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Afeez Jinadu
Nigerian Institute of Social and Economic Research, Nigeria

Eugenia Okwilagwe
University of Ibadan Nigeria, Nigeria

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Assessment and Modelling of Research Undertaking, Digital-Technology Construct and Researchers' Statistical Software Skills

Afeez Jinadu, Eugenia Okwilagwe

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Abstract

The study investigated the structural equation modelling of nine variables consisting of research undertaking, digi-tech construct (digital nativity, category of adoption of digital technologies, digital literacy, digital citizenship, statistical software anxiety, self-efficacy and knowledge) and researcher statistical software skills in the Sub-Sahara Africa. Human Functioning Theory and ex-post facto design were adopted. Multi stage sampling techniques were used to select 744 researchers across the Southwestern, Nigerian Universities and research institutes. Assessment of Researcher Digital Literacy-(KR_{20}=0.86), Researcher Statistical Knowledge and Performance Skills-(KR_{20}=0.82) and Researcher Statistical Software Operation Ability-(π=0.93) tests, Researcher Digital Construct Response-(r=0.84) and Researcher Statistical Software Anxiety and Efficacy-(r=0.87 and 0.76) scales were used. Data were analysed using path analysis. Eighteen out of the 35-hypothesised paths significantly explained the consistency of the causal model. Research undertaking-(0.02), digital nativity-(0.02), literacy-(0.01), citizenship-(0.06), statistical software anxiety-(0.01), statistical software self-efficacy-(0.02) and statistical software knowledge-(0.18) have 90.7% direct effect, whereas research undertaking-(0.01), digital literacy-(0.09), citizenship-(0.01) and statistical software anxiety-(0.02) accounted for 9.3% indirect effects on researcher statistical software skills. There was a positive causal effect of research undertaking and digi-tech construct on researcher statistical software skills. Therefore, researchers undertaking studies without inputs from digi-tech construct may not achieve sophisticated statistical software skills.

Introduction

Efforts aimed at providing functional and desired outcomes have been the concern of research endeavours directed at improving human life through enhanced agricultural productivity and food security, developed technologies and longevity. The impacts of these translate into growth rate and refining of social groups. Research has become an important element and drivers in many sectors where policymakers can spread the benefits of innovations (UNESCO, 2010). The central idea of evidence-based reforms is that policies and practices ought to be fashioned on evidence from rigorous research that offer compelling ways of improving policies and practices for national development (Obanya, 2012). As a process of elucidating real challenges and seeking evidence-based solution,

research should give rise to industrialization by creating opportunities for job seekers, increased financial gains, goods and services production, improved transportation and communication system, social, economic and political integration of nations (Obanya, 2014).

One of the challenges bedevilling educational research in Nigeria as reported by Odia (2013), is total loss of sharply defined doctrine of national refinement that spells out the direction, subject matter and the anticipated outcomes of research conducted in response to the demands and order of importance of needs of the Nigerian economy, society and polity (National Planning Commission, 2015 and Central Bank of Nigeria, 2015). Another significant factor that could have greater impact on research results is the statistical software operations adopted by researchers. Statistical software operation is the putting into service computer applications to handling social science and education researches data. The concepts consist of variables such as: anxiety, attitude, adoption, use, self-efficacy, knowledge and skills. The four most apt and insightful components- anxiety, self-efficacy, knowledge and skills will be considered for this work because of the perceived relationship with the other variables of interest, the suggestions that further insight be provided on them by previous studies, and the availability of empirical literature on them.

Application of statistical software is not only difficult, but also constitutes a challenge for some researchers who develop phobia for the usage or who is deficient in the knowledge and not able to obtain desired results from the research data collected. Resulting from this, many researchers engage in plagiarism by regurgitate research works carried out by others with objective of fulfilling the requirements for the completion of their studies (Ololube, Eke and Uzoza, 2009; Onwiegbuzie, 2004; Okpala, 1995 in Okwilagwe and Jinadu 2016). Akinboye in Okpala and Onocha (2012) assert that when researchers without research knowledge and statistical software operations, peculiarly in the field of data analysis allow such deficiencies to bear upon them, it could lead to a delaying, marring and or discrediting research results in the long run. These challenges stem from the inefficient researcher's statistical software operations which can constrain the quest to present valid and reliable research results as well as influence the subsequent generalisation of findings.

In research, softwares are used in data analysis to enable the researcher to easily organise statistical data for the purpose of making reliable inferences. These softwares designed to ease information management, description or testing of hypothesis are in distinct classes from the simple to the more complex ones. Their effective employment in data analysis vary in accordance with individual to individual researcher's ability and the knowledge. Ololube and Egbezor (2009) contended that the deployment of technology in pedagogy rely upon the extent of acquired factual information and competences needed for the application of ICT by large section of students and lecturers. Therefore, the probability that a research will be successful is greatly dependent on high statistical software operations efficiency of the researcher. When this is true, other stages of research, such as the sequential steps necessary: data collection, organisation, analysis, and interpretation, reporting of research outcome, become easier.

Statistical software anxiety is a very important factor that may influence statistical software skills positively or negatively. Cruise, Cash and Bolton (2008) specified statistic anxiety as experiencing of fear as a result of

receiving a statistical lesson. Statistical software anxiety, therefore, is defined as a state of fear of approaching contact with statistical software which may or may not be in agreement with the actual danger presented to the software users. Statistical software anxiety is associated with decreased use or avoidance of the package and it can seriously affect some researchers' scholarly development. If untreated, it can lead to complete statistical software avoidance. Onwuegbuzie and Wilson (2003) reported that the proportion of graduates going through unsatisfied levels of statistics anxiety is 66 to 80. Ololube, Eke and Uzoza, (2009) affirmed that statistical software anxiety, low efficacy, low knowledge and low statistical software skills by researchers may diminish research results' integrity. This occurs when statistical analysis is delayed and consequently contracted out to professionals in statistical software operations for a possible professional touch (Onwuegbuzie, 2004).

