way for the adoption of the Nigeria Certificate in Education (NCE) which was championed by the College of Education Abraka in Delta State and Uyo in Cross River State. Teacher Education at the university level was heralded by the Elliot Commission of 1945. It must however be noted that the Ashby commission of 1959 gave teacher education the necessary thrust for effectiveness and efficiency at the university level. The report of the commission recognized the vital importance of well-trained teaching staff, noting its priority in skilled manpower training and development. It further recommended that the number of graduate teachers is radically increased to at least 50% of the total number of teaching staff on the role of any secondary. This landmark development led to the awarding of B.A. and B.Sc.(Education) in all Nigerian Universities. It is worthy of note that the University of Nigeria Nsukka was the first to inaugurate this innovative teacher education programme in 1961. The University of Ibadan followed the Nsukka example in 1963 while Ahmadu Bello and the University of Lagos began their B.Sc. program in 1963 and 1965 respectively (Oraifo, 2008). In 1967, Obafemi Awolowo University began her degree program in teacher education while that of the University of Benin commenced in the year 1973.

Despite the huge effort that has been expended so far on the development of teacher education in Nigeria, it is highly disturbing that students are still confronting learning difficulties in their science subjects. Of all the physical sciences offered in Nigeria, physics has been considered to be the most difficult, abstract and theoretical. Many students find the subject boring and un-enjoyable (Hirschfeld, 2012). Interest in high school physics is decreasing, learning motivation is declining, and the examination results are getting worse (Garwin & Ramsier, 2003). Bello and Akinfesola, (2015) observed a consistent decline in students' performance in secondary school physics between the years 2004 and 2013 with consequent low enrolment into the physics education programme in the Universities and Colleges of Education in Nigeria (Amusa, 2020). Several research studies have however attempted to unravel the possible reasons for this persistent poor performance. Owolabi and Oginni (2013) identified inappropriate teaching method while Adeyemo (2010) observed that the inability of physics instructors to make use of a variety of non-verbal teaching aids have partly culminated into low achievement in physics. Bello (2012) therefore advocated for the use of appropriate teaching methods and relevant teaching equipment. This position was further corroborated by Jegede and Adedayo (2013). Adeyemo (2010) however advocated for the use of guided discovery and other methods that emphasized students-centeredness and not the routine traditional lecture method of teaching.

Samela (2010) had argued that the teacher's inadequate pedagogical content knowledge and qualification are some of the reasons for the low achievement in physics. Another factor observed by Sadiq (2003) is the fact that teaching is geared around memorization of basic concepts and their reproduction in the examinations. It can be inferred from these submissions that the curriculum of science teacher education needs to be rejuvenated through the inclusion of a more dynamic and efficient instructional strategy such as scientific argumentation instructional strategy.

**What is Scientific Argumentation?**

In science education, scientific argumentation is conceived as discursive practice through which scientific knowledge claims are justified or evaluated based on empirical or theoretical evidence (Jimenez-Aleixandre & Erduran, 2008). According to Sampson and Clark (2011), scientific argumentation is a knowledge building and validating practice in which individuals attempt to establish or validate a conclusion, explanation, conjecture or other claims based on reasons. Argumentation in everyday context is often described as a dialogic exercise, process of debate or discussion between people with different viewpoints. Argumentation that is scientific in nature according to Duschl, Schweingruber and Shouse (2007), is a form of logical discourse whose goal is to tease out the relationship between ideas and evidence.

In the explanation of Alexander (2010), argumentation (dialogic teaching) harnesses the power of talk to stimulate and extend pupils' thinking and advance their learning and understanding. It helps the teacher more precisely to diagnose pupils' needs, frame their learning tasks and assess their progress. It empowers the student for lifelong learning and active citizenship. Students learn to narrate, listen, explain, analyze, speculate, imagine, explore, evaluate, discuss, argue, justify, and think about what they hear, give others time to think, respect alternative viewpoints and ask questions. This method teaches the democratic principle of fair hearing based on a scientific viewpoint. The term argument, according to Sampson and Clark (2008), is the artefacts that a student or group of students create when asked to articulate and justify claims or explanations while the term argumentation refers to the processes of constructing these artefacts.

