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A MATHEMATICAL MODEL FOR THE ADOPTION OF INFORMATION AND COMMUNICATION TECHNOLOGY IN SCHOOL LIBRARIES IN NIGERIA

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ABSTRACT

This study focused on the development of a mathematical model required for estimating the number of adopters of ICT devices among libraries located in Nigeria. Data for this study was collected from 121 respondents selected based on a research survey approach using simple random sampling. 9 ICT devices were identified, namely: PCs, printers/fax machines, search engines, e-library systems, bulk SMS services, library management systems, bar/QR code readers, projectors and video conferencing. The results showed that the earliest ICT devices were adopted for use in 1997, such as: PCs, printers/fax machines and search engines. The remaining ICT devices were adopted in 2000, such as: e-library, bulk SMS services, library management system, bar/QR code readers, projectors and video conferencing. Polynomial functions of degree, m was used to formulate the mathematical model for the adoption of each ICT device identified based on the cumulative frequency of yearly adopters.

Keywords: ICT adoption, Mathematical modeling, Polynomial model, Library services.

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INTRODUCTION

The library can be referred as an institutional asset and a knowledge repository with the responsibility to put together all activities of collection, processing, organization, storage and dissemination of information resources in print and electronic format for the purpose of meeting the needs of users (Obinyan & Akande, 2019). The relevance of libraries in the Nigerian educational system cannot be over-emphasized. This is as a result of the association of library with education which is an instrument of societal transformation. According to Daluba and maxwell (2013), the library is associated with education and education is a societal instrument of change which consequently, affects the social, political, economic, scientific and technological changes. However, recent transformation in information handling methods by librarians proposes the ideological and sociological view point, that the library is an institution or organization that provides access to information-based resources.

Likewise, library gives a sense of scholarship with interactive and collaborative learning. Library assisted students to engage optimally with the ever-changing information environment and provides easy access for gathering recent information about new technologies and advancements (Patrick, Aghojare, & Ferdinand, 2015). Library services are the activities that libraries and their personnel render to meet the information needs of their users. Library services are viewed as varied activities that is rendered to library users for effective and efficient patronage and given the required information for research work (Onuoha & Subair, 2013).

In addition, Ogunrombi (2004), highlighted that there is a correlation between quality of information resources and the quality of education (research and scholarship) because no educational system would be greater than the quality of its teachers (Bitagi & Udoudoh, 2014). They argued that the quality of education and research depends on the quality of information sources available and accessible by users. Hence, Ogbebor (2011), sees information resources as an organized collection of published and unpublished books and audiovisual materials which a library uses to meet the informative, research, educational and recreational needs of its users. Furthermore, Chimah and Nwokocha (2013), affirmed that information resources are those materials, strategies, manipulations, apparatuses or consultations including all forms of information carriers that can be used to promote and encourage effective learning and research,

as well as developmental projects. Bitagi & Garba (2014), opined that information resources constitute a range of materials and equipment gathered by a library in order to meet the information needs of both intended and anticipated users. It was further stated that the availability of all forms and types of information resources in academic libraries is highly imperative if libraries are to meet up with satisfying the information needs of both users and researchers in their parent institutions.

The revolution in information technology no doubt has tremendously influence the delivery of education. As rightly observed by Uwaifo (2013) that there is significant change in the way information resources are provided to the member of university community. With the invention of Information and Communication Technology, libraries now use various types of technologies to aid the services they render. Everyday new technological advances affect the way information is handled in libraries and information centers. The impacts of new technologies are felt by libraries in every aspect. Computing technology, communication technology and mass storage technology are some of the areas of continuous development that reshape the way that libraries access, retrieve, store, manipulate and disseminate information to users. Universities through a number of ways embrace the electronic provision of information to facilitate study programmes and research. With the integration of online information services, electronic books, electronic document delivery services and digital libraries in its library systems, university lecturers can now access information from various sources. Hence, this study focuses on the identification of the various types of ICT devices which are adopted by Libraries in Nigeria alongside the mathematical modeling of the level of adoption of the identified ICT devices.

OBJECTIVE OF THE STUDY

The aim of this study is to formulate a mathematical model that can be used to determine the number of adopters of ICT in School libraries in Nigeria through the following objectives;

i.   to identify the various ICT devices adopted in school libraries in Nigeria;

ii.   to identify the most commonly used ICT devices in school libraries in Nigeria;

iii.   to identify the year of adoption of each ICT devices in school libraries in Nigeria;

iv.   to formulate mathematical model for the number of adopters of each ICT devices in school libraries in Nigeria.

RESEARCH QUESTION

To study answered the following research questions:

1. what are the ICT devices adopted in school libraries in Nigeria?
2. What are the most commonly adopted ICT devices in school libraries in Nigeria?
3. When were the various ICT devices adopted in school libraries in Nigeria?
4. What are the mathematical models that can be used to estimate the number of adopters of ICT devices?

REVIEW OF LITERATURE

Obinyan and Akande (2019), worked on the assessment of the level of satisfaction of nursing students with library services in selected universities. The study adopted the use of a secriptive survey research design by collecting data from 193 nursing studets in 100 to 500 level using questionnaires distributed across 200 studeent. The study revealed that majority of the students adopted the use of services such as: library loan services (52.3%), user-education services (56.5%), electronic services (50.3%) and photocopying services (50.8%). The study also showed that outdated library materials, unfriendly attitude of library staff to users, lack of awareness of the range of services libraries offer, library that do not subscribe to recent electronic databases, inadequate seats and reading tables, erratic power supply affecting the use of electronic library resources, books that are not always found in the right shelves according to subject area were challenges respondents' face in using library services. The study was limited to the assessment of student satisfaction with library services.

Similarly, Idowu *et al.* (2017), worked on the development of infusion model for the adoption of ICT by the Nigerian transport sector. The study adopted a survey approach in collecting information from 100 members of staff selectled randomy from six (6) different private inter-state transport companies. The study identified a number of ICT devices which were associated with the operations of the transport business among the selected companies such as: smartphones, SMS, e-mails, company website, bulk SMS, ticket reservations, vehicle trackers, POS systems and 2-way radio systems. The results of the study showed that the earliest ICT tools adopted were: SMS, e-mails, bulk SMS, company websites, ticket reservations and vehicle trackers in 2001 while smartphones, POS and 2-way radios systems were adopted by 2006. The study was limited to the adoption of ICT services for use by the transport sector.

Likewise, in the work of Egejuru *et al.* (2017), on the development of an ICT infusion model for the agricultural sector in Nigeria. The study collected data using a stratified random

sampling of 200 respondent selected from 6 agricultural research and academic institutes within the South-Western part of Nigeria. The various ICT deviced adopted for use included: smartphones, Short Message Services (SMS), e-mail, computers, office hardware, wireless media technologies, global position satellites, geographical information systems, radio-frequency identification technology and automated systems. The results of the study further showed that the earliest adopted ICT devices were computer and office hardware in 1994, e-mails in 1995, SMS and wireless technologies in 1998 and smartphones in 1999 - all adopted before the 21st century. The study was limited to the adoption of ICT services for use by the agricultural sector.