Apart from statistical software anxiety, previous researches also examined researchers' statistical self-efficacy. It has been suggested by previous work that researchers' statistical self-efficacy tends to be low. Suggestion of Onwuegbuzie (2000) that degree of fear may be a determinant of self-efficacy is germane to the current study. Aside from statistical software anxiety and self-efficacy in software operations are statistical software knowledge and skills. Statistical software knowledge, according to Chance (2002), is the understanding of data, statistical constructs, terminologies, method of gathering data, and calculation of descriptive and inferential statistics using statistical software. This is important in the development of skills which needs further investigation. For an effective skill, it is mandatory for those responsible for any activity to have knowledge of the concepts and techniques to carry out performance tasks; one should also have knowledge of both the process and the context in which the analysis will be performed, else the benefits of the analysis may not be achieved.

Statistical software skills refer to the quality of being able to operate statistical package right with order to deal with, control, search, analyse, display and interpret numeric data. Chance (2002) described statistical software skills as the primary focus of data processing and statistical education which should take precedence in the teaching of statistical education. It is irrefutable that the being able to apply statistical package is an important skill needed in becoming producer of data called data scientists and consumers of data. By implication, it may be said that statistical software knowledge is related to statistical software skills. Previous studies have not established a causal connection between the statistical software skills, knowledge, self-efficacy, anxiety and other variables of interest under investigation. These relationships need further investigation.

Observably, the statistical software anxiety, self-efficacy, knowledge and skills particularly of researchers appeared to be rarely studied and need further investigation. Little is known about how researchers' statistical software anxiety, self-efficacy, knowledge and skills are influenced by research undertaking and digi-tech construct. Researchers, cut across postgraduate students and lecturers that form the academic community as well as practitioners at federal research institutes, state planning, statistics and research departments and private consulting firms. Many educational researchers, according to Akinboye in Okpala and Onocha (2012), are either totally ignorant or uneasy about tools for educational research, and when statistical strategies are included in the tools for research purposes, a large proportion of practising educators become confused.

Research undertaking, as employed in this work, is current research conducted by researchers determined by

funding agencies and the quantity of fund received. Yusuff (2012) affirm that research takes any or a combination of five forms:

(i) Individual research brought into being and carried out either by a researcher or a number of researchers. It sources for funds through Board of Research in the institution.

(ii) Institutional set in motion, to be watched and directed by the establishment or its division such as faculty or department. It calls for a number of researchers who source for funding internally unless such is received being rooted in outside origin;

(iii) Licenced or legal is set about by an outside body, such as government or its organs, private sectors and NGOs organisations which also fund the research. The funding agency holds the controlling property of the outcomes of such research.

(iv) Collaborative is a combined mental energy of shared intended outcomes. It involves exchange of thoughts, methods and facilities by individual and among a number of researchers of same or across fields, institutions or parts of the world.

(v) Student, a type of a pre-service or a graduate project set about by students, directed by his or her department. It is made known in student's thesis or dissertation afterwards mostly financed by the student together with the supporter or division in form of scholarship or grants as a reward for academic diligence and industriousness.

Financing by all odds is key in university research. In Nigeria, federal university revenues according to Yusuff (2012) are incurred principally from three areas. The Federal Government (84%), income yielding revenue (7%) and students' tuitions (9%). It has been recommended that 5 percent of gross national product be earmarked for research, rather than the present 1.3 percent of its spending (Yusuff, 2012). Besides, there have been complaints in the past that university managements are holding on to and afterwards turn aside research money for other uses. The funding of university and by extension research could have implications on the nature of research undertaking and peculiar response to digi-tech construct and the subsequent implications on statistical software operations.

Digi-tech construct, in this study, refers to digital and technological variables used to denote researchers' behaviour regarding digital technologies. The concept, digital signifies data presented in number form and used primarily by computer. The first of such constructs is digital nativity. Prensky in Okwilagwe and Jinadu 2019, Jinadu 2020a referred to those born close to the last 20 years of the 20th century as digital natives. He provided adequate ground for the tag with the account saying they are all speak native digital dialects of computers and cyberspace. Okwilagwe and Jinadu (2019) and Jinadu (2020a) reported that indeed, they possess the adept for digital eloquence in varying degrees. Contrasting them with researchers who only discovered the digital dialects as grown-ups, he minted the term digital migrants, a concept that ably characterises researchers that are on the way of imbibing a fresh language, like immigrants in new country.

Also included in the digi-tech construct of this study are: category of adoption of digital technologies, digital literacy and digital citizenship. Researchers are categorised into digital technology adopters. Rogers (2003) propounded the theory of adoption of technology and dissemination of innovations. In his view, individual's adoption of innovations are usually distributed along a bell-shaped curve which he classified as (a) innovators

(those that tend to be experimentalists), (b) early adopters (those that may be technically advanced and concerned with technology for resolving professional and academic challenges), (c) early majority (those that are practical lover and constitute the first part of the mainstream adopters), (d) late majority (those that are not well situated with the digital technologies and are the sceptical second half of the mainstream) and lastly, (e) the laggards are those that may not adopt digital technologies at all. Usually they are critical of its use by others (Otunla & Jinadu, 2014). Each of the categories is presumed to be related to a particular level of efficiency in statistical software operations. Previous studies have yet to confirm this. However, it has been established in this study.

Digital literacy stands for being able to carry out pieces of work in an effective manner in a digital situation. It entails being able to look at, say out and translate written media, to regurgitate information and pictures by way of digital rearrangement and to judge and put into service fresh factual information through digital companionship. Aviram & Eshet-Alkalai (2006) identified it to be collection of expert procedures, mind and group arousal competences. Digital citizenship is outlined as standard behaviour regarding use of technology. The current digital period where digital creatures are employed widely is endeavouring to produce digital nationals from the companionship. Digital citizenship is the attribute of a real digital urban centres. Digital citizens are those who use the cyberspace time to time and efficiently (Mossberger, Tolbert and McNeal, 2011). The goals of 21st century digital citizenship include to educate, respect and protect (Common Sense Media, 2011, Jinadu, 2020b). 'Educate' involves communication, literacy and commerce aspect of digital tools. 'Respect' entails the etiquette, access, and law regulating the use of digital tools while 'protect' involves the rights and obligation, defence, wellbeing and welfare of users of digital tools (Jinadu, 2020b). Unlike previous studies which have not established a connection between these two variables and among other concerned variables, this work investigated this connection.