Contemporary science educators who have worked on argumentation are yet to agree upon a single definition of scientific argumentation. Gonzalez-Howard and McNeill (2016) viewed scientific argumentation by its structure and as a dialogic process. In terms of structure, it was considered as a framework that includes a claim, evidence, and reasoning. As a dialogic process or activity, it encompasses the action people take as they use and make sense of the argument's structural elements. This activity according to Ford (2012) includes constructing and critiquing claims and their justification as well as evaluating and revising claims.

Numerous studies have shown that people have a natural ability to engage in this type of discourse which involves justifying, defending and attacking viewpoints during a conversation (Amusa, 2016a). Osborne, Erduran and Simon (2004) described argumentation as the coordination of evidence and theory to support or refute an explanatory conclusion, model or prediction. During the processes of scientific inquiry, scientists make **claims**, based on observable **evidence**, and clarify with the **justification** of the evidence as relevant to the claims. Other scientists often make **rebuttal** claims, pointing to other evidence that counters the evidence for the previous claim. The key points are that any scientific **claims** coming from an investigation must be based on observable (empirical) **evidence**, and that evidence must be **justified** as connected with the claims (Amusa, 2016a; Amusa. 2016b). Kuhn (2005) proposed a triangle model which identified three elements that explain what argumentation means and how they are used. The three elements include:
One's perspective: This represents someone's theoretical ideas or unproved theories which are often applied during argumentation on socio-scientific issues

Other's perspective: This simply refers to supporting and opposing view
External information: This refers to facts, pre-existing theories accepted by scientific communities, or unproven theories that are supported by evidence.

Kuhn further emphasised that the process of argumentation may even take place in an individual mind when one articulates a point of view. Arguments are generated as an inner chain of reasoning. Alternatively, this process may take place among two or more people with opposing viewpoints on an issue.

As a pedagogical strategy in physics education, scientific argumentation can been described as an instructional strategy that can be adopted by physics teachers to teach physics students through a perfect blend of relevant classroom activities such as presentation, debates, collaborative learning, questioning techniques, etc. towards equipping them with appropriate skills which will enable them to (1) extract, generate and articulate established scientific knowledge claim(s) in clear and acceptable language (2) coordinate series of empirical evidence to justify or attempt to refute(by creating evidence-based rebuttals), established scientific claims, theories or models- to extend and entrench the students' knowledge construct and enhance their conceptual understanding of the subject matter.

Borrowing from the description of Gonzalez *et al*. (2016), in a science classroom, scientific argumentation requires the teacher to create opportunities for students to articulate, either through writing or talking, their conceptual understandings of a topic. By making their thinking visible to peers, other students can then challenge, question, or build upon these understandings. Through such actions, the class develops a clearer understanding of the science being learned. In such a manner, as noted by Newton, Driver and Osborne (1999), that knowledge is co-constructed by the group as the group interaction enables the emergence of an understanding whose whole is more than the sum of individual contributions.

It is important to know that scientific argumentation is quite different from typical arguing that goes on between people, which is seldom based on tangible evidence, and typically involves opinions, beliefs and emotion. The goal of a confrontational dispute is for one person's point of view to "win" over another's. In scientific argumentation, however, explanations are generated, verified, communicated, debated, and modified. Ideally, the goal of all participants in scientific argumentation is to refine and build consensus for scientific ideas, based on evidence, to come as close as possible to understanding the reality of the natural world.

