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Communication in Science and Science Communication in Nigerian Institutions of Learning-The Trend this Far

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Abstract

Throughout the globe, there is a general trend hitherto that every nation is becoming fervent in and adopting the tenets of science and its relational output to navigate their cultural, political, economic, security and creativity prowess. Effective public communication of science topics is needed for various reasons. This paper examined the means to: improving scientific literacy, overcoming public mistrust, discovering inaccurate styles of communication in science, identifying categories of communications in science, as well as presenting comparative studies within international cycle that show best science communication practices. Media materials and interaction with teachers and students provided the approach adopted to sieve opinions on an adapted teaching practice assessment template used as instrument whose reliability index gave .79 through scorer reliability test for data collection. Data obtained were analysed using mean and t-test statistics of which the results revealed similarities in the style adopted by science communicators in communicating science in schools and a correlation existed between science communication and communication in science in schools. Personal 'top tips' for ensuring success in science communication by science educators in Nigeria especially at the secondary school level were well proposed.

Background to the Study
In nature, communication is triggered by a signal which arises in the form of sound, posture, movement, colour, scent, or facial expression all of which are sent and received through all of the human senses of sight, hearing, smell, touch, and taste. World Encyclopaedia 2004 edition has it that signals are used by animals to influence the behaviour of other animals and since they face a variety of social situations in which communication is needed, animals usually have several different signals each suited to a different situation. Animal signals have been shaped by natural selection so that they reach the intended receiver efficiently and stimulate a response. To ensure efficient transmission, a signal must be able to travel through the environment from sender to receiver as well as being recognizable to the receiver, or it will not have any effect on behaviour.

Vocal communication may be most developed among animal primates, but in humans, language develops at a very early age which is why infants begin to learn language by trial-and-error during the "babbling baby" phase of six-month childhood age. Infants afterwards pick out the sounds used by the people around them and repeat only those sounds while the other sound begins to drop away and are forgotten. Though children quickly and effortlessly learn a vocabulary of thousands of words, it is known that such ability to learn language rapidly seems to be genetically influenced. Studies have revealed that language is not the only form of human communication as evidences have suggested that odours and nonverbal signals (body language) may also be important (Johnson & Raven, 2004).

Signals in the form of sound is the sensation detected by the ear caused by the vibration of the air surrounding it. It is anything that can be heard and registered in the form of music, speech or indicator recorded on a tape, as part of a film or broadcast on radio or television. Serway and Beicher (2000) maintained that sound waves though slower than light is an important form of longitudinal waves that can travel through any material medium with a speed that depends on the properties of the medium. As the waves travel, the particles in the medium vibrate to produce changes in density and pressure along the direction of motion of the wave. The changes which result in a series of high and low-pressure regions do produce sinusoidal pressure vibrations if the sources of the sound waves vibrate sinusoidally. Serway et al (2000) have categorised sound waves into three based on frequency ranges as: audible waves which lie within the range of sensitivity of the human ear can be generated in a variety of ways, such as by musical instrument, human vocal cords, and loudspeakers; infrasonic waves which have frequencies below the audible range and particularly used by Elephants to communicate with each other, even when separated by many kilometres; and ultrasonic waves that have frequencies above the audible range which play significant role in medical imaging and as "silent" whistle to retrieve dogs although humans cannot detect it at all.

It is in the ears that the energy in sound waves becomes converted to electrical signals which are transmitted to and interpreted by the brain. Johnson and Raven (2004) have established that sound waves enter the ear through the ear canal and strike the tympanic membrane (eardrum) causing it to vibrate. Behind the eardrum, three small bones of the middle ear (the hammer, anvil, and stirrup) transfer the vibrations to a fluid-filled chamber –the cochlea, a coiled structure that contains mechanoreceptors called hair cells, within the inner ear. The hair cells rest on a membrane that vibrates when waves enter the cochlea. Serway et al (2000) have found that waves of different frequencies cause different parts of the membrane to vibrate and thus stimulate different hair cells. When hair cells are stimulated, they generate nerve impulses in the auditory nerve which travel to the brain stem through the auditory nerve. The thalamus then relays the information communicated to the temporal lobe of the cerebral cortex, where the auditory information is processed (Johnson, et al 2004).

