International Journal of Social Science and Human Research

ISSN (print): 2644-0679, ISSN (online): 2644-0695

Volume 07 Issue 01 January 2024

DOI: 10.47191/ijsshr/v7-i01-106**,** Impact factor- 6.686

Page No: 816-826

Perception of Learners and Facilitators on the Best Practices for Effective Teaching and Learning of Science Courses in Open and Distance Education

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ABSTRACT: The study investigated the perceptions of learners and facilitators on the best practices for effective teaching and learning of science courses in open and distance learning. A descriptive survey design was used for the study. Eight research questions were posed to guide the study. A total of 180 students and 30 tutorial facilitators selected by purposive sampling from study centres in the South-east and South-south geopolitical zones in Nigeria constituted the sample. Two different questionnaires were used for data collection. Data was analyzed using means and percentage frequencies. Findings reveal that using practical demonstration, engagement with hands on activities and use of examples constitute the best practices for teaching science courses in open and distance learning mode as perceived by the facilitators. Availability of functional internet facilities, using practical demonstrations and availability of personal computers/laptops for tutorials are among the instructional modes that students perceive as best practices for learning science courses in open and distance learning . Facilitators and students perceive lack of well-equipped laboratory as a constraint to the attainment of best practices in the teaching and learning of science courses in open and distance. Recommendations were made based on the findings.

INTRODUCTION

Science is a systematic body of knowledge derived through observations and experimentations. Scientific knowledge differs in both content and forms from other forms of knowledge such as religion and art. Science disciplines are systematic, provable, and reliable and supported by evidence. De Haro (2020) defined science as a systematic method of investigation of nature, understanding and harnessing it to serve human needs. This implies that through the study of science subjects, such as biology, physics, chemistry, nations are able to understand, explore and control their environment. Thus, the success or failure of science subjects' instructions at any level of education has critical implications for the society. Effective teaching and learning of science subjects equips students with skills and knowledge for successful science careers in the future, thereby contributing to the much needed scientific and technological advancement of Nigeria. On the other hand, ineffective teaching and learning of science subjects will have negative consequences to the quest for development of manpower in science-based occupations and the overall development of the nation. It is for these reasons that effective teaching of science subjects should be emphasized at all levels of the educational system both in the conventional and in the open and distance learning mode

Effectiveness refers to the degree to which intended objectives are achieved and the capacity of producing a desired result. Effective teaching entails providing maximum opportunities for all students to learn. It can be defined as teaching which leads to improved student achievement using outcomes that matter to their future success. Thus student progress is the yardstick by which teacher effectiveness can be assessed. Bulger (2013) and Sean (2002) identified Four Aces of effective teaching as –outcomes, clarity, engagement and enthusiasm. The aces represent principles that when systematically implemented can enhance student learning and can be used as a vehicle for improving instructional effectiveness. Effective teaching strategies help to engage students in developing critical thinking skills and keep students on tasks. It engenders sustained and useful classroom interaction and in general enables and enhances the learning of the course content. Goodrum (2019) identified six main principles of effective teaching of science, these include:-

1. Dealing with students ideas and conceptions,
2. Encouraging students to apply new concepts or skills into different contexts.
3. Encouraging student participation in lessons.
4. Encouraging student enquiry.
5. Encouraging co-operative learning among student and

6. Offering continuous assessment and providing corrective feedback.

Effective teaching and learning in science subjects is a continuous procedure and does not happen at once. Hence, Boettcher (2011) observed that planning an effective learning environment needs a conception and understanding of mental procedures, knowledge and pedagogic principles and basic learning theories that define the effectiveness and its value