In addition, Usman (2016), worked on the assessment of the fcators which affect the demand for information resources among library users in North-west Nigeria. The study adopted descriptive survey and used quantitative methodology to collect data, via the use of questionnaire from 376 registered users that were randomly sampled for the study. The study revealed that both library users and their libraries are responsible for the observed critical factors affecting demand for information resources, among the University libraries in North-West Nigeria. The results of the study also showed that users of University libraries in North-West Nigeria are fairly satisfied with information resources they demand because of the poor articulation of their information needs and their inability of using catalogue to demand for information resources. The study was limited to the identification of factors affecting the demand for information resources among library users.

METHODOLOGY

This study made use of structured questionnaire as the instrument of data collection from respondents of the selected location in Nigeria to elicit information about the ICT devices used among respondents selected from members of staff consisting of lecturers and librarians alongside students of tertiary institutions selected from south-western Nigerian States. The instrument of data collection was used to collect information from the respondents of the study, which included: demographic information, ICT devices adopted at each libraries alongside the time of adoption of the ICT devices. Following the collection of data from the respondents, the data was analyzed using standard descriptive statistics tools: tables for data presentation and graphs for data presentation. The mathematical model for ICT adoption was formulated using polynomial expressions of degree, m estimated from cumulative total of users for each year from the year of adoption of each ICT device. The study population identified for this study

are the users of academic and research libraries of academic institutions. 150 questionnaires were distributed among the respondents with the necessary information provided.

This study also, incorporated the use of descriptive statistical techniques for the purpose of analyzing the data collected for this study from the respondents. The descriptive statistics methods used helped in the simplification of the data collected in a sensible way by the provision of descriptive summary using frequency tables and charts. The ICT infusion model was formulated using the Microsoft® Excel's built-in functionality for estimating the trend line of graphical tables and charts – which in this case is a polynomial function of degree, m. For the purpose of this study, the IT infusion model was formulated as a function of the number of years; x from the base year y_0, up to a required year y_x using a polynomial equation of degree, m for each identified IT component. Equation (1) shows how to determine number of years, x that is required to determine the number of users of the ICT devices by the year, from the base year y_0.

$$x = Y_x - Y_0 + 1 \qquad (1)$$

The number of ICT devices adopted by the respondents of the academic institutions for each year, u_t was considered as a sequence of terms as shown in Equation (2). Following this, the cumulative total for each successive year was determined till the final year - 2017 as shown in Equation (3). Assuming an ICT device which was used starting from a base year, $Y_0 = 2003$; it will be observed from Equation 1 that the total number of terms in the sequence of users from 2003 till 2017 is t = 2017-2003+1=15 years.

$$u_t = u, u_2, u_3, u_4, \ldots\ldots\ldots, u_{15} \qquad (2)$$

The cumulative total number of ICT devices used by respondents of the libraries for each year from the base year till the present year was considered as a series of terms (equation 3). In equation (2), it was observed that each u_t for $1 \le t \le 15$ represents the number of users of the IT device for each successive year from 2003 till 2017. Equation (2) was converted to a sequence of the cumulative sum of users for each successive year as shown in Equation (3). Thus each S_t $1 \le t \le 15$ represents the cumulative total number of users of ICT devices x years after the base year of infusion, Y_0 as shown in Equation 4.

$$S_t = u_1, (u_1 + u), (u_1 + u_2 + u_3), \ldots\ldots (u_1 + u_2 \ldots.. + u_{15}) \qquad (3)$$

$$S_t = S_1, S_2, S_3, S_4, \ldots\ldots\ldots\ldots, S_{15} \qquad (4)$$

where: $S_1 = u, S_2 = (u_1 + u_2),, \ldots\ldots\ldots. S_{15} = (u_1 + u_2 \ldots.. + u_{15})$

Hence, the mathematical model for ICT adoption was thus a polynomial equation of degree m which is the best line fit of the cumulative number of users of each ICT device by year, Y_t - t years after the base year, Y_0. Thus, the IT infusion model is a polynomial fit of Equation (4) expressed in terms of t (the number of years after the base year). Hence, the IT infusion model is expressed as shown in Equation (5).

$$S(t) = a + bt + ct^2 + \ldots\ldots + dt^n \tag{5}$$

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

The questionnaire used for this study was distributed among the respondents selected from the libraries located in Ogun State, South-Western Nigeria for which out of the initial 150 questionnaires distributed, only 121 respondents provided the necessary information required for this study as presented in the questionnaires. Table 1 gives a summary of the number of respondents selected from each type of library considered for this study. Out of 121 respondents selected for this study; 76.0% of the respondents were selected from academic libraries, 10.7% from research libraries, 9.9% from special libraries and 3.3% failing to provide the type of libraries they belong to. Out of the 121 respondents selected from the libraries, 24.8% were selected from private libraries, 69.4% were selected from government and 5.8% failed to provide details thus referred to as missing data.

Table 1: Distribution of Library Type

Library Type	Frequency	%
Academic	92	76.03
Research	13	10.74
Special	12	9.92
Missing	4	3.31
Total	121	100.00

Table 2 shows the distribution of the different classes of libraries from which the respondents were selected from. The results showed that out of the 121 respondents selected, majority were academic with a proportion of 76.0%, 10.7% were research, 9.9% were special while 3.3% were missing. According to Table 3 which shows the distribution of gender, 68.6% were male while 30.6% were female with 0.8% respondents were missing.

Table 2: Distribution of Library Class

Library Class	Frequency	%
Private	30	24.79
Government	84	69.42
Missing	7	5.79
Total	121	100.00

Table 3: Distribution of Gender of Respondents

Gender	Frequency	%
Male	83	68.60
Female	37	30.58
Missing	1	0.83
Total	**121**	**100.00**

Table 4 shows the distribution of the employment of the respondents. The results showed that 64.5% of respondents selected were students, 20.7% of respondents were lecturers, 11.6% of respondents were librarians, and 1.7% of respondents had other type of employment while 1.7% of respondents were secretaries. Table 5 shows the distribution of the number of years of experience of the respondents. The results showed that except for the students, 4.1% of respondents had below 5 years, 11.6% of respondents had between 6 to 10 years, 9.1% of respondents had between 11 to 20 years, 9.1% of respondents had above 20 years of experience while 0.87% were missing.