Earlier, there was a study on the influential elements for the adoption of commercial statistical software among online MBA prentices in accredited universities in the Midwest, United States using the TAM model developed by Davis in 1986. The study failed to incorporate innovation adoption including those of digital technologies and other digi-tech constructs. Besides, TAM model framework suggested that technology's end users may different over professional bounds. This has necessitated the inclusion of researchers in this study. Issa, Zurida, Mohd & Firas (2013) examined the mediating effect of self-efficacy on level of use of instructional computer and attitude and found a consistent model for mediating position of self-efficacy on level of employment of instructional computer and attitude. The findings of Chance (2002) indicates that knowledge and reasoning are linked to general skills. Little is however, known about professional computer technologies such as statistical software knowledge and skills. These relationships were only observed using linear correlation but not causal or additive relationship unlike the structural equation modelling used.

Structural equation modelling (SEM) is a universal concept employed to delineate a group of statistical models employed to test the validness of substantive propositions with observed information. It is a statistical procedure that makes a verification of hypothesis from the appraisal of a structural proposition based on certain processes. The term presumed that the causal under investigation are exemplified by number of structural regression equations, in which the connections can be modelled vividly to allow a well-defined formulation of the proposition under investigation (Byrne, 2010, Kline, 2011 and Okwilagwe & Jinadu, 2016). Previous studies that that have

used structural equation model such as Amatari (2013), investigated the extent to which geo-economic factors in the Niger Delta influence parental participation in the education of their wards and the concomitant effects of the linkages on pupils' achievement in English language and Mathematics using linear structural relation (LISREL). The software requires writing computer programming language called syntax before analysis which not all researchers can execute. Others have used multiple regression analysis and manual calculation (Okpala, 1985, Okpala, 2006, Ashamu, 2012 and Sanni, 2013). In the process, vital information could be distorted and fit indices not estimable. While Odule (2017) and Jinadu (2024) used AMOS, however evidence of satisfactory assumptions of SEM were not reported. However, Analysis of Moment Structure (AMOS) was employed in these work with evidences of satisfying its assumptions. AMOS is versatile in modelling both graphics and parameter estimation simultaneously without writing syntax. Its appraisal techniques, modelling abilities and comprehensiveness of application are robust (Arbuckle, 2013).

Previous studies have investigated variables affecting anxiety, self-efficacy and or knowledge, but mostly that of college students. These investigations were subsequently tied down to variables such as achievement, interest and attitude which are outside statistical software skills being considered in this study. However, anxiety, self-efficacy and knowledge cannot be limited to only college students, teachers and their academic achievement. It is possible to extend them to researchers as it was done in this study. Besides, studies that considered research undertaking and digi-tech construct seem relatively rare.

Literature reviewed on variables in this study so far also indicated failure to test hypothesised models in a path analytical study comprising research undertaking, digi-tech construct and statistical software skills. Correlation and/ or multiple regression were employed to analysed data collected. These methods of analysis do not reflect the causal nature of such relationships and do not take care of most measurement errors. This amounts to disregarding errors, which may imply serious faults in the end. Other studies that have used path analysis and supplemented it with other statistical packages also suffer from not being able to bring out both basic calculations and graphics simultaneously, but instead, require writing computer programming called syntax, which is able to do that. Therefore, the researcher investigated the extent to which research undertaking, digi-tech construct and statistical software skills have causal relationship.

Research Questions

1. Is the model which describes the causal effects among research undertaking, digital nativity, category of adoption of digital technologies, digital literacy, digital citizenship, statistical software anxiety, self-efficacy, knowledge and researchers' statistical software skills consistent with empirical data?
2. What are the most meaningful causal paths and model involving the causal effect among the variables (research undertaking, digital nativity, category of adoption of digital technologies, digital literacy, digital citizenship, statistical software anxiety, self-efficacy, knowledge and researchers' statistical software skills)?
3. What are the fit indices of the re-specified causal path model?
4. What are the estimated direct, indirect, and total causal effects?

Theoretical Background

This study is anchored on human functioning and social cognitive theories. Self-efficacy, knowledge and skills are key variables to both digi-tech construct and statistical software operations. Also, digital nativity, literacy, citizenship and category of adoption of digital technologies are well fastened in the theory of these two theories that have evolved over time. Human functioning theory was put forward in 1986 by Bandura. It gives key assignment to knowing, experience, self-regulative, and self-brooding procedure in people adjustment and transformation. People are seen to organize, reflect and regulate on their own rather than responsive organisms being dictated by the forces of environment or inner impulses.