OPEN AND DISTANCE LEARNING

Open and distance learning (ODL) has become globally accepted as an integral part of higher education. This system came into existence because of the universal demand for education, thirst for knowledge and the failure of the conventional education system to cater for the demand for higher education. Consequently, open and distance learning in recent times has emerged as an alternative to the conventional system, as it has not only proved to be cost effective but also has the potential to reach out to a large segment of the unreached, the marginalized and the needy. Hence, many developing countries such as India, South Africa and recently Nigeria have embraced this mode of learning .Open and distance learning refers to approaches to learning that focus on freeing learners from the constraints of time and place, while offering flexible learning opportunities (UNESCO 2002). Saykili (2018) defined open and distance learning as the type of education that takes place outside the conventional school system. It is impacted without necessarily having a personal interaction with the learners. It is a process of education in which all or most of the teaching is conducted by someone geographically removed from the learner. Most of the instruction between the learner and the instructor are conducted through electronic or print media. Open and distance learning is an amalgam of two approaches to education that focuses on expanding access to learning and the use of multimodal delivery systems such as technology and printed modules. It is characterized by two factors – its philosophy and its use of technology (Chikuya, 2007; Freeman, 2004). The philosophy of open and distance learning aims to remove barriers to education to allow students study what they want, when they want and where they want. This philosophy implies that education should be made available to all regardless of time, place and age. (Freeman, 2004; Rowe, 1994). Mudasiru(2006) defined open and distance learning as a term used to describe the student centeredness of distance education and it deals with the use of print and electronic technology to present individual lessons to learners at a distance .The success of open and distance learning (ODL) has driven universities to increase the courses offered online including science courses. Some challenges arise when teaching science courses to students who are not physically co-located and have individual learning schedules. However in open and distance learning, for the field of science and engineering, the practical sessions have been conducted by some open and distance learning providers, based on an existing practical model and often by setting up laboratories at the study centres. Incorporating practical work into open and distance learning of science subjects is a worldwide challenge that calls for careful planning and creative curriculum development. While most science educators would agree that studying science without any exposure to practical work would result in a rather idiosyncratic qualification (Bennett, Metcalfe, Scarron, Thomas and Williams, 1995), there has been growing realization that the laboratory is not the only place in which the objectives of science can be achieved. Consensus is spreading that the benefits students derive from practical work cannot necessarily be measured by the number of hours spent in a laboratory. Ezekannagha (2007) describes science as an attempt by human beings to organize their experiences about nature into meaningful systems of explanations. Science subjects therefore when properly offered to learners is expected to produce in them qualities such as scientific and technological knowledge, skills and attitudes such as keen observation, manipulation, open mindedness, patience, tolerance, aptness, curiosity, critical mindedness, objectivity etc. to enable them operate completely in their environment. The offering of science subjects in open and distance learning is to give citizens such scientific knowledge, skills and qualities that would enable them improve in their day to day living within their society and for the nation to move forward in self-reliance and sustainable development.

Iwasan (2017) pointed out the benefits of science and technology education as follows;

- Ability of man to produce high quality goods and services has improved tremendously.
- New drugs, vaccines, sophisticated equipment and tools have been produced which are helping in the diagnosis and treatment of various diseases thereby enhancing longevity.
- High yielding varieties of crops and animals as well as disease-resistant varieties have been developed.
- Through science and technology transportation and communication have improved remarkably, sophisticated buildings that provide comfortable accommodation for people have also been constructed.

This important role of science subjects have been clearly expressed in the National Policy of Education (FME 2013). The National Policy on Education states as part of its goals of education, the need to develop in the individual a sound basis of scientific and reflective thinking ability to solve personal and social problems using the methods of intelligence and adaptability to his changing societal environment. The development of scientific literacy in individuals still remains the central concern of science education in all its ramifications. Science subjects should therefore help to prepare individuals to be informed in science as well as to be active participants in civic life, productive workers and life-long learners who will be able to influence their society positively.

QUALITY OF LEARNING AND STUDENTS' PERFORMANCE IN SCIENCES IN OPEN AND DISTANCE LEARNING

Regarding the quality of learning through open and distance learning, much of the research has concluded that learning in open and distance learning is as good as the learning in face-to- face (traditional classroom) education(Hong,2000; Kleinman &Entin,2002; Rovai,2002). Kleinman and Eitin (2002) compared the performance and attitude of in-class and distance learning students in an introductory computer science course. The analysis of students' data indicates that there is no significant difference between the two groups in their learning outcomes. Likewise, Landis (2006) found that there was no significant difference between distance learning students and traditional on-campus students in allied healthcare education. However, Gary (2004) compared course performance overtime between online and traditional classroom students in a required management information systems course included in the Business School's common professional component. The online delivery method was found to be effective but the performance as measured by final grades showed a lower score than students enrolled in traditional sections of the course. Ngaruko, Saria and Jiwaji (2012) found that open and distance learning undergraduate students in physical sciences at the Open University of Tanzania, exhibited poor academic performance. They suggested that the performance could be improved if the mode of study is complemented with occasional face –to- face sessions and online dialogue between the tutors and the students through teleconferencing. Adewara, Adeleke, Ogundeji and Ahani (2010) compared the performance of distance learning students with full-time students at the University of Lagos. The results indicate that there was a statistical significant difference in the final grade of these groups of students.

Literature review reveals various results from individual comparative studies on whether students' achievement in distance education is better or worse than in face- to –face education. A good many reviews of the literature on distance education effectiveness have concluded that distance education courses are as effective as face-to –face courses (Cavanaugh 2001, Zhao &Tan 2004). This study will therefore investigate the perceptions of facilitators and learners on the best practices for teaching and learning of science courses in the open and distance learning mode at the National Open University of Nigeria.

STATEMENT OF PROBLEM

The need to incorporate modern trends in science teaching and learning to meet global best practices cannot be underestimated in today's changing world. Open and distance learning has ushered in a new system of imparting scientific knowledge to students who are physically separated from the instructors. Challenges arise in teaching science students who are not physically co-located and have individual teaching schedules. Teaching science subjects involve high level of demonstration and interactivity between the instructor and the students. For instance, hands-on experiences and mathematical calculations are required in practical physics, chemistry and biology for effective teaching and learning to take place. However, better demonstration and interactivity can also be achieved by using flash technologies, animated simulations and employing synchronous communication technology which works as collaborative platforms to allow the instructor and students to have real time application and sharing of information.