Table 4: Distribution of Employment of Respondents

Respondent	Frequency	%
Secretary	2	1.65
Student	78	64.46
Lecturer	25	20.66
Librarian	14	11.57
Other	2	1.65
Total	**121**	**100.00**

Table 5: Years of Experience of respondents selected for this study

Years of Experience	Frequency	%
None	79	65.29
below 5	5	4.13
6 to 10	14	11.57
11 to 20	11	9.09
above 20	11	9.09
Missing	1	0.83
Total	**121**	**100.00**

Table 6 shows the distribution of the capacity of the libraries considered in this study. The results showed that 20.7% of respondents selected belong to libraries with capacity of below 50, 39.7% of respondents selected belong to libraries with capacity between 51 to 100, 23.1% of respondents selected belong to libraries with capacity above 100 while 16.5% of respondents did not specify the capacity of the libraries from which they were selected from. Table 7 shows the distribution of the level of ICT compliance of the respondents. The results showed that 17.4% of respondents said theirs was excellent, 45.5% of respondents said theirs

was good, 25.6% of respondents said theirs was average, 6.6% of respondents said theirs was fair and 1.7% of respondents said theirs was poor while 3.3% were missing.

Table 6: Distribution of the Capacity of Libraries

Library Capacity	Frequency	%
below 50	25	20.66
51 to 100	48	39.67
above 100	28	23.14
Missing	20	16.53
Total	**121**	**100.00**

Table 7: Distribution of Level of ICT Compliance

IT Compliance	Frequency	%
Poor	2	1.65
Fair	8	6.61
Average	31	25.62
Good	55	45.45
Excellent	21	17.36
Missing	4	3.31
Total	**121**	**100.00**

Table 8: Distribution of Year of Adoption of ICT Devices

ICT Device	Year of Adoption (Y_0)	Initial Users	Present Users	%
Personal Computers	1997	1	98	80.99
Printers/Faxes	1997	1	81	66.94
Search Engines	1997	1	86	71.07
Electronic Library	2000	2	72	59.50
Bulk SMS Services	2000	2	53	43.80
Library Mgt. System	2000	1	41	33.88
Bar/QR Code Reader	2000	1	31	25.62
Projectors	2000	1	50	41.32
Video Conferencing	2000	1	33	27.27

The various types of ICT tool that were adopted in the libraries were: PCs/laptops, printers/fax machines, search engines, electronic library services, bulk SMS services, library management systems, bar/QR code readers, projectors and video conferencing system. Information about the year of adoption of each ICT devices were requested from each respondents. Table 8 shows the results of the distribution of the number of adopters of each ICT device from the earliest year of ICT device adoption till 2017. The results showed in descending order of majority adopters that 81% of respondents have been using personal computers since 1997; 71.1% of respondents have been using search engines since 1997; 66.9% of respondents have been using printers/fax machines since 1997; 59.5% of respondents have been using e-Library systems since 2000; 43.8% of respondents have been using bulk SMS

services since 2000; while 41.3% of respondents have been using projectors since 2000. Every other device were adopted by less than 40% of respondents since the year 2000.

Table 8 shows the distribution of the year of adoption for each ICT devices adopted for use among the libraries considered in this study. The results showed that among the adopted ICT devices, the earliest year of adoption of ICT devices was in 1997 for 3 ICT devices and the latest yea was in 2000 for 6 ICT devices. Table 9 was generated from Table 7 by determining the cumulative frequency of adopters for each subsequent year starting from the year of adoption of each ICT device till 2017. Table 10 was generated from Table 9 by determining the cumulative frequency of adopter for each subsequent years starting from the year of adoption of each ICT device till 2017. Thus, number the results showed that trend of the increase in the number of adopters of each ICT device as represented by the bar chart in Figure 1.

Table 9: Distribution of the Number of Yearly Adopters of ICT devices.

ICT Components	y97	y98	y99	y00	y01	y02	y03	y04	y05	y06	y07	y08	y09	y10	y11	y12	y13	y14	y15	y16	y17	Users	% Users
Personal Computers	1	1	1	2	4	1	0	1	5	3	11	7	6	14	5	8	8	9	8	3	0	98	**80.99**
Printers/Faxes	1	0	1	4	2	0	0	2	4	2	10	2	8	12	9	8	5	5	4	2	0	81	**66.94**
Search Engines	1	1	0	3	0	1	1	0	6	2	8	2	10	17	5	8	9	7	2	2	1	86	**71.07**
Electronic Library	0	0	0	2	0	0	0	0	4	1	6	4	8	10	2	5	9	11	4	6	0	72	**59.50**
Bulk SMS Services	0	0	0	2	1	1	0	0	1	0	3	4	10	8	5	9	3	2	3	1	0	53	**43.80**
Library Mgt. System	0	0	0	1	0	0	0	1	1	0	2	2	6	6	1	4	5	3	4	5	0	41	**33.88**
Bar/QR Code Reader	0	0	0	1	0	0	0	0	0	0	3	1	0	2	2	4	4	4	3	7	0	31	**25.62**
Projectors	0	0	0	1	0	2	0	0	0	0	1	2	4	6	5	7	4	6	3	8	1	50	**41.32**
Video Conferencing	0	0	0	1	0	1	0	0	0	0	1	2	3	7	1	4	4	2	3	3	1	33	**27.27**

Table 10: Distribution of the Cumulative Number of Yearly Adopters of ICT devices