Communication in science refers to the process through which scientific information is conveyed, shared, and interpreted as coded in sound waves. It includes the verbal or written, transfer of scientific concepts, ideas, findings, and theories among scientists and non-scientists alike. Science communication is the use of appropriate skills, media, activities, and dialogue to produce awareness, enjoyment, interest, opinion-forming and understanding to science. It describes a variety of practices that transmit scientific principles, methods, knowledge, and research to non-audiences in an accessible, understandable or useful way (Asworth, Bowater & Yeoman, 2013). Diviu-Miñarro and Cortiñas-Rovira (2020) have purported that dissemination of information about science has undergone a major upsurge in recent years. Whereas Côté and Darling (2018) maintained that communication of research has always been a fundamental part of academic work, the demand to convey results to the society has grown at an increasing pace, with calls for the scientific community to commit to and engage with society, and to facilitate the relationship between the scientific world and the world of laypeople (Anzivino, 2021).

To communicate in science, it is important to understand the different theories of mass communication which make one as an observer to be more conscious of how the media may affect one's disposition. Relevant theories worthy of consideration include: cultivation theory which according to Gerbner, Gross and Morgan(1986) was designed to unravel the enduring impacts of media assumption with a primary focus on television and a believe that social media can influence-and-skew-people's perceptions of reality; the spiral of silence theory that deals with human communication and public opinions and purports that people's willingness to express their opinions on controversial public issues is affected by their largely unconscious perception of those opinions as being either popular or unpopular. This could cause people to either change their willingness to express their opinion because of the fear of being socially isolated or sense the opinions on controversial topics of those around them and modify their public behaviour accordingly (Neelle-Neumann, 1974).

Ayesh, Saul and Olivia (2024) clarified the hypodermic needle theory as a linear communication theory which suggests that a media message is injected directly into the brain of a passive, homogenous audience. It assumes that media texts are closed, and audiences are influenced in the same way. In this case, media consumers are uniformly controlled by their biologically based instincts and that they react uniformly to whatever stimuli that come along. It is in the view of Authoritarian theory as conceived by Mark to be highly concentrated of and centralised by government's power and maintained by political repression and the exhibition of potential or supposed challengers by armed force (en.m.wikipedia.org>wiki>Author...).

Anyone who adopts this model use the position of power to convey a message in a forceful and commanding manner by creating a sense of urgency and importance in the mind of the audience in such a manner to make people take the message more serious.

Yet the Libertarian theory by Robert in the 1970s is another political position that advocates a radical redistribution of power from the coercive state to voluntary associations of free individuals. It does not matter if the voluntary association takes the form of a free market or of communal cooperatives. This theory advocates for a government that has less control over the lives of its citizen but allows people to be responsible for themselves. While in opposition to government bureaucracy and tax, it promotes private charity, tolerate diverse lifestyles, supports the free market and defend liberties (en.m.wikipedia.org>wiki>liberta…). To crown it up, the Soviet-communist theory embraces democratic and open discussion of policy issues within a party foremost and the requirement of total unity in upholding the agreed policies. Maxrxism-Leninism (en.m.wikipedia.org>wiki>ideology…) maintained that even if the policies were unpopular, they were agreed to be correct because the party was enlightened. So also, the social-responsibility theory according to Whimster (2018) requires that individuals are accountable for fulfilling their civic duties. It demands that the actions of an individual must benefit the whole of the society. It views communication as a process of anticipating stakeholders' expectations and allows free press without any censorship although the content of the press would have to be discussed in public panel.

Statement of the Problem

Scientists have applied figure of speech globally over the years to convince the world that science is every person's enterprise so much so that all and sundry would need to be adequately informed to benefit concomitantly. It can never be a hyperbole to say that the best place to communicate science to learners effectively is in the school premises where a science role model is assigned to implement the objectives of science curriculum. This being so because the science communicated in schools provides skills, media, activities and dialogue that enable the general public, mediators and science practitioners to interact with one another effectively as Evans and Durrant (1989) suggested that "interest in science may well be a stronger predictor of attitudes than is scientific understanding." Though other medium at home and in the society could also transmit scientific information, it is only those from the school that could be guided by a curriculum. It has been reported that members of the public seek out science information that is entertaining, but which helps citizens to critically participate in risk regulation and S&T governance (*Könneker & Lugger, 2013*), this is why when communicating scientific information to the public, educators would have to bear this aspect in mind. Since it is possible for deviations to arise due to the present proliferation of information sources, learners may be prone to misleading information. This assumption prompted this study on the tendency of how science is being communicated in institutions of learning in Nigeria to this moment.