Newton, *et al*. (1999) pointed out that talking offers an opportunity for conjecture, argument and challenge. In talking, learners articulate reasons for supporting conceptual understanding and attempt to justify their views. Others will challenge, express doubt and present alternatives so that a clearer conceptual understanding will emerge. When students engage in argumentation in the classroom, they have a chance to confirm and extend their previous knowledge and to construct for themselves through the ideas of other students (Cross, Taasoobshirazi, Hendricks & Hickey, 2008).
Lin and Hung (2016) observed that despite the significance of this method of instruction in supporting students to learn science effectively, efforts to instruct students in argumentation have not always had a successful outcome. This is because

students tended to form unwarranted opinions and ignore alternative viewpoints in discussion (Zohar & Nemet, 2002), using disconfirming evidence and relying upon uncritical statements for backing their assertions (Hogan, 2002), and failure to cite sufficient evidence for claims when writing scientific argumentation (Sandoval & Millwood, 2005). Similarly, Cavagnetto, Hand, & Norton-Meier (2010) found that most of the arguments made by students in the context of scientific discourse are related to claiming and data, whereas students rarely provide rebuttals to challenge the proposed ideas or used distorted data to support their idiosyncratic ideas.

To overcome these obstacles in the implementation of scientific argumentation in the science classroom, McNeill (2011) suggests that argumentation should be taught with explicit strategies that consider student's knowledge background and emphasize a collaborative learning environment. A study posited that basic elements of scientific argumentation should be taught by science teachers in the first and second lessons before going further on the strategy(Lin & Hung 2016). Moreover, science teachers should believe that students of all academic levels can engage in argumentation activities that involve higher-order thinking (Zohar & Dori, 2003).

One of the perspectives from which researchers have investigated the role of argumentative discourse in science education is the effectiveness of argumentation on students' conceptual understanding of scientific concepts. There is a widespread consensus that students’ engagement in argumentation discourse contributes to their conceptual and epistemological development in science education (von Aufschnaiter, Erduran, Osborne & Simon 2008). Jimenez-Aleixandre & Erduran (2008) indicated that learning argumentation supports the development of communicative competencies and critical thinking, enhances the enculturation of the scientific community, and empowers the students to speak and write scientifically. The components of communicative competencies and critical thinking in the practice of argumentation make it very imperative to examine the place of verbal ability and critical mindedness in this study.

**The argument for Scientific Argumentation Instructional Strategy**

Scholars in science education have argued that the ultimate aim of the current reform movement in science education should be to help students become more proficient in science (Duschl, Schweingruber & Shouse, 2007; National Research Council, 2008). It is also reflected in the Next Generation Standards (NGSS) (NGSS Lead States, 2013) that school science should mirror authentic scientific endeavours (Duschl, 2008). Furthermore, the idea of science, as a set of practices, stems from the perspective that science includes specialized ways of talking, writing and reasoning (National Research Council, 2012) and the contemporary views of science proficiency highlight the centrality of students engaging in science practices to better understand the field's epistemic basis (Duschl & Grandy, 2013). One potential way to satisfy these aims is to incorporate opportunities for students to engage in argumentation in the science classrooms (Passmore & Svoboda, 2012). This position was also supported by Duschl, Schweingruber and Shouse (2007) who posited that one way to help improve the teaching and learning of science is to promote and support students’ engagement in scientific argumentation. However, research findings (Osborne, 2010; Simon, Erduran, & Osborne, 2006) have established that science teachers have not done enough justice to the teaching of science through dialogic pedagogy.

Consequently, science students do not have the opportunity to participate in authentic scientific argumentation in the classroom.

These predicaments have exposed the weakness of some of the pedagogical strategies, especially the traditional lecture method often used in teaching science. Any teaching strategy that has placed high emphasis on what should be believed in rather than why something should be believed in is indeed a problem to the learning and teaching of science. Without a doubt, arguments from authorities are a justified and legitimate form of argument. However, the predominance of such forms of argument in the science classroom undermines the rationale for a discipline that is distinguished by its central commitment to evidence as to the basis of justified belief and rational means of resolving differences and controversies.