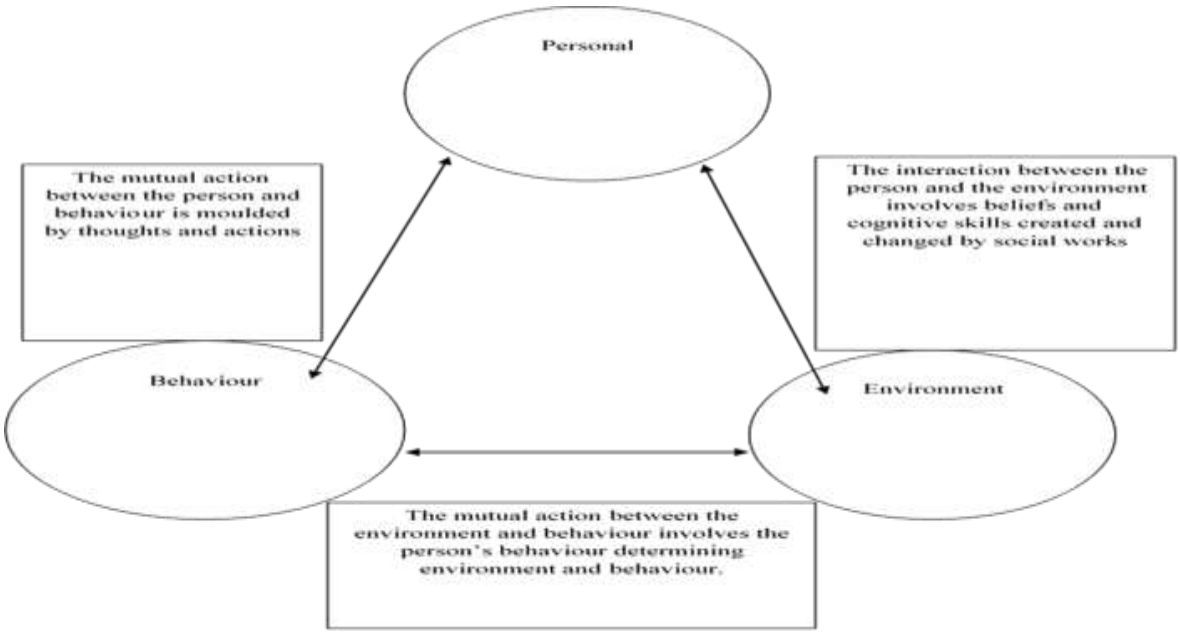

Figure 1. Human Functioning Theory Analogy

Source: Bandura (1986)): Reciprocal Determinism

Going by what we have in Figure 1, human functioning is seen as the combination of a changing mutual action of personal, behavioural, and environmental forces. As an example, people reading consequences of own actions creates and changes their surroundings and the personal agents they have and later create and change behaviours. For example, a researcher who is efficient in statistical software operations will have as many factors as possible responsible for that efficiency. His/her knowledge, called digital literacy, nativity, digital citizenship and category of adoption of digital technology, which are all personal, will interact with research type and the sponsor which act as avenues to exhibit the personal factors (the environment) to produce behaviours such as statistical software anxiety, self-efficacy, knowledge and skills. This is why Bandura's (1986) view mutual determinism, as notion (a) personal agents in class of knowing, bear on biological cases (b) behaviours (c) environment develop mutual actions that lead to triadic reciprocity. It is applicable to digital nativity, digital literacy, digital access and category of digital technologies on one hand, and research type and sponsor, on the other hand affecting statistical software operations. Bandura changed the name of his theory to social cognitive to distinguish it from common social learning theories and stress that cognition perform a major assignment in individual's being able to create reality,

regulate, analyse information, and perform behaviours.

Method

Research Type and Design

The study adopted *ex-post facto* design of correlational research type because the variables had occurred much earlier before measurement. Ex post facto design became necessary because it allowed the researchers to compare the two data collection methods and draw the inferences. This is relevant because it examines the cause-and-effect relationship between independent and dependent variables (Jinadu, Akere and Balogun, 2023). It also hypothesises how the independent variable, which is not controlled or manipulated, influences or affects the dependent variable.

Population and Sampling

The target population comprise all the researchers in the South-Western states of Nigeria. Multi-stage sampling procedure was adopted to select sample. In the first stage, south western Nigeria was stratified along the existing six states and simple random sampling was used to select three states (Lagos, Osun and Ekiti). In the second stage, researchers were stratified along subsisting federal, state and private sectors. In the third stage, researchers in each sector were further stratified into university and research institute. The university community was further stratified into lecturer and student researchers. Random sampling was employed to choose three departments each from two behavioural sciences faculties within the federal universities selected. Purposive sampling was used to select researchers who are currently undertaking research out of which random sampling was further used to choose twenty (20) research students and one (1) lecturer from each of the selected department making sixty (60) research students and three (3) lecturers from a faculty. A total of one hundred and twenty (120) research students and six (6) lecturers were drawn from federal universities communities replicated in state universities. For Private universities, random sampling was further employed to choose ten (10) research students and one (1) lecturer each from three departments making 30 research students and three lecturers each from private universities selected.

For research institutes, random sampling was employed to choose two (2) research practitioners from the federal research institutes. This was done for the federal sector in the two other states which was subsequently replicated to select two research officers each from state ministries of education planning, research and statistics department and one researcher each from private consulting firms. For two states, a total of 290 researchers were selected each and 164 researchers from the third state making a total of seven hundred and forty-four (744) researchers for the study.

Instrumentation

Assessment of Researcher Digital Literacy Test

The assessment of researcher digital literacy test is an instrument that was developed by the researcher to measure

researcher's level of digital literacy. It has two segments. Segment A is on researcher personal data. Segment B is on researcher level of digital literacy of some digital devices used every day in home and offices. The initial test contain 85 items of multiple choice tests with four options letter A, B, C and D. Respondents were asked to pick the correct option. These items were subjected to pilot testing among researchers who were not part of the final sample for the study. The face and content validity was established by giving the draft to psychometricians and the consistency of the scale was investigated through pilot testing of the instrument on a small sample of 85 researchers outside the main sample. The results were analysed using Kuder-Richardson method of reliability (K-R_{20}) which yielded 0.86.

Researcher Digital Constructs Response Scale

Researcher digital constructs response scale is a self-reporting instrument that was designed by the researcher. The instrument has three parts. Part A elicits information on researcher's age, experience in the use of internet and breadth of use, current research and the funding agency for the research. Part B was adapted from Nordin, Ahmad, Zubairi, Ismail, Rahman, Trayek and Ibrahim (2015) digital citizenship questionnaire. The original instrument was constructed based on four indicators: Etiquette/Responsibility, wellbeing/health, commerce and security. However, this section was designed based on five indicators: etiquette, responsibility, welfare, commerce and security. The original instrument has a reliability of 0.79 and was used to gather data on digital citizenship of university graduates in Canada. Section C was adapted from Shang, John and Keng's (2011) Adoption of Digital Mobile Services questionnaire which is a modified survey questionnaire from Moore and Benbasat (1991), Dupegne and Driscoll (2005) and Stachewicz (2011) based on the work of Rogers in (1995) who measured consumer's adoption of capacitive switch technology in industrially designed user interface control. Adoption of Digital Mobile Services questionnaire has seven indicators: perceived usefulness, perceived ease of use, trust, personal initiatives, characteristics, context and intention to use. However, this section of the instrument was constructed by the researcher based on four indicators. This is to avoid unnecessary repetition and duplication of items in the Adoption of Digital Mobile Services questionnaire. The four indicators are: usefulness, ease of use, compatibility and risk. The reliability coefficient of the original instrument was 0.75 where it was used by the developer to collect data on mobile student information system of Norwegian University of Science and Technology, Trondheim, Norway. The content validity was determined by giving some copies to experts and its reliability re-determined using Cronbach's Alpha which yielded 0.84 and 0.85 for digital citizenship and category of adoption sub sections respectively.