| ICT Components	y97	y98	y99	y00	y01	y02	y03	y04	y05	y06	y07	y08	y09	y10	y11	y12	y13	y14	y15	y16	y17	Users	% Users
Personal Computers	1	2	3	5	9	10	10	11	16	19	30	37	43	57	62	70	78	87	95	98	98	98	**80.99**
Printers/Faxes	1	1	2	6	8	8	8	10	14	16	26	28	36	48	57	65	70	75	79	81	81	81	**66.94**
Search Engines	1	2	2	5	5	6	7	7	13	15	23	25	35	52	57	65	74	81	83	85	86	86	**71.07**
Electronic Library	0	0	0	2	2	2	2	2	6	7	13	17	25	35	37	42	51	62	66	72	72	72	**59.50**
Bulk SMS Services	0	0	0	2	3	4	4	4	5	5	8	12	22	30	35	44	47	49	52	53	53	53	**43.80**
Library Mgt. System	0	0	0	1	1	1	1	2	3	3	5	7	13	19	20	24	29	32	36	41	41	41	**33.88**
Bar/QR Code Reader	0	0	0	1	1	1	1	1	1	1	4	5	5	7	9	13	17	21	24	31	31	31	**25.62**
Projectors	0	0	0	1	1	3	3	3	3	3	4	6	10	16	21	28	32	38	41	49	50	50	**41.32**
Video Conferencing	0	0	0	1	1	2	2	2	2	2	3	5	8	15	16	20	24	26	29	32	33	33	**27.27**
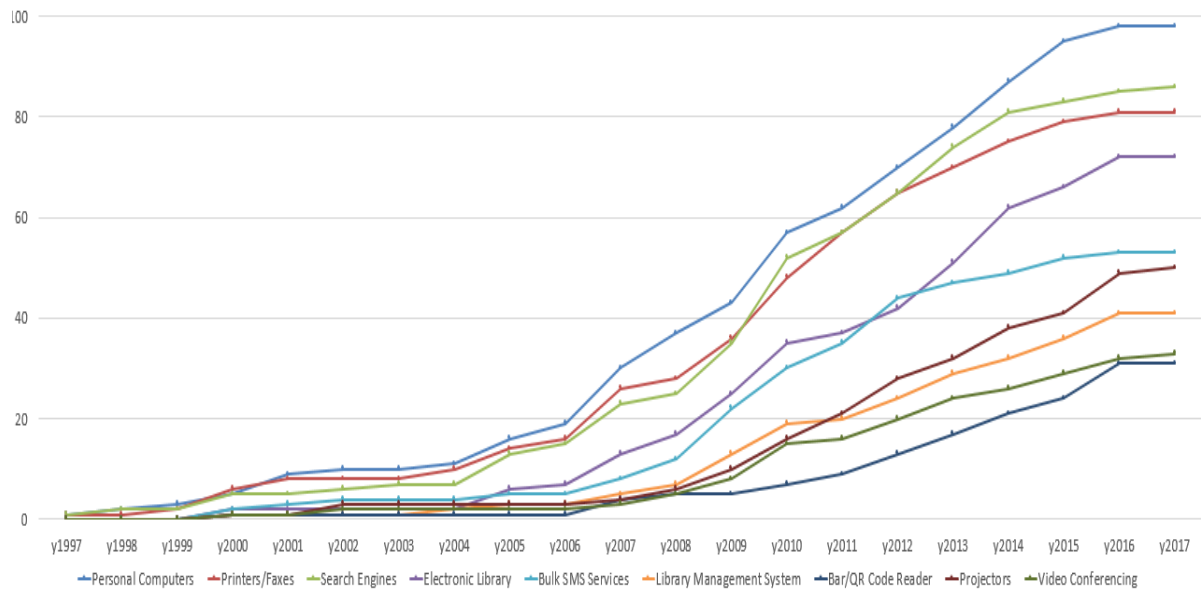
Figure 1: Bar Chart Plot of Cumulative Frequency of ICT Adopters

For the purpose of the formulation of the mathematical model for the adoption of ICT devices, the polynomial function $S(x)$ with respect to x which represents the number of years after the base year, Y_0 for each ICT devices was considered for the study. The Microsoft Excel Data Analysis Toolkit was used for the estimation of trend lines via polynomial fits from the graphs and charts of the cumulative total number of ICT adopters. Thus, the total number of adopters of each ICT devices was estimated at a given year, Yx a number of years from the year of adoption x from the year of ICT adoption.

DISCUSSION

Model for adoption of use of PC

Following the results of cumulative sum of the number of adopters of PC among libraries in Nigeria, it was observed that the year of adoption was 1997 with 1 initial user. Using Equation 1, the number of years from 1997 till 2017 is 21 years which corresponds to the 21 red dots shown in Figure 2. According to Figure 2, the year of adoption Y_0 (1997) is point x=1 which corresponds to 1 on the y-axis while each consecutive year, Y_x on the x-axis corresponds to the cumulative number of adopters of PCs x years after the base year (year of adoption). The estimation of the best fit (black line) for the use of PC from the cumulative distribution showed that the mathematical model for the adoption of PCs can be represented using a polynomial of degree $m=5$ as shown in Equation 6 which had a coefficient of determination, R^2=0.9977.

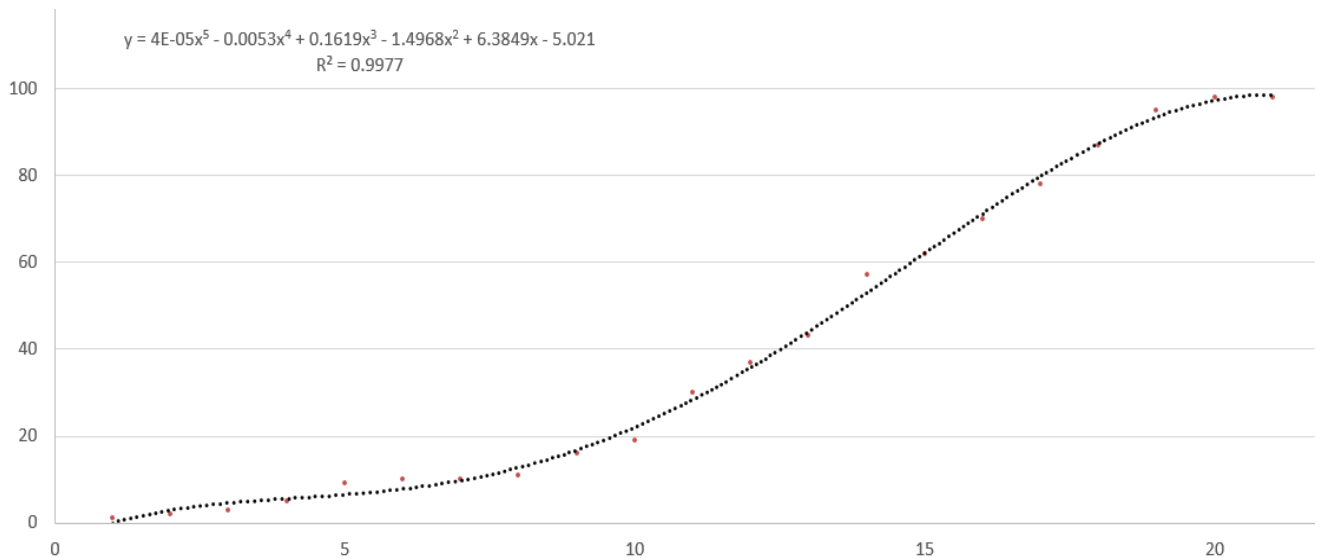$$S(x) = -0.001x^5 - 0.001x^4 + 0.061x^3 - 0.526x^2 + 2.422x + 2.422 \qquad (6)$$

$y = 4E\text{-}05x^5 - 0.0053x^4 + 0.1619x^3 - 1.4968x^2 + 6.3849x - 5.021$
$R^2 = 0.9977$

Figure 2: Polynomial Fit for the Adoption of PC among Libraries

Model for adoption of use of printers/fax machines

Following the results of cumulative sum of the number of adopters of printers/fax machines among libraries in Nigeria, it was discovered that the year of adoption was 1997 with 1 initial user. Using Equation 1, the number of years from 1997 till 2017 is 21 years which corresponds to the 21 red dots shown in Figure 3. According to Figure 3, the year of adoption Y_0 (1997) is point x=1 which corresponds to 1 on the y-axis while each consecutive year, Y_x on the x-axis corresponds to the cumulative number of adopters of printers/fax machines x years after the base year (year of adoption). The estimation of the best fit (black line) for the use of printers/fax machines from the cumulative distribution showed that the mathematical model for the adoption of printers/fax machines can be represented using a polynomial of degree $m=5$ as shown in Equation 7 which had a coefficient of determination, $R^2=0.9963$.