Objectives of the Study

This paper was to ascertain the trends assumed in science communication and communication in science in the context of Nigerian schools as regards:

I. Identification of communication categories in science
ii. Discovery of inaccuracies in communication
iii. Improvement of scientific literacy
iv. Overcoming public mistrust
v. Best ways to communicate science as we grow

Method

The study is a reviewed work on communication as practiced in science and analysis of same accordingly. Though this study cannot claim to have exhausted the work reviews on communication, an approach to examine the possible theories on communication was carried out. This was followed by analysing the approaches for science communication and communication in science in schools through a bit of data obtained from media materials and the interactions between teachers and students with a sample of 40 science lessons from schools categorised into A and B based on locations (North and South of Kontagora) were assessed to ascertain the extent to which science communication by way of inclusion of media/information technology materials and communication in science by way of the utilization of curriculum contents and instructional aids featured in the course of teaching and learning science. An adapted teaching practice assessment template was used for data collection. The template which was structured to address a scope on categories of communication, inaccuracies, science literacy, trust for science and mechanisms to ensure success in science communication was tested for its reliability using scorer reliability test that yielded .79 index which assured the confidence in it to produce

Results and Discussions

Table 1: Mean Scores of Communications of Science in Schools

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
FSC	A-school	20	25.7000	.17885	.48720
	B-school	20	25.1500	.34849	.30153
ISC	A-school	20	18.4045	.87391	.19541
	B-school	20	19.8215	.98137	.21944
ISL	A-school	20	24.8500	.02600	.50945
	B-school	20	23.1000	.40236	.79229
OPM	A-school	20	15.3000	.61775	.58535
	B-school	20	16.3000	.47429	.26258
BWSC	A-school	20	22.4090	.85758	.19176
	B-school	20	24.0605	.91605	.20483

***Source**: Field work 2024

Table 1 shows closeness in mean scores between the categories of schools on the aspects observed. This implied that similarities existed in the styles adopted for communication of science in all the lessons observed in the schools.

Table 2: Correlation of Science Communication and Communication in Science

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	.835	.060	9.339	.000[c]
Ordinal by Ordinal	Spearman Correlation	.793	.080	8.026	.000[c]
N of Valid Cases		40			

*Source: Field work 2024

Table 2 shows that a significant correlation existed between how teachers and students engaged themselves in science communication and communication in science (r = .835 or .793 at p = .000 based on normal approximation). Squaring r = .835 or .793 produces (r^2) = .697225 or .628849 and multiplying any of these squared r values by 100 gives 69.72 or 62.88. This invariably indicated that science communication either contributed 69.72% or 62.88% to communication in science in the schools selected for this study while other concealed factors could be responsible for the communication replicas adopted by teachers and students in science in the lessons examined in the sampled schools.

Forms of Science Communication (FSC)

By human nature, it is typical for scientists to exchange and thereby spread new ideas on scientific knowledge which might be communicated through informal and formal networks. Prospective scientists may informally communicate their experiments with other scientists who may spread the information further. Spreading new ideas in science was assumed to be done through informal STAN newsletters, computer networks, electronic journals, fax machines, and even telephone. Scientific information was best spread however through classroom interactions as an informal way to exchange ideas in the lessons in schools under this study. This enabled scientific theories, principles, facts and laws to be taught to a wider audience by exploring newspapers, magazines, media apps and radio and TV programmes.

The uses of publications to communicate science in the form of special magazines known as "scientific journal" were noticed. Such type of journals (like STAN Journal) enables scientists to announce formally the results of their works as they carried technical articles concerning research in a given field of study and were principally circulated to individuals working in that field. Every Journal is being expected to have a set of editors or reviewers do receive articles reporting scientific

findings from which they selected for publication only those articles that reflected painstaking research. Reference publications known as indexes, abstracts, and digests also served as channels through which science was communicated.