This research work is therefore focused on finding out the best practices in the teaching and learning of science subjects in open and distance learning mode.

PURPOSE OF THE STUDY

The aim of this study is to determine the best practices in the teaching and learning of science subjects in open and distance learning mode. Specifically, the study sought to determine:

RESEARCH QUESTIONS

The research was guided by the following research questions:

1. What are the instructional modes/strategies that constitute the best method of teaching science in open and distance learning?
2. What are the instructional modes/strategies that constitute the best method of learning science in open and distance learning?
3. To what extent do facilitators use these instructional modes in teaching science courses in open and distance learning?
4. To what extent do students utilize these instructional modes in the learning of science courses?
5. What are the existing constraints towards attaining best practices for teaching and learning science courses as perceived by Students?
6. What are the existing constraints towards attaining best practices for teaching and learning science courses as perceived by Facilitators?

7. What are the suggestions towards attaining best practices in the teaching and learning of science courses in ODL as perceived by students?

8. What are the suggestions towards attaining best practices in the teaching and learning of science courses in ODL as perceived by facilitators?

SCOPE OF THE STUDY

Perception of Learners and Facilitators on the Best Practices for Effective Teaching and Learning of Science Courses in Open and Distance Education

The study was mainly concerned with the perception of learners and facilitators on the best practices for teaching and learning of science courses in open and distance learning mode . The National Open University of Nigeria (NOUN) which has over one hundred and twenty (120) study centres located across the country was used for the study.

METHODOLOGY

The study was a descriptive study carried out in six study centres in the South- East and South –South geopolitical zones. The population covered all NOUN students who have registered for science courses either in the faculty of science or in the department of science education. Purposive sampling was used to select 180 students pursuing B.Sc. degree in science and science education and 30 facilitators who facilitate science courses in the six centres. Two questionnaires were used namely –Questionnaire on Best Practices for Teaching and Learning Science in ODL (Facilitators) and Best Practices for Learning Science in ODL(for students) .Each of the questionnaire had four sections.-Section A and B require responses on a four point scale of –Very Large Extent,(VLE), Large Extent(LE(. Moderate Extent (ME) and Small Extent (SM) . Section C & D of the instrument require open – ended responses from the respondents. Experts in ODL and science education validated the instrument. The reliability of the instrument was determined using the Test –Retest method. A reliability coefficient of 0.86 was obtained using Spearman Brown's Formula.

The data was collected from the facilitators and learners by administering the instruments and collecting them back through the research assistants / counselors at the different study centres. The responses were tallied and the frequencies and mean scores for each item was computed. The mean scores / frequencies were used in answering the research questions. A mean rating of 2.50 and above implies acceptance/agree while a mean score below 2.50 implies rejection/disagree.

ANALYSIS AND PRESENTATION OF FINDINGS

Research Question 1: What are the instructional modes/strategies that constitute the best method of teaching science in open and distance learning?

Table 1: Mean Response of Facilitators on the extent to which the under-listed modes/strategies constitute best practices for teaching science courses in ODL.

S/N	Item	VLE	LE	ME	SE	N	Mean	Remark
1	Using practical demonstrations	15	15			30	3.5	Accepted
2	Engagement with hands-on activities	10	15	5		30	3.17	Accepted
3	Use of examples	18	10	2		30	3.53	Accepted
4	Regular feedback on exercises done	10	18	2		30	3.27	Accepted
5	Effective use of communication skills	8	10	10	2	30	2.80	Accepted
6	Use of diagrammatic illustrations	8	11	10	1	30	2.87	Accepted
7	Use of real objects	12	15	3		30	3.3	Accepted
8	Use of improvised objects	8	8	10	4	30	2.67	Accepted
9	Availability of functional internet facilities	10	15	5		30	3.17	Accepted
10	Available personal computers /laptops for our tutorials	10	18	2		30	3.27	Accepted
11	Access to internet facilities /connectivity	14	15	1		30	3.43	Accepted
12	Multimedia projectors are used for power point presentations in classes.	5	10	10	5	30	2.50	Accepted
13	Regular electricity supply	6	18	4	2	30	2.93	Accepted
14	Offering learners' support	4	14	10	2	30	2.67	Accepted
15	Offering counseling services	6	10	10	4	30	2.60	Accepted

Responses from Table 1 indicated that all the mean ratings were greater than the cut-off point of 2.50, which implies that all the items were accepted as capable of engendering best practices in the teaching of science courses in ODL as perceived by the facilitators used for the study. Engagement with hands-on activities and use of examples were among the instructional modes/strategies rated very highly by the facilitators.