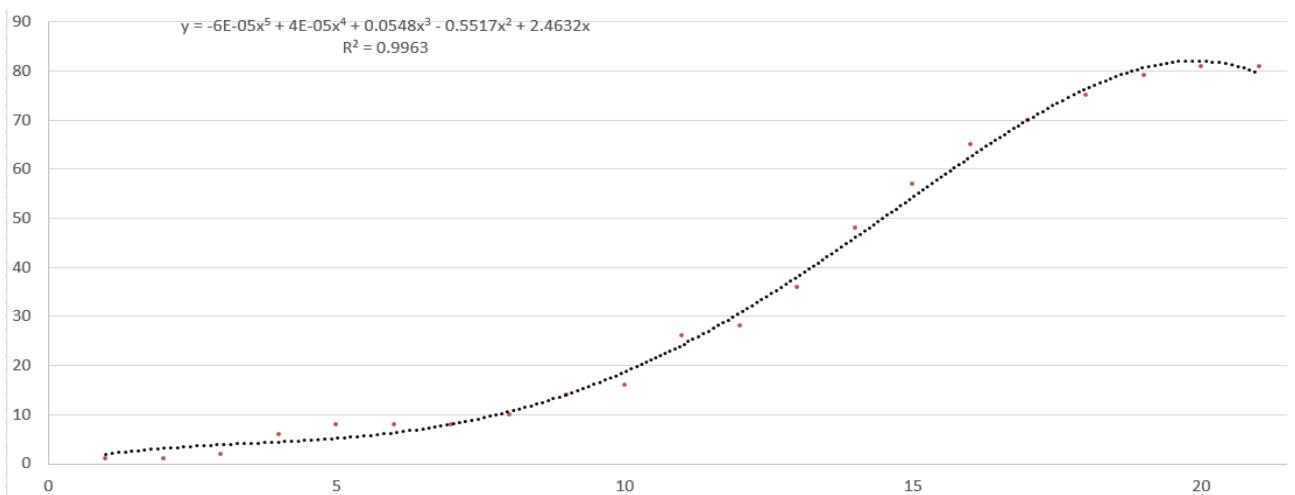$$S(x) = -0.0001x^5 - 0.001x^4 + 0.054x^3 - 0.552x^2 + 2.463x + 2.463 \tag{7}$$

$y = -6E\text{-}05x^5 + 4E\text{-}05x^4 + 0.0548x^3 - 0.5517x^2 + 2.4632x$
$R^2 = 0.9963$

Figure 3: Polynomial Fit for the Adoption of printers/fax machines among Libraries

Model for the adoption of use of search engines

Following the results of cumulative sum of the number of adopters of search engines among libraries in Nigeria, it was seen that the year of adoption was 1997 with 1 initial user. Using Equation 1, the number of years from 1997 till 2017 is 21 years which corresponds to the 21 red dots shown in Figure 4. According to Figure 4, the year of adoption Y_0 (1997) is point x=1 which corresponds to 1 on the y-axis while each consecutive year, Y_x on the x-axis corresponds to the cumulative number of adopters of search engines x years after the base year (year of adoption). The estimation of the best fit (black line) for the use of search engines from the cumulative distribution showed that the mathematical model for the adoption of search engines can be represented using a polynomial of degree $m=5$ as shown in Equation 8 which had a coefficient of determination, $R^2=0.9958$.

$$S(x) = -0.0001x^5 - 0.001x^4 + 0.079x^3 - 0.790x^2 + 2.874x \qquad (8)$$
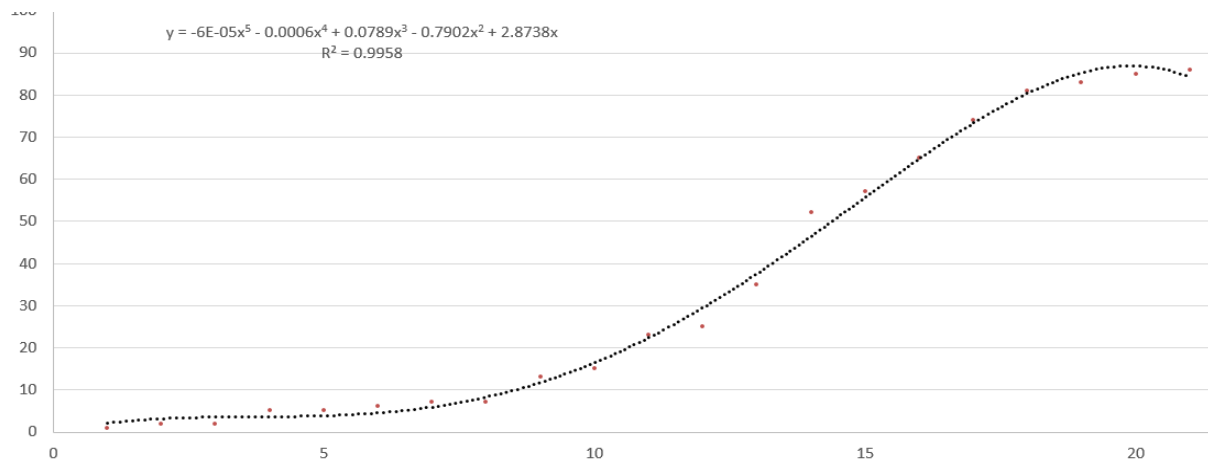

Figure 4: Polynomial Fit for the Adoption of search engines among Libraries

Model for the adoption of use of electronic library (e-library) systems

Following the results of cumulative sum of the number of adopters of e-library among libraries in Nigeria, revealed that the year of adoption was 2000 with 2 initial users. Using Equation 1, the number of years from 2000 till 2017 is 18 years which corresponds to the 18 red dots shown in Figure 5. According to Figure 5, the year of adoption Y_0 (2000) is point x=1 which corresponds to 2 on the y-axis while each consecutive year, Y_x on the x-axis corresponds to the cumulative number of adopters of e-library x years after the base year (year of adoption). The estimation of the best fit (black line) for the use of e-library from the cumulative distribution showed that the mathematical model for the adoption of e-library can be represented using a polynomial of degree $m=5$ as shown in Equation 9 which had a coefficient of determination, $R^2=0.9961$.