Passmore and Svoboda (2012) argued that instructional activities based on constructing, articulating and defending arguments make students more active in the classroom since they clarify their understanding and share ideas with other students. Therefore, students' engagement in argumentation discourse is an effective way for their development of conceptual understanding in science class (Von Aufschnaiter, Erduran, Osborne & Simon 2008). As students engage in these practices, they comport themselves in the ways of scientists, using spoken and written language to make sense of the natural world (Hand *et al*., 2003). Furthermore, scientific argumentation not only provides students with a deeper understanding of the process by which scientific knowledge is formed and refined over time but also encourages them to actively partake in the social construction of their knowledge (Osborne, 2014). For students to be deemed successful in science, it is often assumed that they adopt these communicative practices while in the classroom (Gee, 2012) which also foster increased content learning (Passmore & Svoboda, 2012).

This failure in the science classroom has been ascribed to the fact that most teachers lack the pedagogical knowledge necessary to design lessons that foster student engagement in scientific argumentation and have limited resources to assist them (Simon, Erduran, & Osborne, 2006). Besides the regular in-service training that can be organized for practising teachers on new ideas, innovations and pedagogical strategies to enable them to fit into the new teaching and learning environment, pre-service teachers should also be given adequate attention to the emerging trends in teaching methodologies through a well-revised teacher education curriculum.

## Teachers' Professional Development in Scientific Argumentation

Simon, Erduran and Osborne (2006) observed that the development of argumentation in school science involved a partnership between researchers and the teachers. The researchers provide both the theoretical ideas and practical resources to stimulate change in teachers' practice while the teachers made an important contribution in return. Through working collaboratively with teachers to develop argumentation activities and teaching strategies and through analyzing teachers' practice as these were implemented in classrooms, we hoped to gain insights that would inform subsequent curriculum initiatives aimed at a wider audience of practitioners. Simon *et. al*. (2006) further noted that achieving this successful partnership with teachers involves working within several constraints. First, the curriculum followed by teachers was often rigid; and teachers had to plan carefully how to include alternative activities that allowed argumentation to take place. Secondly, even though the teachers were provided funds to attend meetings, there was a limit to the frequency with which they could be absent from school to share ideas and collaborate in the development.

Current thinking has recognized that a centrally important concept for any curriculum innovation is that of 'ownership' (Ogborn, 2002). Innovations succeed when teachers have a sense that new approaches belong to them, at least in part. As Ogborn (2002) argues, there 'has to be something of real novel value for teachers to identify with'. However, the need for ownership requires that teachers are a central feature of the process of development and not marginalized to becoming deliverers of someone else's innovations. They must be free to adapt, transform and develop the ideas to their context and, if necessary, change their aim, function or implementation. Only in this manner can teachers begin to own new practices and incorporate them into their regular repertory of strategies and approaches to the teaching of science.

To ensure students' successful engagement in argumentative discourse, the implicit scientific norms need to be explicitly unpacked and supported (Kelly & Chen, 1999). Scientific argumentation needs to be explicitly taught by the teacher through appropriate modelling and other support to alter the typical classroom discourse (Simon, Erduran & Osborne, 2006). The way a teacher frames a scientific argumentation writing task influences the product that the students produce (Kelly & Chen, 1999). Furthermore, Kelly and Chen (1999) emphasized the importance of using evidence to support claims and providing examples of strong and weak writing can support students in using evidence to justify claims and articulating their reasoning linking the evidence to the claim. Teachers' use of different types of questions can also impact students' ability to use evidence in their writing. Simon *et al*. (2006) have identified several different types of teachers talk, such as knowing the meaning of arguments and evaluating arguments that may promote students' ability to engage in argumentation.

Lin and Hung (2016) called for science teachers’ professionalism in argumentation practices by emphasizing the need to reconcile students’ emotional rebuttals (i.e. personal attack) and guide the argumentation to be more based on rational and scientific evidence. Three types of reconciling strategies were identified by Lin and Hung (2016). The first type consisted of reconciling strategy via teachers' management which is often deployed when a student's argument is flooded with emotional rebuttals. The second type of strategy consisted of the use of qualifiers to bridge two opposing assertions. The third type of strategy for reconciliation suggests that science teachers can extend students classroom debate to other scientific activities. To achieve these goals, Lin and Hung (2016) advised science teachers to be more conscious of what is still unclear or insufficient in the arguments proposed by students as backing or rebuttals, and should then encourage them to correct any insufficiencies by exploring related information at the library or the internet or by conducting scientific experiments. On the whole, the three reconciling strategies make argumentation activities to be more focused on knowledge evaluation and justification.