Researcher Statistical Software Anxiety and Efficacy Scale

Researcher statistical software anxiety and efficacy scale is a self-reporting instrument to elicit information on researcher's statistical software anxiety and statistical software self-efficacy. The instrument was adapted from statistical software adoption behaviour questionnaire of Barbeite and Weiss (2004) with a reliability of 0.76 and Hsu, Wang and Chiu (2009) with a reliability of 0.83. Each of the sections was constructed on two indicators: learning and use. The researcher statistical software anxiety consists of twenty-four (24) items initially and statistical software self-efficacy have twenty-six (26) items. The content validity of the scale was re-investigated

and the reliability re-assessed using Cronbach's Alpha which yielded 0.87 and 0.76 for statistical software anxiety and statistical software self-efficacy sub-sections respectively.

Researcher Statistical Software Knowledge and Skills Test

The researcher statistical software knowledge and skills test is an instrument formulated by the researcher to assess researchers' level of statistical software knowledge of data coding, data management, analysis and interpretation. It has two segments. Segment A deals with researcher demographic data, Segment B is on statistical software knowledge of data coding, cleaning, assumptions, types of statistical test, analysing descriptive, linear and multiple correlations, mean differences and causal paths. The initial test contains items of multiple choice tests with a four-option format lettered A, B, C and D. Respondents were asked to select the correct option. These items were subjected to pilot testing using 85 researchers who were not part of the final sample. The content validity was investigated and the reliability using Kuder-Richardson method of reliability ($K\text{-}R_{20}$) which yielded 0.82.

Researcher Statistical Software Operation Ability Test

Researcher statistical software operation ability test is an ability test that was designed by the researcher to measure researcher's statistical software skills. It is a two-section instrument. Section one contains test items covering all aspects of statistical data analysis of both descriptive and inferential statistics while section two has the keys developed by the researcher for marking the test provided for the respondents. Respondents were asked to perform some tasks on the data supplied in the researcher statistical data package. In order to investigate the reliability of the instrument, two trained observers rated sixty respondents on naming variables, labelling variables, computing variables, recoding variables, running internal consistency, running frequency counts, running cross tabulation, running means of variables and post hoc analysis. Data collected were analysed and its reliability coefficient was investigated using Scott's Pi which yielded 0.93.

Data Collection and Analysis Procedure

The researcher monitored the data gathering exercise. Four research assistants were co-opted for the study; they were intimated with the objectives of the study and the purpose of their selection as research assistants. Research assistants were trained on the administration of the instruments for two days before the commencement of the study. The administration was carried out in sequence based on the days and periods allowed by the head of department of the faculties and directors of research institutes used. Data collection exercise lasted eight weeks and the data collected were analysed by structural equation modelling (SEM) involving a multivariate analytical technique known as path analysis.

Results

Figure 2 shows a model which describes the causal effects among research undertaking, digital nativity, category of adoption of digital technologies, digital literacy, digital citizenship, statistical software anxiety, self-efficacy,

knowledge and researchers' statistical software skills and it is consistent with empirical data. The figure indicated that some paths are not statistically significant and are to be deleted. The paths coefficients (beta weight) with their p as indicated.

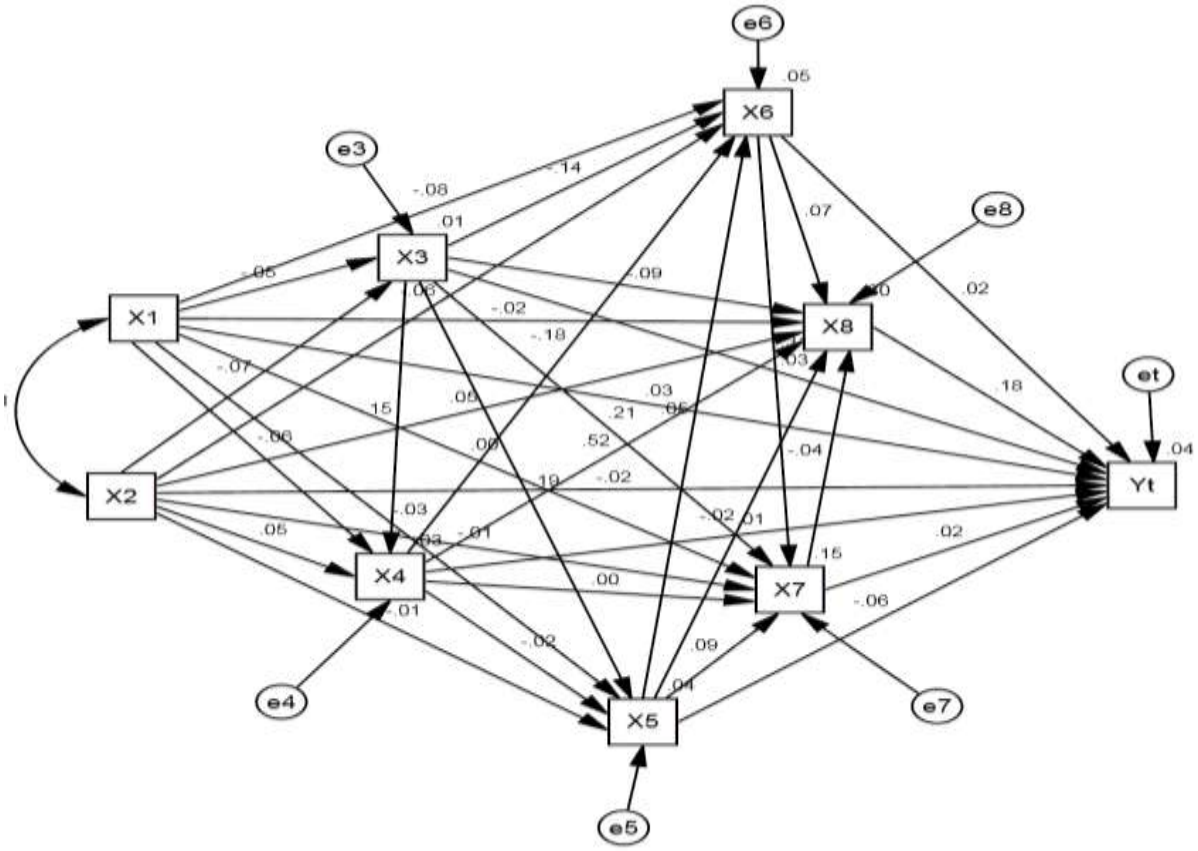

Figure 2. Hypothesised Recursive Path Model for the Nine Variables

X_1 = Research undertaking; X_2 = Digital nativity; X_3 = Category of adoption of technologies;