$$S(x) = -0.00001x^5 - 0.0016x^4 + 0.0149x^3 - 0.2277x^2 + 0.7787x \qquad (9)$$
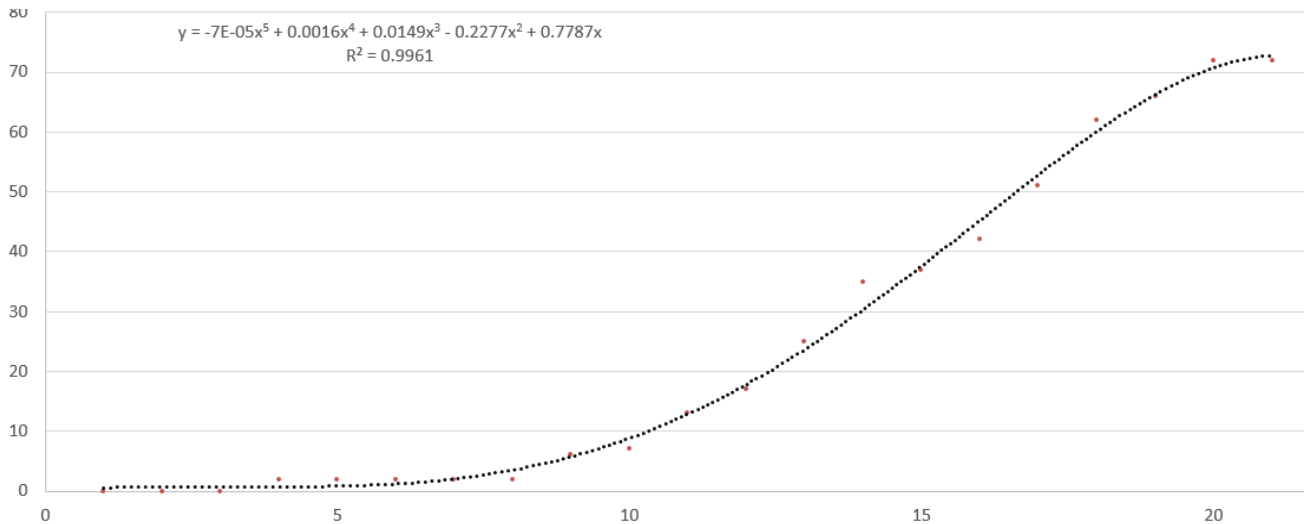
Figure 5: Polynomial Fit for the Adoption of e-library systems among Libraries

Model for adoption of use of bulk SMS services

The results of cumulative sum of the number of adopters of bulk SMS among libraries in Nigeria, shown that the year of adoption was 2000 with 2 initial users. Using Equation 1, the number of years from 2000 till 2017 is 18 years which corresponds to the 18 red dots shown in Figure 6. According to Figure 6, the year of adoption Y_0 (2000) is point x=1 which corresponds to 2 on the y-axis while each consecutive year, Y_x on the x-axis corresponds to the cumulative number of adopters of bulk SMS x years after the base year (year of adoption). The estimation of the best fit (black line) for the use of bulk SMS from the cumulative distribution showed that the mathematical model for the adoption of bulk SMS can be represented using a polynomial of degree $m=5$ as shown in Equation 10 which had a coefficient of determination, $R^2=0.9961$.

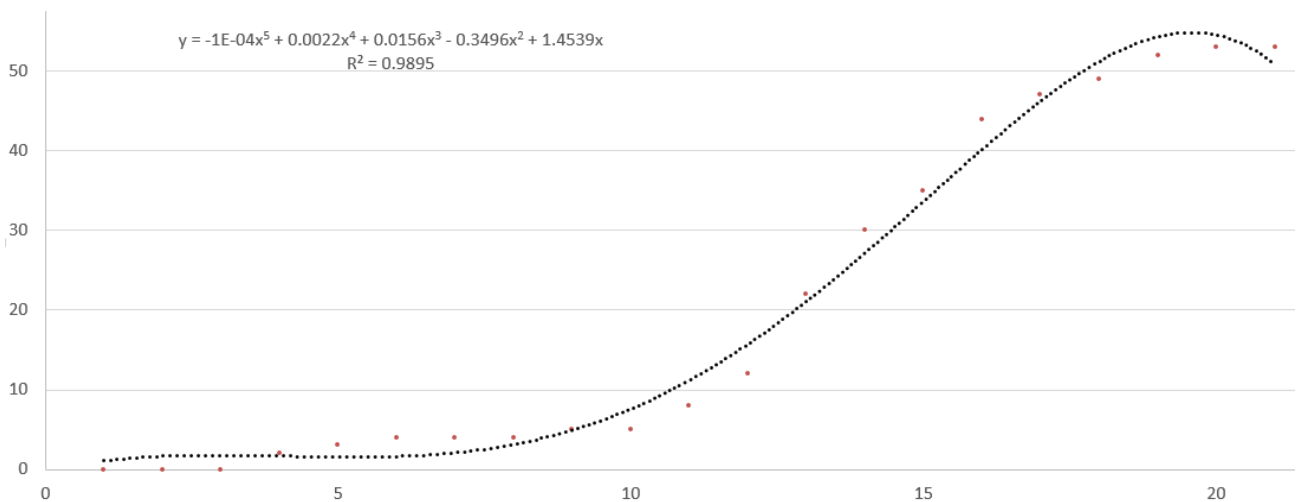$$S(x) = -0.0001x^5 + 0.0022x^4 + 0.0156x^3 - 0.3496x^2 + 1.4539x \qquad (10)$$

Figure 6: Polynomial Fit for the Adoption of bulk SMS services among Libraries

Model for the adoption of use of library management system

The results of cumulative sum of the number of adopters of library management system among libraries in Nigeria, state that the year of adoption was 2000 with 1 initial user. Using Equation 1, the number of years from 2000 till 2017 is 18 years which corresponds to the 18 red dots shown in Figure 7. According to Figure 7, the year of adoption Y_0 (2000) is point x=1 which corresponds to 1 on the y-axis while each consecutive year, Y_x on the x-axis corresponds to the cumulative number of adopters of library management system x years after the base year (year of adoption). The estimation of the best fit (black line) for the use of library management system from the cumulative distribution showed that the mathematical model for the adoption of library management system can be represented using a polynomial of degree $m=5$ as shown in Equation 11 which had a coefficient of determination, $R^2=0.9948$.