**Scientific Argumentation Activities for Teacher Education**

One of the major challenges confronting the implementation of SAIS is the designing and development of instructional templates or plans that foster scientific argumentation. This is due to the overlap or confusion that usually arises from the definition given to some of the major components that make up scientific argumentation. Kelly, Druker and Chen (1998) observed that students and teachers alike often experienced difficulty in determining what count as a claim, data, warrant, rebuttal and backing. Hence, Amusa (2016) compressed the six argumentation components proposed in the Toulmin Argumentation Pattern, TAP (1956) into a tripod arrangement that entails all the components in the TAP. The three broad components are claim, justification and rebuttal. The usage of these components will be illustrated in the scientific argumentation activity template as developed by Lin and Hung (2016) on socio-scientific issues (SSIs) and was built on four steps:

Introduce the students to the concept of Scientific Argumentation
Ask students to collect related information from textbooks, libraries, the internet and other sources
Ask the students to organize the information that they collected to generate an argument in response to the argumentative question and to reflect on the possible counter-arguments
Hold a role-play debate activity in which all the students address their positions and counter-positions, in addition to assessing alternatives.

Lin and Hung (2016) further argued that the idea to hold a role-play debate activity was based on suggestions in previous studies regarding argumentation and role-play debates as cited in Foong and Daniel (2013) and Molinatti, Girault, and Hammond, (2010).

Pre-service physics teachers are to follow the under listed guidelines in their quest to implement SAIS during their teacher education programme. It is important to note that most of the study reviewed focused on topics in the realm of Socio-Scientific Issues (SSI). In this study however, the emphasis is purely on scientific topics as contained in the senior secondary physics curriculum not socio-scientific issue as described by Lin and Hung (2016). Amusa (2016) presented the following sub-steps for the smooth implementation of scientific argumentation instructional strategy in the science classroom after the selection of the appropriate topic for the lesson:

The physics teacher introduces the basic components of scientific argumentation as it will be used in the class to students. These components are claims, justification and rebuttal.

The teacher introduced the students to the new topic explaining the difficult aspect of it and prepared them for argumentation exercise by dividing them into different groups through a semi-democratic process. The grouping depended on the number of sub-topics and the classroom population. This first stage of the activity lasted for a whole period of forty minutes. In the subsequent classes, students were made to sit according to the group.

Students were given time to meet as a group and discuss the topic assigned to them in preparation for the presentation and also studied the topics assigned to other groups to enable them to create rebuttal after listening to their presentations. This compelled the students to study all the sub-topics that make up the topic of the week. During the group study, they were tasked to extract the basic claims in the given sub-topic. Furthermore, the students were asked to appoint their main and supporting presenters during their group study, choose any name of physicists to identify their group and tidy up their strategies for the classroom presentation.

The presentation should be fixed on the day when the students have a double period of forty minutes each. On the whole, eighty minutes will be used for the presentation. There are two different approaches to the students' presentation. In the first approach, all the groups will be asked to do their presentation one after the other for an average of six minutes, while the rebuttal session follows immediately. Students should be asked to write down their rebuttals during each of the presentations. After the whole presentation, the teacher declared the rebuttal session open and students were allowed to direct their questions or argument to any of the groups. In the second approach, the rebuttal session follows the presentation of each of the groups. The former approach conserves time better than the latter.

The student's level of mastery of the topics or academic achievement will be fairly assessed during the presentation and subsequent response to rebuttals. To prevent the domination of the group by the brilliant students in the group, the teacher must ensure the participation of all the group members by calling on the passive ones to respond to rebuttals raised against their group. This action of the teacher in scientific argumentation class often compelled the brilliant ones in the group to move along with the slow learners during group study to prevent a poor grade.