Table 2: Mean Response of students on the extent to which the under-listed modes/strategies constitute best practices for learning science courses in ODL.

S/N	Item	VLE	LE	ME	SE	N	Mean	Remark

1	Using practical demonstrations	40	110	30		180	3.06	Accepted
2	Engagement with hands-on activities	35	100	40	5	180	2.92	Accepted
3	Use of examples	30	110	30	10	180	2.89	Accepted
4	Regular feedback on exercises done	35	65	60	20	180	2.64	Accepted
5	Effective use of communication skills	30	50	74	26	180	2.47	Rejected
6	Use of diagrammatic illustrations	14	66	80	20	180	2.41	Rejected
7	Use of real objects	50	50	60	20	180	2.72	Accepted
8	Use of improvised objects	30	40	50	60	180	2.22	Rejected
9	Availability of functional internet facilities	90	50	36	4	180	3.26	Accepted
10	Available personal computers /laptops for our tutorials	65	75	26	14	180	3.06	Accepted
11	Access to internet facilities /connectivity	60	80	20	20	180	3.00	Accepted
12	Multimedia projectors are used for power point presentations in classes.	40	50	53	37	180	2.52	Accepted
13	Regular electricity supply	35	55	55	35	180	2.50	Accepted
14	Offering learners' support	60	80	15	25	180	2.97	Accepted
15	Offering counseling services	55	85	25	15	180	3.00	Accepted

Responses from Table 2 indicated that with the exception of items 5, 6, and 8 all the mean ratings were greater than the cut-off point of 2.50, which implies that all the other items were accepted as capable of engendering best practices in the learning of science courses in ODL as perceived by the students used for the study

Table 3: **Mean responses of facilitators on the extent to which they use the under-listed modes/strategies for teaching science courses in ODL**.

S/N	Item	VLE	LE	ME	SE	N	Mean	Remark
16	Using practical demonstrations	10	12	8		30	3.07	Accepted
17	Engagement with hands-on activities	11	12	4	3	30	3.03	Accepted
18	Use of examples	8	15	7		30	3.03	Accepted
19	Regular feedback on exercises done	7	18	5		30	3.07	Accepted
20	Effective use of communication skills	5	15	8	2	30	2.77	Accepted
21	Use of diagrammatic illustrations	7	14	4	6	30	2.80	Accepted
22	Use of real objects	10	12	6	2	30	3.00	Accepted
23	Use of improvised objects	10	10	4	6	30	2.80	Accepted
24	Availability of functional internet facilities	8	10	7	5	30	2.70	Accepted
25	Available personal computers /laptops for our tutorials	10	14	6		30	3.13	Accepted
26	Access to internet facilities /connectivity	10	20			30	3.33	Accepted
27	Multimedia projectors are used for power point presentations in classes.	5	15	8	2	30	2.77	Accepted
28	Regular electricity supply	8	10	7	5	30	2.70	Accepted
29	Offering learners' support	8	10	5	7	30	2.63	Accepted
30	Offering counseling services	6	14	4	6	30	2.60	Accepted

Responses from Table 3, indicated that all the mean ratings were greater than the cut-off point of 2.50, which implies that all the items were accepted as being used by the facilitators for engendering best practices in the teaching of science courses in ODL. The item means ranged from 2.60 for item 30, to 3.33 for item 26. Using practical demonstrations, access to internet facilities/connectivity and availability of personal computers /laptops for tutorials were among the instructional modes/strategies utilized and rated very highly by the facilitators .

Table 4: Mean Response of Students on the Extent to which they use the Under-listed modes/strategies for learning science courses in ODL.

S/N	Item	VLE	LE	ME	SE	N	mean	Remark
16	Using practical demonstrations	40	100	30	10	180	2.94	Accepted
17	Engagement with hands-on activities	45	90	40	5	180	2.97	Accepted
18	Use of examples	40	100	30	10	180	2.94	Accepted
19	Regular feedback on exercises done	50	60	50	20	180	2.78	Accepted

20	Effective use of communication skills	30	60	64	26	180	2.52	Accepted
21	Use of diagrammatic illustrations	14	76	70	20	180	2.47	Rejected
22	Use of real objects	50	50	60	20	180	2.72	Accepted
23	Use of improvised objects	40	40	50	50	180	2.39	Rejected
24	Availability of functional internet facilities	80	50	36	14	180	3.09	Accepted
25	Available personal computers /laptops for our tutorials	70	70	26	14	180	3.09	Accepted
26	Access to internet facilities /connectivity	60	70	25	25	180	2.92	Accepted
27	Multimedia projectors are used for power point presentations in classes.	40	70	33	37	180	2.63	Accepted
28	Regular electricity supply	35	65	40	40	180	2.53	Accepted
29	Offering learners' support	40	100	15	25	180	2.86	Accepted
30	Offering counseling services	55	80	25	20	180	2.94	Accepted

Responses from Table 4, indicated that all the mean ratings except for items 21 and 23 were greater than the cut-off point of 2.50, which implies that all the other items were accepted as being used by the students for engendering best practices in the learning of science courses in ODL.