Latest discoveries in science were found to be communicated through scientists' gatherings. Gatherings of this nature served as an avenue for scientists to meet other experts in their various fields. It has become a kind of tradition that scientists participated in gatherings of

JETS clubs at primary and secondary school levels, while national and international conferences, seminars, workshops and conventions were evidence of practices in tertiary institutions. Whereas professional societies, business, and governments have set up research institutes where scientists also share information as they work together, some countries have as well jointly sponsored research institutes to minimise the cost of expensive laboratory equipment. Scientific discoveries spread further as scientists converged from around the world to work and study at these laboratories.

Inaccuracy in Science Communications (ISC)

When some scientific jargons were pronounced by science teachers in the classrooms but not written on the board, learners perceived or understood them partially with some pitfalls. Inaccurate conception of what was communicated further induced misleading communication in science by those to spread it. The use of jargons in relation to Piagetian developmental theory of accommodation and assimilation was another area in which authors and teachers were yet to address. The use of 'synthetic drugs' in science communication at primary school level in-text and in communication of science during teaching was considered to be beyond the developmental stages conceived by a theory for accommodation and assimilation. The complementary and compensating roles of human senses in science communication and communication in science with regards to the use of tangible materials and technology cannot be dissociated from government policy as far as supplies to schools and curriculum implementation is concerned.

As contained in the findings of Walter Lewinin a particular work based on demonstration of conservation of potential energy revealed in Randy (2009) and Miller (2008)that it can be difficult to captivatingly share good scientific thinking as well as scientifically perfect information. It was found in this study that Science communication in-text for the definition of habitat was stated as 'a place of abode' but found to be misleading to teachers during WAEC marking coordination (communication in science) and corrected as 'a place where organisms live' for simple. It was surprising that even popular Biology texts communicated the castoff definition. Another case hitherto in Mathematics class indicated teachers still communicated the concept of 'change of subject' using 'cross multiply' (a misleading short cut of steps) and the learners expressing a sign that placed 'multiplication' on 'equal to', which made the whole muddle-up of what was communicated since such expression does not exist anywhere or make any sense in science communication. Maintaining the normal steps of 'multiply both side by' or 'divide both side by' or 'square both sides' or 'square root both sides' is thus mandated for model communication. For this, Krulwich and Olson in(Randy, 2009;Miller, 2008) believed that scientists must rise to that challenge of using metaphor and storytelling.

Improvement of Science Literacy (ISL)

It is found in this paper that science literacy and science communication are two contending issues in science learning in secondary school. It is the study of teaching style that lay emphasis on 'what I see I remember, what I hear I forget and what I do I know' for teachers to justify how they impart knowledge on the learners. Both media items and teacher made instructional items applied in the course of lesson delivery played crucial roles in improving students' science literacy in both categories A and B schools. Science literacy was characterised of three components such as knowledge of science content; understanding science as a way of knowing; and understanding and conducting scientific inquiry (nap.nationalacademics.org>chapter).

Bybee (1997) had suggested four levels of scientific literacy to include: interrelated features that involve an individual; scientific knowledge and use of that knowledge to identify questions; acquisition of new knowledge; and explanation of scientific concepts, while Dani (2009) outlined four aspects of scientific literacy as: knowledge of science, investigative nature of science, science as a way of knowing and interaction of science, technology and society. In order to achieve scientific literacy, scientists were required to read and comprehend articles about scientific topics; explained various types of natural phenomena; determined the accuracy of scientific information by evaluating both the sources and the methodology used to acquire it (Online.sou.edu>education>msed). Equipped with these prerequisites then, it was possible to advance some formidable steps for the improvement of science literacy in schools through: making a framework explicit; modelling and critiquing explanation; providing a rationale for creating explanations; connecting scientific explanations to everyday explanation; and having assess and provide feedback to students (www.discoveryeducation.com>info).