The rebuttal session consumed more time than any other components of argumentation. At this point, the student or group that raised rebuttals need to be satisfied with the response given. If they are not satisfied, however, any members of the class can respond to such rebuttals and that attracts some points to their group. This was so because the student that raised rebuttals had their response ready to cross-examine any other response provided. The role of the teacher is very important during the rebuttal session. They are: to determine intelligent and confusing rebuttals and responses.

The "face-off" during rebuttal sessions often precipitates some degree of misconception on the topic that is being treated. Hence, the physics teacher presented the final submission by clarifying all forms of misconception.

The student audience will be rated successful if and only if they can raise quality, strong and challenging rebuttals.

During this presentation, the quality and quantity of students' arguments will be traced using an adapted model of the Toulmin Argument Pattern (TAP). It should be recalled that TAP illustrates the nature of an argument in terms of:

Claim: This is an assertion that is presented publicly (during the class presentation) for general acceptance
Data: This refers to the specific facts that are presented to support an established claim

Backings: These are generalizations making explicit the body of experience relied on to establish the trustworthiness of the ways of arguing applied in any particular case
Warrant: This provides a link between data and claim
Rebuttals: These are the extraordinary or exceptional circumstances that might undermine the force of a supporting argument.

The argumentation exercise will be analyzed under three broad components: Claim, Justification(data, warrant and backing), and Rebuttals. The components "data", "warrant" and "backing" were merged into justification. Meanwhile, another component, called "Submission" was introduced at the last step of the presentation.

Submission refers to the conclusive summary presented by the teacher to harmonize all the claims, data and backings in the light of established scientific knowledge. This submission becomes very necessary to prevent any form of misconception that may arise in the process of argumentation. This last component is not part of the Toulmin Argumentation Pattern (TAP), but a control mechanism introduced by Amusa (2016) to deal with any forms of misconception.

The quantity and quality of rebuttals created by each of the groups should be rated to assess the level of students' participation in the argumentation exercise.

**Rebuttals in Scientific Argumentation**

A rebuttal is the most critical component of scientific argumentation. It demands a high order critical thinking level to refute or attempt to refute established scientific claims Amusa (2016). After the group presentation which lasted for about six minutes, other members of the class are expected to pose open questions one after the other as rebuttals in an attempt to refute all the claims made by the presenter. The main presenter and other members of his group will be allowed to respond to all the rebuttals that will be raised to the satisfaction of the questioner who has also been instructed to prepare a response for any question raised. Amusa (2016) also noted that most students always have difficulty in raising valid rebuttals.

Rebuttals in form of multiple-choice questions which are often picked from the practice exercise in the textbook were not accepted. Any intelligent based rebuttal which begins with an argument prompts such as "Why do you think that……?", "Can you think of another argument for your view?", "Can you think of an argument against your view?", "How do you know that…….?" and other high cognitive based questions were acceptable. Erduran *et. al*. (2004) perceived the presence of a rebuttal as a significant indicator of a quality argument since a rebuttal and how it counters another's argument forces both participants to evaluate the validity and strength of that argument. Furthermore, Kuhn (1992) suggested that the cognitive skill of argument is to some extent founded on an understanding of how to rebut an opposer's point of view. In this sense, students' ability to formulate strong rebuttals is a significant outcome for the teaching of argumentation.

While responding to all the rebuttals raised, the students should be introduced to appropriate response frame to support the process of presenting argument through the use of stem such as "My argument is………", "My reasons are that…..", "The evidence to support my argument is ………" and so on. It must however be emphasized that the whole exercise was designed to facilitate effective learning and improve knowledge attainment of the subject matter among students.

**Instructional Plan on SAIS**

In the preparation of science teachers towards the use of scientific argumentation instructional strategy, the sample instructional plan presented below (Amusa 2016a)can be used as a template for lesson preparation on scientific argumentation.