Table 5: Percentage & Frequencies of Existing Constraints towards attaining best practices for teaching and learning science courses as perceived by students (N= 180).

S/N	Existing Constraints encountered by students	Frequencies	Percentage
1.	No problems encountered while in practical science activities.	18	10%
2	Problems of adjusting to time for practical classes	36	20%
3	Inability to understand the practical classes properly	27	15%
4	No residential facility in the study center	9	5%
5	Practical classes are done superficially	22	12%
6	Communication problems at the study center	14	8%
7	Large number of students engage in practicals at a time	9	5%
8	problem to understand the Language used in the practical class.	9	5%
9	Absence of functional laboratories in some study centres	36	20%

Responses from Table 5, indicated the existing constraints towards attaining best practices for teaching and learning science courses in ODL as perceived by students. The major constraints as perceived by the students included absence of functional laboratories in some study centres, Problems of adjusting to time for practical classes and shallow treatment of practical courses.

Table 6: Percentage Frequencies of Existing Constraints towards attaining best practices for teaching and learning science courses as perceived by Facilitators.(N=30)

S/N	**Existing Constraints towards attaining best practices in teaching science at ODL**	**Frequencies**	**Percentage**
1.	No major problem while guiding the learners for their practical activities.	12	40%
2	Learners are irregular in attending practical classes in science	6	20%
3	Learners are very less aware about the theory part of the practical	6	20%
4	There is lack of well-equipped laboratory for the ODL learners	5	15%
5	No provision for repeat/practice of the practical activities/experiments;	1	5%

Responses from Table 6, indicated the existing constraints towards attaining best practices for teaching and learning science courses in ODL as perceived by the facilitators. The major constraints as perceived by the facilitators included lack of well-equipped

laboratory for the ODL learners at study centres, irregularity of students in attending to practical classes in science, paucity of students' awareness about the theory part of the practical.

Table 7: Percentage Frequencies of Suggestions towards attaining best practices for teaching and learning science courses as perceived by students. (N=180)

S/N	Suggestions towards attaining Best Practices in teaching/learning science	Frequencies	Percentage
1	No suggestion was indicated towards effective implementation of practical based courses under ODL system	45	**25%**
2	Timing of the practical should be designed according to the needs of the learners	45	25%
3	Home based practical should be conducted	36	20%
4	Study center should have its own practical instruments and laboratory	18	10%
5	Practical should be conducted in small groups	18	10%
6	Practical should be conducted during the holiday time	9	**5%**
7	E-based practical should be encouraged.	9	**5%**

Responses from Table 7 indicate students' suggestions towards attaining best practices in the teaching and learning of science courses in ODL. The major suggestions included:-

i. timing of the practical sessions should be designed according to the needs of the learners,
ii. home based practicals should be conducted,
iii. study centres should have its own practical instruments and laboratory
iv. practicals should be conducted in small groups

Table 8: Percentage Frequencies of Suggestions towards attaining best practices for teaching and learning science courses as perceived by Facilitators (N=30).

S/N	Suggestions towards attaining Best Practices in teaching/learning science	Frequencies	Percentage
1	No suggestion was indicated regarding effective implementation of practical based courses under ODL system.	9	30%
2	Theory part of the practical should be properly taught before doing practical	6	20%
3	Special practical arrangement may be done for candidates who could not adjust to scheduled time due to their job.	5	16.67%
4	Sufficient number of practical classes should be allotted on the time table	5	16.67%
5	Laboratory technicians and counselors should be well trained about ODL system.	5	16.67%

Responses from Table 8 indicate facilitators' suggestions towards attaining best practices in the teaching and learning of science courses in ODL. The major suggestions included:-

i. Theory part of the practical should be taught properly before carrying out the practical,
ii. Special practical arrangement may be done for candidates who could not adjust to scheduled time due to their job,
iii. Laboratory technicians and counselors should be well trained about ODL system a nd sufficient number of practical classes should be allotted in the time table.

DISCUSSION OF FINDINGS

I. Instructional modes/strategies that constitute best practices for teaching /learning of science courses

A- Findings from Table 1, indicate that using practical demonstrations, engagement with hands-on activities and use of examples were highly rated and accepted as best practices in the teaching of science courses in ODL as perceived by the facilitators. This finding concurs with Hodson (2014) who posits that quality practical work can engage students, develop their understanding of concepts and also enable them to understand the process of scientific investigation.

B –With regards to the findings from Table 2, the use of practical demonstrations, availability of functional internet facilities, and availability of personal computers /laptops for tutorials were among the instructional modes/strategies that the students rated very high. With the recent introduction of "noun i-learn" and online facilitation in NOUN the role of personal computers/laptops and internet availability in ODL cannot be over emphasized in enhancing students' learning. Ani (2015) explained the importance of the internet in this digital age. He noted that the internet is the cheapest and fastest means of sourcing, providing and compiling information across the globe and from varied sources. In the absence of computers/laptops and functional internet facilities, the students are disadvantaged and little or no learning will take place.