X_4 = Digital literacy; X_5 = Digital citizenship; X_6= Researchers' statistical software anxiety;

X_7 = Researchers' statistical software self-efficacy; X_8 = Researchers' statistical software knowledge and Y_t = Researchers' statistical software skills

Table 1 reveals the path coefficients and associations among the variables. This is necessary since the initial judgement failed there is need to examine the path coefficients and the correlations in order to decide paths to be deleted and those to be retained. Two sets of structural equation modelling analysis (Amos Version 23.0) were conducted in line with the structural diagram. For the first structural equation modelling analysis that is for the hypothesised model, the path coefficients and Zero order correlations are given in Table 1.

Table 1. Path Coefficients and Zero Order Correlations among Variables in the Hypothesized Model

Path	B	R	Std Error	Sig	Decision
P31	-0.048	-0.047	0.154	NS	Delete
P32	-0.069	-0.068	0.822	NS	Delete
P41	-0.065	-0.058	0.119	NS	Delete

Path	B	R	Std Error	Sig	Decision
P42	0.049	0.060	0.636	NS	Delete
P43	-0.148*	-0.189**	0.028	S	Retain
P51	-0.029	-0.036	0.098	NS	Delete
P52	-0.015	-0.029	0.523	NS	Delete
P53	0.194*	0.200**	0.023	S	Retain
P54	-0.021	-0.049	0.030	NS	Delete
P61	-0.079*	-0.063**	0.132	S	Retain
P62	-0.059	-0.061	0.703	NS	Delete
P63	-0.142*	-0.097**	0.032	S	Retain
P64	-0.180*	-0.160*	0.040	S	Retain
P65	0.048	0.034	0.049	NS	Delete
P71	-0.002	-0.034	0.096	NS	Delete
P72	-0.012	-0.048	0.512	NS	Delete
P73	0.206*	0.195**	0.023	S	Retain
P74	-0.002	-0.087	0.030	NS	Delete
P75	0.092	0.144**	0.035	S	Retain
P76	0.312*	0.296**	0.026	S	Retain
P81	-0.021	-0.050	0.075	NS	Delete
P82	0.046	0.082	0.398	NS	Delete
P83	-0.093*	-0.191*	0.019	S	Retain
P84	0.521*	0.532*	0.023	S	Retain
P85	-0.020	-0.068	0.028	NS	Delete
P86	0.071*	-0.017*	0.022	S	Retain
P87	-0.039	-0.086	0.028	NS	Delete
Pt1	0.027*	0.016**	0.036	S	Retain
Pt2	-0.019*	-0.005*	0.190	S	Retain
Pt3	0.029	-0.018	0.009	NS	Delete
Pt4	0.013*	0.100*	0.013	S	Retain
Pt5	-0.062*	-0.067*	0.013	S	Retain
Pt6	0.018*	0.012*	0.010	S	Retain
Pt7	0.017*	0.003*	0.013	S	Retain
Pt8	0.179*	0.180*	0.017	S	Retain

S= Significant Alpha less than 0.05; NS= Non-Significant alpha greater than 0.05

The table revealed that seventeen paths were not significant out of thirty-five paths which are to be deleted. Therefore paths P_{31}, P_{32}, P_{41}, $P_{42,}$ P_{51}, P_{52}, P_{54}, P_{62}, P_{65}, P_{71}, P_{72}, P_{74}, P_{81}, P_{82}, P_{85}, P_{87} and P_{t3} were deleted. The second set of structural equation modelling analysis was conducted without the deleted paths. But before that, the efficacy of the hypothesised model was judged and found to be inferior this suggests that the hypothesised model is not fit hence, the need for examination and subsequent deletion of the insignificant path for further decision.

Table 2 shows the most meaningful path model for researcher's statistical software skills. Variables that are not substantial were gotten rid of the model while others that were significant were retained to produce a path model that explains researcher's statistical software skills. A combination of the two criteria (statistical significance and meaningfulness) were adopted to ascertain paths that are substantial and those that are not.

Table 2. Meaningful Causal Paths and their Path Coefficients

Path	B	R	Std Error	Significant	Decision
P43	-0.148*	-0.148**	0.043	S	Keep
P53	0.200*	0.200**	0.036	S	Keep
P61	-0.080*	-0.063**	0.034	S	Keep
P63	-0.128*	-0.097**	0.027	S	Keep
P64	-0.183*	-0.160**	0.036	S	Keep
P73	0.208*	0.195*	0.033	S	Keep
P75	0.092*	0.144**	0.027	S	Keep
P76	0.314*	0.296**	0.036	S	Keep
P83	-0.108*	-0.191**	0.033	S	Keep
P84	0.525*	0.532**	0.027	S	Keep
P86	0.057*	-0.017*	0.036	S	Keep
Pt1	0.025*	0.016*	0.032	S	Keep
Pt2	-0.020*	-0.005**	0.023	S	Keep
Pt4	0.010*	0.100**	0.030	S	Keep
Pt5	-0.058*	0.067**	0.025	S	Keep
Pt6	0.012*	0.012**	0.021	S	Keep
Pt7	0.023*	0.003*	0.018	S	Keep
Pt8	0.176*	0.180*	0.023	S	Keep

Coefficient of paths and correlations are substantial at alpha less than 0.05

The study adopted the two criteria (statistical significance and meaningfulness) for the trimming exercise to forestall a path coefficient of smaller magnitude being found to be substantial based on large sample. The basis for significant paths, as put forward by Backblock and cited in Kerlinger and Lee (2000), was that both path coefficient and correlation must be significant at $p<0.05$, hence, significance, with respect to this study, connotes statistical significance as well as meaningfulness. The non- significant paths were cut of the model to re-create the substantive ones presented.