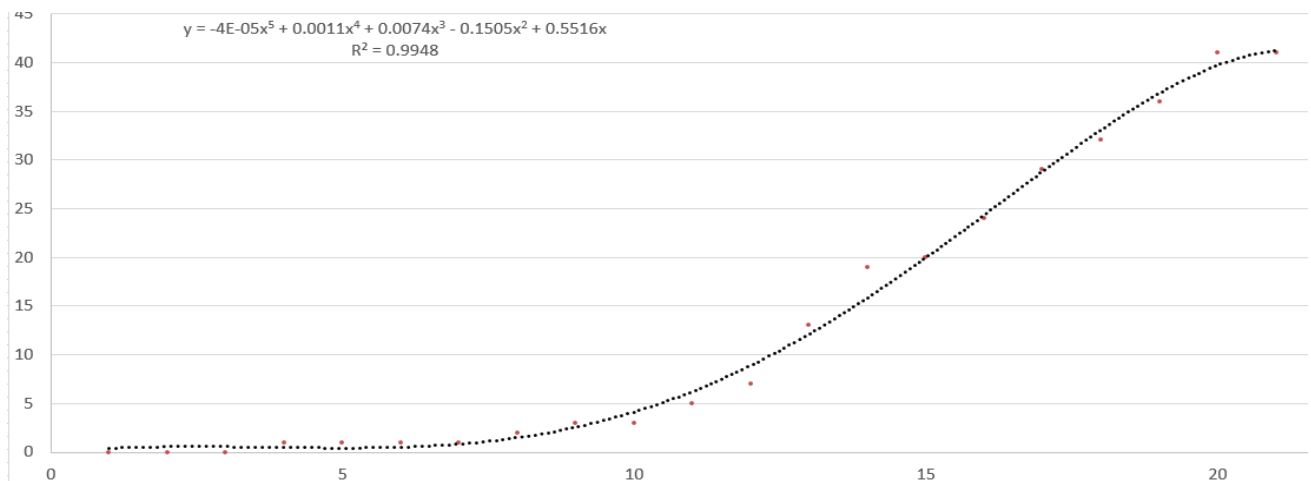$$S(x) = -0.0001x^5 + 0.0011x^4 + 0.0074x^3 - 0.1505x^2 + 0.5516x \qquad (11)$$

Figure 7: Polynomial Fit for the Adoption of Library Management System

Model for the adoption of use of bar/QR code readers

Following the results of cumulative sum of the number of adopters of bar/QR code readers among libraries in Nigeria, it was observed that the year of adoption was 2000 with 1 initial user. Using Equation 1, the number of years from 2000 till 2017 is 18 years which corresponds to the 18 red dots shown in Figure 8. According to Figure 8, the year of adoption Y_0 (2000) is point x=1 which corresponds to 1 on the y-axis while each consecutive year, Y_x on the x-axis corresponds to the cumulative number of adopters of bar/QR code readers x years after the base year (year of adoption). The estimation of the best fit (black line) for the use of bar/QR code readers from the cumulative distribution showed that the mathematical model for the adoption of bar/QR code readers can be represented using a polynomial of degree $m=4$ as shown in Equation 12 which had a coefficient of determination, $R^2=0.9905$.

$$S(x) = -0.0003x^4 + 0.0197x^3 - 0.2253x^2 + 0.8026x \qquad (12)$$
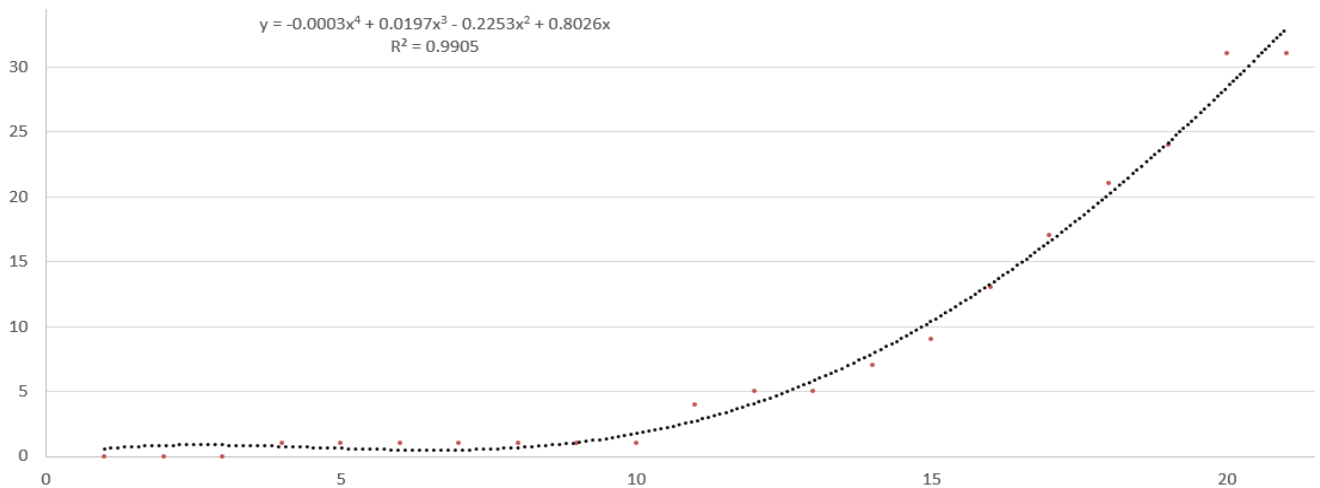
$$y = -0.0003x^4 + 0.0197x^3 - 0.2253x^2 + 0.8026x$$
$$R^2 = 0.9905$$

Figure 8: Polynomial Fit for the Adoption of Bar/QR Code Readers

Model for the adoption of the use of projectors

The results of cumulative sum of the number of adopters of projectors among libraries in Nigeria, affirmed that the year of adoption was 2000 with 1 initial user. Using Equation 1, the number of years from 2000 till 2017 is 18 years which corresponds to the 18 red dots shown in Figure 9. According to Figure 9, the year of adoption Y_0 (2000) is point x=1 which corresponds to 1 on the y-axis while each consecutive year, Y_x on the x-axis corresponds to the cumulative number of adopters of projectors x years after the base year (year of adoption). The estimation of the best fit (black line) for the use of projectors from the cumulative distribution showed that the mathematical model for the adoption of projectors can be represented using a polynomial of degree $m=4$ as shown in Equation 13 which had a coefficient of determination, $R^2=0.9914$.

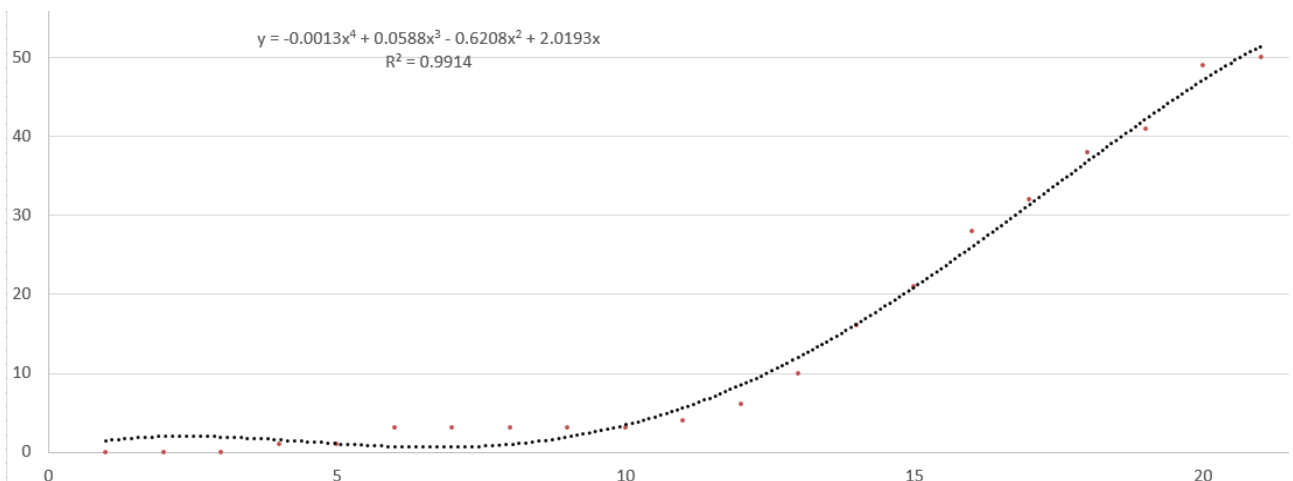$$S(x) = -0.0013x^4 + 0.0588x^3 - 0.6208x^2 + 2.0193x \qquad (13)$$