II. Extent of use of the instructional modes/strategies in teaching/learning science courses.

C- Findings from Table 3, reveals that the facilitators rated using practical demonstrations, access to internet facilities/connectivity and availability of personal computers /laptops for tutorials very highly as instructional strategies for best practices in teaching of science courses. This correlates with Sung et al (2016) whose research studies confirm that integrating computer, laptop and mobile devices with teaching and learning enhances students' performance.

D- Table 4 reveals that engagement with hands-on activities, access to internet facilities/connectivity and availability of personal computers /laptops for tutorials were among the instructional modes/strategies utilized and rated very highly by the students .Owoyemi and Akinsete (2012) in their study on "Learning science at a distance- NOUN students perception of practical work in learning science" found that the students were of the opinion that it is more challenging to learn science without any practical work. Their work also revealed that NOUN students were of the view that it is essential for a science course to include practical sessions even though the course materials have been delivered to them

III. Constraints hindering the attainment of the best practices for teaching/learning of science courses.

E - Findings from Table 5 emphasize the major constraints that hinder the attainment of best practices for learning science courses in ODL as perceived by the students. These include absence of functional laboratories in some study centres, problems of adjusting to time for practical classes and shallow treatment of some practical courses. Nnaka (2016) noted that lack of science laboratories and lack of internet facilities constitute major challenges to teaching and learning of science in ODL. Moreover available evidence and visit to NOUN study centres reveals that most of them lack the physical infrastructure to accommodate a science laboratory.

F- Findings from Table 6 indicate that the major constraints towards attaining best practices for teaching science courses in ODL as perceived by the facilitators include lack of well-equipped laboratory for learners at study centres, irregularity of students in attending to practical classes and paucity of students' awareness about the theory part of the practical. Records from study centre time tables shows that practical sessions are usually scheduled from 1.00pm to 4.00pm .This is very inconvenient for the students most of whom are employed, consequently the attendance is usually very low.

IV. Suggestions of Facilitators and Students towards attaining best practices in teaching/learning of science courses.

G. Major suggestions by students towards attaining best practices for learning science courses as shown in Table 7 include-

i. Timing of the practical should be designed according to the needs of the learners.

ii. Home based practical should be conducted.

iii Study centres should have their own practical instruments and laboratory.

iv. Practical should be conducted in small groups.

This agrees with Owoyemi & Akinsete (2012) Nnaka (2013) who emphasized that any meaningful teaching and learning of science must include practical work. The practical can be done in the laboratory or at home through various multimedia.

H. Findings from Table 8 shows that the facilitators indicated that the major suggestions towards attaining best practices for teaching science courses include-

i. Theory part of the practical should be taught properly before doing practical.

ii Special practical arrangement may be done for candidates who could not adjust to the scheduled time due to their job.

iii Laboratory technicians and counselors should be well trained about ODL system and

iv . Sufficient number of practical classes should be scheduled on the time table.

Kandamby (2019) in his study on –"Effectiveness of Laboratory Practical for Students' Learning" noted that students' active involvement in learning before the commencement of practical with the assistance of the instructor observing physical outcomes have shown better results in students' learning outcome. Therefore the theory part of the science courses should be thoroughly taught to the students before the practical begins.

CONCLUSION AND RECOMMENDATIONS

Utilizing the best practices in teaching and learning of science courses in ODL is a desirable goal and is achievable. The study revealed that for the facilitators the use of practical demonstration, engagement with hands-on-activities, and use of examples were perceived as the best practices in the teaching of science courses in ODL. The students perceived using practical demonstration, availability of functional internet facilities and possession of personal computer/laptop for tutorials as best practices for the learning of science courses in ODL. The instructional modes/strategies that ought to be utilized for science teaching in ODL include the use of practical demonstration, provision of access to internet facilities and availability of personal computers/laptop , while engagement with hands-on-activities, access to the internet and possession of personal computer/laptop were rated highly as instructional modes/strategies for the learning of science courses in ODL.

The major constraints that hinder the attainment of the best practices in teaching /learning of science courses in ODL include- absence of functional laboratory in most study centres and problem of adjusting the practical time – table to meet the needs of students. Finally, in order to attain the best practices for teaching/learning of sciences courses in ODL, establishment of science laboratories in study centres, home based practical, timing of the practical to suit the needs of the students, conducting of the practical in small groups and training of laboratory technicians in ODL systems were suggested. Best practices in the teaching/learning of science courses can be attained if the identified constraints are eliminated and the suggestions implemented. Based on the findings of the study the following recommendations were:-

i. NOUN Study Centres that have adequate physical infrastructure should have fully equipped science laboratories.
ii. All NOUN Study Centres should be equipped with functional internet facilities, so that students and facilitators can make use of any multimedia facility that is available.
iii. It is necessary for NOUN to partner with information and communication technology companies in the country to assist students to acquire their personal computers/laptops
iv. Training and retraining of science tutorial facilitators and laboratory technicians on the use of various electronic media for instructional delivery.