Figure 3 shows the resulting re-specified path model which depicts a close affinity between data collected and the hypothesised path model when statistical comparison was performed. In view of this, the re-specified path model in Figure 3 is consistent with the empirical correlations. The researcher hereby concludes that the model that explains the causal effects among the variables (research undertaking, digital nativity, category of adoption of digital technologies, digital literacy, digital citizenship, statistical software anxiety, self-efficacy, knowledge and researchers' statistical software skills) is consistent with the observed associations among the variables. The new

structural equations are as shown.

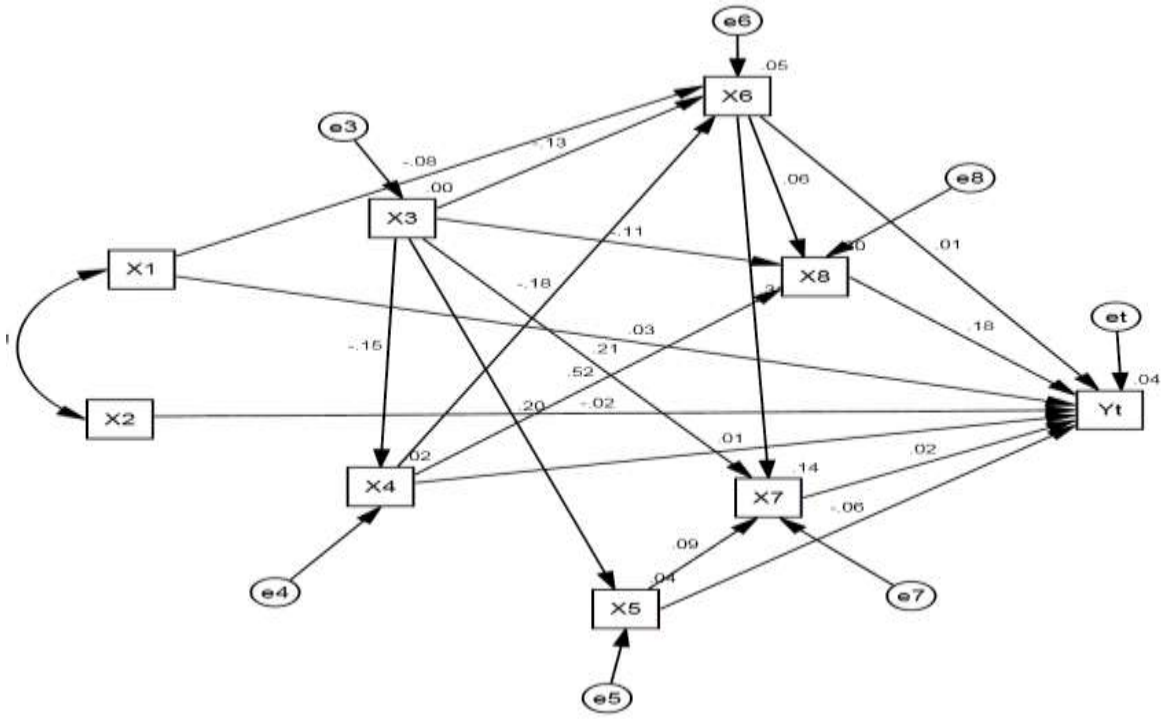

Figure 3. Re-specified Recursive Path Model for Researcher Statistical Software Skills

Table 3 shows the model fit for the hypothesised model and the re-specified model. It is shown that initial value of $\chi 2_{(0)} = 0.000$, p<.000, which is inferior to the value of the re-specified model with $\chi 2_{(17)} = 21.832$, p=0.191. The non-significant Chi-square of the re-specified model shows that the distinction between the initial and the re-specified model is not substantial hence, the re-specified model is good. This claim is brought as a result of the affinity of goodness of fit estimate for sample size which is sample sensitive. The little the Chi-square the superior a model, this is based on the recommendations by Hair et al, 2006); Schumacker and Lomax, 2004) and Hu and Bentler, (1998).

Table 3. Model Fit Summary of the Hypothesised and the Re-specified Model

Fit indices	Recommended level	Initial Model	Re-specified Model	Remark
Goodness				
$\chi 2$	≥ 1	0.000	21.832	Good
Df	≥ 1	0.000	17.000	Good
P	≥ .05	0.000	0.191	Good
CMIN/Df	≥ 1	0.000	1.284	Good
Incremental				
NFI	≥ .95	1.000	0.959	Good
TLI	≥ .95	0.000	0.979	Good
RNI	≥ .95	0.000	0.991	Good
CFI	≥ .95	1.000	0.990	Good
Absolute				

Fit indices	Recommended level	Initial Model	Re-specified Model	Remark
GFI	> .95	0.000	0.994	Good
AGFI	≈ 1.00	0.838	0.983	Good
SRMR	≤ .08	12.487	0.040	Good
RMSEA	≤ .06	0.134	0.019	Good

Key: χ2= Chi-square; Df = Degree of freedom; P= Probability level; CMIN/Df= Minimum Discrepancy per Degree of Freedom; NFI= Normed fit index; TLI= Tuker-Lewis index; RNI= Relative Non-Centrality fit Index; CFI= Comparative fit index; GFI= Goodness-of-fit; AGFI= Adjusted Goodness-of-fit; SRMR= Root Mean Square Residual; RMSEA= Root Mean Square Error of Approximation.

In addition to the Goodness-of-fit, Incremental Fit Indices were considered: Normed Fit Index (NFI) = 0.959; Tuker-Lewis Index (TLI) = 0.979; Relative Non-centrality Index (RNI) = 0.991 and Comparative Fit Index (CFI) = 0.990. Also considered are the Absolute Fit Indices: Goodness-of-Fit Index (GFI) = 0.994; Adjusted Goodness-of-Fit (AGFI) = 0.983; Standard Root Mean Residual (SRMR) = 0.040 and Root Mean Square Error of Approximation (RMSEA) = 0.019. In all, these incremental and absolute fit indices are within the acceptable and recommended level for judging a model to be fit. This suggests a perfect model fit. Hence, the re-specified model is fit, converge to an admissible solution and was retained considering the fit indices obtained. Table 4 presents the estimated direct, indirect and total effects of research undertaking and digi-tech constructs on researcher statistical software skills. Research undertaking, digital nativity, digital literacy, digital citizenship and statistical software self-efficacy have direct causal effects on researchers' statistical software skills.