$$y = -0.0013x^4 + 0.0588x^3 - 0.6208x^2 + 2.0193x$$
$$R^2 = 0.9914$$

Figure 9: Polynomial Fit for the Adoption of Projectors

Model for the adoption of the use of video conferencing systems

The results of cumulative sum of the number of adopters of video conferencing systems among libraries in Nigeria, revealed that the year of adoption was 2000 with 1 initial user. Using Equation 1, the number of years from 2000 till 2017 is 18 years which corresponds to the 18 red dots shown in Figure 10. According to Figure 10, the year of adoption Y_0 (2000) is point x=1 which corresponds to 1 on the y-axis while each consecutive year, Y_x on the x-axis corresponds to the cumulative number of adopters of video conferencing systems x years after the base year (year of adoption). The estimation of the best fit (black line) for the use of video conferencing systems from the cumulative distribution showed that the mathematical model for the adoption of video conferencing systems can be represented using a polynomial of degree $m=4$ as shown in Equation 14 which had a coefficient of determination, $R^2=0.9914$.

$$S(x) = -0.0012x^4 + 0.0477x^3 - 0.4793x^2 + 1.4856x \qquad (14)$$

CONCLUSION

The study developed a mathematical model that can be used to determine the total number of adopters of a particular ICT device at any given number of years x after the year of adoption of ICT device using information collected from 121 respondents selected from special, academic and research libraries across south-western Nigeria. Majority of respondents were selected from academic libraries however, based on the information collected from all respondents, majority of them were male students constituting about 80% of the respondents; about 20% of the respondents were females, while 12% were librarians. Significant number of the respondents used libraries with capacities of between 51 and 100. Also, the results further showed that majority of the respondents suggested that their compliance of IT used was good consisting of about 45% of the respondents.

Furthermore, emerging fact from the study has shown that nine ICT devices were commonly adopted among libraries, and these are; PCs/laptops, printers/fax machines, search engines, electronic library services, bulk SMS services, library management systems, bar/QR code readers, projectors and video conferencing system. Also, it was discovered that the earliest ICT devices were adopted for use in 1997 and these are; PCs, printers/fax machines and search engines. The remaining ICT devices were adopted in 2000, such as: e-library, bulk SMS services, library management system, bar/QR code readers, projectors and video conferencing. The study therefore conclude that that the most commonly adopted ICT devices were PCs, search engines since those that had PCs most likely used search engines followed by printers/fax machines which were also most likely adopted alongside PCs by at least 44% of

respondents. The least commonly adopted ICT devices were bar/QR code readers, video conferencing and library management system by at most 35% of the respondents selected for this study. Thus, the knowledge about the number of years from the year of adoption can be used to estimate the number of adopters of ICT devices among school libraries in Nigeria.

REFERENCES

Bitagi, A., & Garba, S. (2014). Evaluative Study of Information Resources and Services Utilization for Research in Academic Libraries in Niger State, Nigeria. *International Journal of Research in Business Management (IMPACT:IJRBM), 2*(5), 121-128.

Bitagi, A., & Udoudoh, S. (2014). Library and Information Resources for Effective Scientific Research in Nigerian Universities. *First International Conference of the School of Technology/Education (STE), Federal University of Technology* (pp. 171-175). Minna: University Press.

Chimah, J., & Nwokocha, U. (2013). Information Resources, Retrieval and Utilization for Effective Research in Tertiary and Research Institutions. *Asian Journal of Humanities and Social Sciences (AJHSS), 1*(3), 43-50.

Daluba, N., & maxwell, C. (2013). Effect of Social Media on the Use of Academic Library by Undergraduate Students in Tertiary Institutions: A Case Study of Kogi State. *Academic Research International Journal, 4*(5), 1-12.

Egejuru, N., Mhambe, P., Balogun, J., Asahiah, F., & Idowu, P. (2017). Information Technology Infusion Model for Agricultural Sector In NIgeria. *Journal of Digital Innovations and Comtemporary Research in Science, Engineering and Technology, 5*(3), 59-78.

Idowu, P., Oyetunji, M., Oladeji, F., & Balogun, J. (2017). An ICt Infusion Model for Nigerian Transport Sector. *Computing, Information Systems, Development Informatics and Allied Research Journal, 8*(1), 103-121.

Obinyan, O., & Akande, E. (2019). Assessment of Nursing Students' Level of Satisfaction with Library Services in Selected Universities in Edo State. *Journal of Library Philosophy and Practice, 2896*(3), 1-18. Retrieved from https://digitalcommons.unl.edu/libphilprac/2896

Ogbebor, O. (2011, December 13). *Library Resources and their Role in Education.* Retrieved from Osarome Blogspot: http://osarome.blogspot.com/2011/12/library-resourcesand-their-role- in.html#!/2011/12/library-resources-andtheir-role-in.html

Ogunrombi, S. (2004). Quality Assurance and Book Crisi in Nigerian Universiyy Libraries. *Gaetway Library Journal, 6*(2), 65-73.

Onuoha, U., & Subair, M. (2013). Undergraduate's use of Libraries in Federal Universities in South-West, Nigeria. *Journal of research and Methods in Education, 3*(5), 12-17.

Patrick, I., Aghojare, B., & Ferdinand, O. (2015). Assess Users' Satisfaction on Academic Library Performance. *International Journal of Academic Research and Reflection, 3*(5), 67-77.

Usman, M. (2016). Critical Factors affceting teh Demand for Information Resources among Federal University Library Users in North-West Nigeria. *International Journal of Academic Library and Information Science, 4*(8), 208-215.

Uwaifo, S. (2013). Use of Electronic resources by University Lecturers in Edo State, Nigeria. *Pacific Northwest Library Association (PNLA) Quarterly, 77*(2), 1-10. Retrieved from http://www.pnla.org