REFERENCES

1) Adewara, J.A., Adeleke, I.A. Ogundeji, R.K. & Ahani, E.B. (2010). Comparison of Academic Performance of Distance Learning Students and Full-Time Students in University of Lagos, *American Journal of Business Education, Vol. 3(9) (Sept. 2010),* p . 17-21
2) Ally, M. (2004). Foundations of Theory for Online Learning. In *Terry Anderson and Fattil Elloumi (eds.) Theory and Practice of Online Learning*, 1, *31, Athabasca University, Canada*
3) Amita, N. & Vibha, J. (2007). Science Education through Open & Distance Learning at a Distance at Higher Education Level. *Turkish Online Journal of Distance Education*. *TOJDE Oct;2007, Vol. 6(4)*
4) Anderson, T. (2007). "Reducing the Loneliness of the Distance Learner using Social Software" *Keynote Address presented at the 2nd Cambridge International Conference on Open and Distance Learning,* September, 2007, Cambridge, UK
5) Ani, C. I. (2015) Accessibility of Internet Services in Nigeria. In G. c. Unachukwu (Ed.), Dynamics of Access to Education in Nigeria. Awka; SCOA Heritage Ltd.
6) Ausubel, D.P. (1974). Educational Psychological Cognitive View. New York: Holt, Rineharm Winston
7) Boettcher, J. (2011). Ten Core Principles for Designing Effective Learning Environment: *Insights from Brain Research and Pedagogical Theory Innovate*, 3(3*). FIschier School of Education and Human Services, Nova South-eastern University*
8) Cavanaugh, C.S. (2001). The Effectiveness of Interactive Distance Education Technologies in K-12 Learning: A Meta-Analysis. *International Journal of Educational Telecommunication*, *7(1):* 73-88
9) Chikuya, C. (2001). Teacher Education within the Context of Open and Distance Learning in Zimbabwe: A Case Study. *Unpublished PhD Thesis*, University of South Africa
10) Cimer, A. (2007). Effective Teaching in Science – A Review of Literature, Some of the Many Principles of Effective Teaching. *Journal of Turkish Science Education, Vol. 4(1),* p. 20-44
11) Crack, F.I. M. & Tulvang, E. (1975). Depth of Processing and the Retention of Words in Episodic Memory. *Journal of Experimental Psychology, General, 104,* 268-294
12) De Haro, S. (2020). Science and Philosophy: A-Love-Hate Relationship. *Foundations of Science, Vol 25,* p.297-314
13) Ezekannagha, G.N. (2007). Effects of Concept Mapping and Cognitive Styles on Achievement of Students in Integrated Science. *Unpublished PhD. Thesis*, University of Nigeria, Nsukka
14) Federal Government of Nigeria (2013). National Policy on Education, Sixth Edition. *NERDC ,Press Abuja.*
15) Freeman, R. (2004). Planning and Implementing Open and Distance Learning System: *A Handbook for Decision Makers, Vancouver, Canada*: The Commonwealth of Learning