TOPIC: RADIOACTIVITY
DURATION: 1 hour 20 minutes (3 Periods of 40min each)
BEHAVIOURAL OBJECTIVES: At the end of the lesson, students would be able to
Justify the existence of the phenomenon called Radioactivity
Establish at least four claims in connection with Natural and Artificial Radioactivity
Establish and Justify four (4) claims each in respect of alpha, beta and gamma particles
State and justify the concept of Half-life
Clearly establish the claims on Nuclear Fission and Nuclear Fusion
Create the appropriate backings to substantiate the claims made above.
Attempt appropriate rebuttals to refute any of the claims established above

INSTRUCTIONAL MATERIALS: Charts showing the deflection of particles (alpha, beta and gamma) in a magnetic and electric field, New School Physics Textbook, and Print out from the internet.

INSTRUCTIONAL METHOD: Scientific Argumentation and Group Presentation
PROCEDURE:
1$^{ST}$ PERIOD (1$^{ST}$ LESSON)
Step 1: Instructor welcomed the students to the class and reminds them of the need to acquire argumentative skills to defend their knowledge of science and learn to ask questions
Step 2: The teacher explains and differentiates between natural and artificial radioactivity
Step 3: The Teacher introduces the students to the three common radiations associated with radioactivity: alpha and beta particles, gamma rays
Step 4: The teacher explains the concept of half-life concerning the decay constant
Step 5: The teacher states the differences between nuclear fission and fusion
Step 6: The teacher places students into groups of four or five in preparation for group presentation. Each group will present to defend an assigned sub-topic while others prepare to create rebuttals to debunk the presented claims.
2$^{ND}$& 3$^{RD}$ PERIOD (2$^{ND}$ LESSON)
Step 7: The teacher welcomes the students for the presentation (2$^{nd}$ lesson) on Radioactivity and makes them sit according to their group
Step 8: Each of the groups is given 10 minutes for presentations while others act as audience waiting to challenge the presenter
Step 9: The teacher acts as a judge/observer to rate the performance of students according to their presentation.
Step 10: Students will be given 5minutes to create rebuttals (if any) by asking relevant questions on the presentation.

Step 11: The presenter is allowed to respond to all the rebuttals created and tries to justify his viewpoints

Step 12: The teacher makes the final submission/remark by harmonizing all the students' presentations which serves as the true position of science on radioactivity.

EVALUATION: The teacher asked the following questions to ascertain the attainment of the objectives for the lesson:

Describe the features of the different radiation that are emitted during radioactivity

Briefly explain the merits and demerits of radioactivity

**Compare and contrast the concept of nuclear fission and fusion**

The variables in the lesson plan can be easily manipulated to reflect the contents of the topic that a teacher intends to teach. The number of steps may differ in line with the volume of the content. However, the three critical scientific argumentation components – claim, justification, rebuttal – must reflect in the behavioural objectives and the instructional procedure.

## Conclusion

Innovation on pedagogical strategies for inclusion in teacher education remains one of the panaceas towards solving the learning challenges that are persistent in the science classroom. One such innovation is the introduction of scientific argumentation instructional strategy. The adoption of this strategy will reduce the prevalent use of the traditional lecture method by the upcoming science educators who stand the chance of occupying the science classroom in the nearest future. It will further entrench the culture of students-centeredness in their training and orientation as 21st-century teachers. It is the hope of concerned stakeholders in science education, with specific reference to physics education that SAIS will open up the way for the long-expected technological and scientific breakthrough in Nigeria.

## Recommendations

Scientific Argumentation Instructional Strategy (SAIS) should be introduced into the science teacher education curriculum as an independent course in the teacher education programme.

Regular professional development and capacity building should be organized to equip all the in-service science teachers with the pedagogical knowledge necessary to design lessons that foster students' engagement in scientific argumentation.

The National Curriculum on Physics should be re-designed to emphasize, encourage and promote the use of scientific argumentation in science classrooms. Both scientific and socio-scientific topics should be included in the curriculum to facilitate students' engagement in dialogic teachings.

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