Science communication as a practice of informing, educating, raising awareness of science-related topics, and increasing the sense of wonder about scientific discoveries and arguments connects Science communicators and audiences. Illingworth and Allen (2020)have emphasised that two types of science communication available in practice are outward-facing or science outreach in which science journalism and science museums find relevance (typically conducted by professional scientists to non-expert audiences) and inward-facing or science "in-reach" that embrace scholarly communication and publication in scientific journals(expert to expert communication from similar or different scientific backgrounds).With these, science communicators can use entertainment and persuasion including humour, storytelling and metaphors (Randy,2009;Miller,2008) or scientists can be trained in some of the techniques used by actors to improve their communication (Grushkin, 2010). Jensen and Gerber (2020) in a study maintained that continually evaluating science communication and engagement activities allows for designing of some planned activities that could be of possible resource efficient while also avoiding well known pitfalls.

Overcome Public Mistrust (OPM)

Science communication as a sphere of activity, consists of three sub-domains that include: scientific communication (professional communication); technical communication (semi-popular science communication) and popular science communication (public communication of science and technology). In each of these domains, principle of science communication is to be considered if the findings in science are to find dependability among the receivers. This is why such principles as: clarity (clearly written), accuracy (accurate data), simplicity (easily accessible reports of medical studies) and understandability are necessary tools for ensuring trust in science communication. Findings from the schools A and B types indicated that in addition to these, accuracy in texts and by teachers were essential for maintaining credibility, respect for the scientific evidence and informing the learners correctly. Controlling common pitfalls in science when telling stories about science such as: oversimplifying complex concepts, neglecting human element, presenting a misleading narrative for dramatic effect and cherry-picking data to fit a desired storyline, as well as change due to technical jargon and specialized terminology (www.linkedin.com>advice) also added values that enabled the public assumed confidence in what science has to offer.

Gregory and Miller (1998) have observed that it is possible for science communication to generate support for scientific research or science education, and inform decision making, including political and ethical thinking. It was considered that the science contained in the curriculum was to be communicated in a manner that it can serve as an effective mediator between the different groups and individuals that have a stake in public policy, industry, and civil society (Jensen & Gerber, 2020). Durant, Evans and Thomas (1989) agreed that science communication may explicitly exist to connect scientists with the rest of the society, but science communication may reinforce the boundary between the public and the experts. Fiske and Taylor (1991) viewed science communication just as one kind of attempt to reduce epistemic asymmetry between people who may know more and people who may know less about a certain subject.

Best Way of Science Communication

It is expedient these days that science practitioners upgrade their activities to reflect global view. Birke, Ockwell and Whitmarsh (2018) documented the practices in which science communication researchers and practitioners now often than not showcase their desires to attend to non-scientists as well as acknowledging an awareness of the fluid and complex nature of (post/late) modern social identities. As the editor of the scholarly journal Public Understanding of Science put it and presented by Howell (2011) in a special issue on publics:

> *"We have clearly moved from the old days of the deficit frame and thinking of publics as monolithic to viewing publics as active, knowledgeable, playing multiple roles, receiving as well as shaping science".*

Evidence-based science communication is another discovery that combines the best available evidence from systematic research, underpinned by established theory, in which practitioners' acquired skills and expertise help reduce the double-disconnect between scholarship and practice (Canfield & Menezes, 2020). Jensen et al (2020) had argued that neither adequately considered the other side's priorities, needs and possible solutions, bridging the gap and fostering closer collaboration could allow for mutual learning, enhancing the overall advancements of science communication as a young field.

The use of opinion leaders as intermediaries between scientists and the public has been described by Nisbet and Scheufele (2009) as a way to reach the public via trained individuals who are more closely engaged with their communities, such as "teachers, business leaders, attorneys, policymakers, neighbourhood leaders, students, and media professionals" (Aikenhead, 2001).The use of traditional journalism which embraces newspapers, magazines, television and radio provides opportunity of reaching large audiences. Society where traditional journalistic (a one-way) method of communication is adopted are aware that there can be no dialogue with the public, and science stories can often be reduced in scope so that there is a limited focus for a mainstream audience, who may not be able to comprehend the bigger picture from a scientific perspective ("Science Gone Social", 2014). Schwartz (2014) however noted that this is not to rule out the new research now available on the role of newspapers and television channels in constituting "scientific public spheres" which enable participation of a wide range of actors in public deliberations.