16) Gary, U. (2004). A Comparison of Undergraduate Students Performance in Online and traditional Courses. *Journal of Computing in Colleges, Vol. 19(4),* p. 99-107
17) Garrison, R. (2000). Theoretical Challenges for Distance Education in the 21st Century: A Shift from Structural to Transactional Issues. *International Review of Research in Open and Distance Learning*, 1(1)
18) Goodrum, D. (2019). The Art of Teaching Science. 3rd Edition, *Routledge eBook*
19) Hodson, D. (2014). Learning Science, Learning about Science doing Science: Different Goals Demand Different Methods. *International Journal of Science Education, 36(15);* 2534-2553
20) Hong, K.S. (2002). Relationship between Students and Instructional Variables with Satisfaction from a Web-Based Course. *Internet and Higher Education, 5*, p.267-281
21) Inyang, W.E. (1993). Learning Theories: Implication for Science Teaching in *Eshiet, I.J. (Ed). Methodology of Science Teaching*. P.H. Tompson and Tompson
22) Iwasan, P.K. (2017). The Importance of Scientific Education and Technology. *International Journal of Current Research, Vol. 9(06), P 53022-53023*
23) Kandamby, G.W.T.C. (2019) Effectiveness of Laboratory Practical for Students' Learning. International Journal for Innovation Education and Research. Vol.7(3).
24) Kleinman, J & Ertin, E.B. (2002). Comparison in Class and Distance Learning Students' Performance and Attitudes in an Introductory Computer Science Class. *Journal of Computing Sciences in Colleges, Vol. 17(6),* p. 206-219
25) Landis, R.B. (2006). Comparison in Academic Performance between Distance Learning and Traditional On-Campus Students in Allied Health Care Education at the Medical College of Georgia (2006) *(Electronic Thesis and Dissertation Paper, 283)*
26) Mannan, M. A. (2018) Science and Subjectivity: Understanding Objectivity of Scientific Knowledge. *Philosophy and Progress, Vol.59 (1-2),* p.43-72
27) Miller, R. (2004). The Role of Practical Work in Teaching and Learning of Science. Retrieved www.i.nationalacademies.org.org/bose/miller_draftpaperjin04.pdf (Accessed Nov, 2021)
28) Mudasiru, O.Y. (2006). Problems and Prospects of Open and Distance Learning in Nigeria. *Online Journal of Distance Education (TUJDE LSSN), Vol. 7(1) 2*
29) Ngaruko, D.D., Saria, J.A. Jiwaji, N.T. (2012). Performance Determinants in Physical Sciences for ODL Undergraduate Students: the Case of Open University of Tanzania. *Journal of the Open University of Tanzania, Vol. 13 (2).*
30) National Open University of Nigeria: Getting to Know Your University, An Orientation and Information Guide for Students of National Open University of Nigeria. (Revised 2007) NOUN Publication.
31) NOUN PROFILE (2014) National Open University of Nigeria.
32) Nnaka, C.V. & Anaekwe M.C. (2017) Challenges of Teaching and Learning Science at a Distance in National Open University of Nigeria, In *F. Maringe & E. Ojo (Eds.)Sustainable Transformation in African Higher education, p.189-201, Sense Publishers.*
33) Nnaka C.V. (2016). Science Education through Open and Distance Learning at National Open University of Nigeria. *International Journal of Library & Educational Science (1 ASET:IJLES), Vol. 2(1),* p. 1-8
34) Nnaka, C. V. (2013) Availability and utilization of multimedia by open and distance learning students: The case of National Open University of Nigeria. East African Journal of Educational Research and Policy (EAJERP) Vol. 7. June 2013.
35) Nsiah, G.K.B. (2013). Best Practices – Distance Education: A Review. *Creative Education, Vol 4 (12)*
36) Offorma, G.C. (1994). Curriculum Implementation and Instruction. Onitsha Uniworld Educational Publishers (Nig.) Limited
37) Okeke, E.A.C. (2007). Making Science Education Accessible to All. 23rd Inaugural Lecture of the University of Nigeria, Nsukka, 9th August, 2007
38) Okeme, I. (2002). Science Teaching Concept, Principles and Methods. Usi Printers and Publishers Co. Ltd, Calabar
39) Owoyemi, T.E.and Akinsete, A.M.(2012) Learning Science at a Distance : National Open University of Nigeria Students' Perception of Practical Work in Learning Science. Proceedings of EPISTEME :(5) India. Retrievedfrom *http:/episteme.hbese.trifr.res.in/index.php/episteme5/5/paper/view/85/8.* Oct.15 2020
40) Rowe, C. (1994). Assessing the Effectiveness of Open Learning: *The British Aerospace Experience. Industrial and Commercial Training, Vol. 4, p.* 22-27
41) Rovai, A. (2002). Building Sense of Community at a Distance. International Review of Research in Open and Distance Learning. IRRODL, 3.1. *Retrieved August 29, 2003 from http://www.irrodl.org.content/v3.1/roval.pdf*
42) Saykili, A. (2018). Distance Education: Definitions, Generations, Key Concepts and Future Directions. *International Journal of Contemporary Education Research, Vol.5(1),* 2-17.

43) Sean, M.B., Derek, J.M. & Richards T.W. (2002). Stack the Deck in Favour of your Students by using the Four Aces of Effective Teaching, *Journal of Effective Teaching, Vol. 5(2), 2002*
44) Skinner, B.F. (1974). About Behaviourism. *New York: Knopt*
45) Warner, C.K., Bell, C.V. & Odom, A.L. (2018). Defining Technology for Learning: Cognitive and Physical Tools of Inquiry, *Middle Grades Review: Vol. 4(1), Article 2*
46) Woodley, R. (2009). Practical Work in School Science – Why it is important? Retrieved from www.gettingpractical.org.uk/documents/SSRSSAT000.pdf (Accessed Nov. 2021)
47) Yao-Ting-Sung, Kuo-En Chang & Tzu-Chien Liu (2016). The Effects of Integrating Mobile Devices with Teaching and Learning on Students Learning Performance: A Meta-Analysis and Research Synthesis. *Elsevier, Vol, 94,* p. 252-275, *March 2016*
48) Zhao, Y., Lei, I., Yan, B. & Tan, S. (2004). What Makes the Difference? A Practical analysis of
49) Research on the Effectiveness of Distance Education. Available Online at *http://ott.edu.msu.edu/literature/report/pdf*