Also in vogue is the live or face-to-face events, such as public lectures in museums or universities, (Tachibana, 2017); debates, science busking, (Collins, Shiffman & Rock, 2016); "sci-art" exhibits, (Milani, 2017)) or Science Cafés and science festivals. Citizen science or crowd-sourced science – a scientific research conducted, in whole or in part, by amateur or nonprofessional scientists could be done with a face-to-face approach, online, or as a combination of the two to engage in science communication ("Science Gone Social", 2014).These days online interaction like websites, blogs, wikis and podcasts can be used for science communication, as can other social media since they have the potential to reach huge audiences, and can allow direct interaction between scientists and the public (Hara, Abbazio & Perkins, 2019) and the content is always accessible and can be somewhat controlled by the scientist. Online communication has now given rise to movements like open science, which advocates for making science more accessible. Törner, (2014) agreed accordingly that online communication of science can help boost scientists' reputation through increased citations, better circulation of articles, and establishment of new collaborations.

Art has been an increasingly used tool to attract the public to science as opined by Lesen et al (2016) and Short(2013). "Public Attitudes to Science 2011"Ipsos-MORI in deduced that either formally or in an informal context, an integration between artists and scientists could potentially raise awareness of the general public about current topics in the Science, Technology, Engineering and Mathematics (STEM). Bodmer (2010) discovered that arts have the power of creating emotional links between the public and a research topic and create a collaborative atmosphere that can "activate science" in a different way. Thus, learning through the affection domain, in contrast to the cognitive domain can increase motivation. Social media science communication is another means by which scientists navigate resources with ease. The use of Twitter by scientists and science communicators serve a great deal in discussing scientific topics with many types of audiences with various points of view (Viallon, 2019).

The use of mental shortcuts called heuristics that allow people who make an enormous number of decisions every day is gaining attention, since to approach all of them in a careful, methodical manner is impractical. To "Heuristics" such as representatives, availability and anchoring and judgment are quick ways of types of heuristics to arrive at acceptable inferences. Inclusive science communication and cultural differences is twin bond that impart reasonably on how science is communicated. It seeks to build further methods for reaching marginalized groups that are often left out by typical top-down science communication. Brown (2015) could establish complementary methods for including diverse voices like the use of poetry, and others like participatory arts by Bultitude (2011), film by Ipsos-MORI (2011) and games by McCartney (2016) all of which could be used to engage various publics to monitor, deliberate, and respond to their attitudes toward science and scientific discourse.

Conclusion

This study that identified categories of communication in science as well as discovered inaccuracies in science communication and how scientific literacy could be improved upon, in addition to overcoming public mistrust and best ways to communicating science as we grow has found that science students who lack motivating learning environment are prone to poor science communication as well as perform badly and consequently drop out of school. Findings reported in studies have shown that science students' success in their studies is directly related to their teachers' ability to communicate effectively.

The dissemination of information about science has undergone a major expansion in recent years through the Internet, which has served to overcome many of the technical and economic barriers. Many initiatives have assisted in this regard like the TED Talks website. One of the barriers to proper communication is the usage of a language that can be associated with self-promotion and aggrandizement which is destructive when incorporated into scientific writing. Similarly, any practice that oversells the novelty of research or fails to provide sufficient scholarship on the uniqueness of results can be ill-disposed to excellent science communication. It is important therefore for stake holders in science cycle to relate openly with one another to ensure updating of their knowledge day-in day-out.

Recommendations

1. Encouragement of teamwork to provide possible means where groups of learners' interactions would abolish competition among members but concentrate more on talking and working together to get the best results.
2. Provision of positive feedback by science educators to promote effective science communication in the classroom by students especially when they are assured that accomplishment on a given task can be more successful when they receive reinforcement anytime they elicit correct response.
3. Adoption of active listening exercises by science teachers who lend their ears to provide a useful means for promoting a supportive and caring environment would make learners to speak out their minds.
4. The inclusion of opinion leaders as intermediaries between scientists and the public when enforced would allow for wider spread of scientific information.
5. It is now time for science teachers to cultivate the habit of communicating science using metaphor and storytelling and develop an attempt to reduce epistemic irregularity between them who know more and the learners who know less.

6. Regular evaluation of science communication and engagement activities to pave way for resource efficiency and to help in overcoming communication pitfalls is required.

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