Table 4. Estimates of Direct, Indirect and Total Causal Effect

Path	Direct	Indirect	Total
P_{43}	-0.148	0.000	-0.148
P_{53}	0.200	0.000	0.200
P_{61}	-0.080	0.000	-0.080
P_{63}	-0.128	0.027	-0.101
P_{64}	-0.183	0.000	-0.183
P_{73}	0.208	-0.013	0.194
P_{75}	0.092	0.000	0.092
P_{76}	0.314	0.000	0.314
P_{83}	-0.108	-0.084	-0.191
P_{84}	0.525	-0.010	0.514
P_{86}	0.057	0.000	0.057
P_{t1}	0.025	-0.002	0.023
P_{t2}	-0.020	0.000	-0.020
P_{t4}	0.010	0.087	0.097
P_{t5}	-0.058	0.002	-0.057
P_{t6}	0.012	0.017	0.029
P_{t7}	0.023	0.000	0.023
P_{t8}	0.176	0.000	0.176

The direct effects as shown in Table 4 are the path coefficients or the beta weights in the structural equation analysis for the re-specified data. The beta weights give the change rise or fall in the criterion variable in standard deviation units where there is one full standard deviation (above the mean) change in the predictor. For example, the direct effect of category of adoption of digital technology on digital literacy is -0.148. This implies that digital literacy decreased by 0.148 for every one standard deviation increase in category of adoption of digital technology, controlling for other predictors and others in that order.

Discussion

The findings of the work in relation to consistency of model that explains the causal effect of research undertaking, digital nativity, category of adoption of digital technologies, digital literacy, digital citizenship, statistical software anxiety, self-efficacy, knowledge and researchers' statistical software skills with the observed correlations among the variables in the model shows that out of thirty five (35) causal paths in the hypothesised model eighteen paths (18) were significant for producing the re-specified causal model. It is not that the path deleted were non-existent in terms of variable linkage but rather they were not strong enough in terms of statistical significance and meaningfulness for consideration in the hypothesised model.

The result with respect to above and meaningful causal paths is in line with that of Okpala (1995) who reported, in the study on teacher attitude variables in assessment and instructional practices as correlates of learning outcomes, that 85 out of 143 hypothesised paths met the criteria of significance and meaningfulness and thus the hypothesised path model was trimmed. The result also agrees well with that of Odule (2017) who worked on learner characteristics and opportunity to learn as determinants of achievement in measurement and evaluation among college of education students in south-west, Nigeria and found out that thirty-one out of thirty-six paths were significant and meaningful in explaining the causal modelling for achievement in measurement and evaluation among college of education students in South West Nigeria.

Findings from the re-specified model show that there were moderately positive significant relationships among statistical software skills, research undertaking, digital nativity, category of adoption of digital technologies, digital literacy, digital citizenship, statistical software anxiety, self-efficacy and knowledge. These are coherent with the determinations of Sommerfelf and Watson (2000) and Pajares and Schunk, (2001) who accounted that statistical software self-efficiency as an excellent forecaster of a particular task goals and accomplishment than general assessment. The findings also support those of Bong and Skaalvik (2003) and Gage and Berliner (1998), where same conclusion was reached that a positive relationship between self-efficacy and specific skills was observed. Pajares (1996), Pajares and Miller (1994), informed that students' appraisal of their being able to handle problems are forecast of their being able to handle such challenges. These appraisal also liaise influence of other predictors such as ICT setting, computer anxiety, and perceived usefulness of computers.

Findings in respect of fit indices that explain causal effects among the variables studied revealed that initial value for model fit is inferior to that of the re-specified model. The non-significant Chi-square of the re-specified model bespeaks that the distinction between the initial and re-specified model is not substantial hence, the re-specified

model is fit. This judgement is drawn on the premise of affinity that goodness of fit calculated has for sample size, which is sample sensitive. The lesser the Chi-square the desirable the model. This is based on the recommendation of Hair et al, (2006) and Hu and Bentler, (1998). Other measures of model fits that are not sample sensitive pointed that the model met the information hence, agreeing with Schumacker and Lomax, (2004) and Hu and Bentler, (1998) who recommended the degree of fitness.

The finding regarding direct, indirect and total effects among research undertaking digi-tech construct and statistical software skills revealed that the direct effects are more than the indirect effects. The result is also in tune with that of Okpala (1995) who reported that the proportion of direct effects is greater than that of indirect effect and out of eight-five significant and meaningful paths, only twelve are direct and seventy-three are indirect. The researcher also reported that the total effect (direct plus indirect) of all the predictor variables answer for a higher percentage of the variability in the criterion. The result also supports that of Odule (2017) who found out that the percentage of total direct effect attributed to the eight independent variables is ninety-two percent while the percentage of total indirect effect is eight percent.

Conclusion

The findings of the work revealed a causal relatedness among the variables of the study (research undertaking, digi-tech construct and researcher statistical software skills). Digital nativity has a positive influence on researcher statistical software skills. Researchers are of different categories of adopters of digital technology which accounts for different levels of digital literacy and citizenship. In addition, statistical software anxiety determines statistical software self-efficacy and knowledge which, in the long run, determines statistical software skills. In other words, decreased statistical software anxiety increases statistical software self-efficacy and knowledge as well as statistical software skills. Conclusively, the findings establish significant causal relationships among research undertaking, digi-tech construct and statistical software skills, a fit model for the data collected and greater proportion of direct causal effects than indirect causal effects.

Recommendations

Researchers should continually embark on research study to bring to bear their effective statistical software skills. It is advocated that researchers of digital native group should make use of their digital nativity while those who are immigrants should consult others of younger nativity when interacting with digital technologies in their areas of difficulty. Since some older researchers are in the laggard category of adopters, they are advised to avail themselves of opportunities offered by the digital world to move through early adopters to innovators and consequently improve their statistical software skills.

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Author Information

Afeez Jinadu

https://orcid.org/0000-0002-8278-9329

Nigerian Institute of Social and Economic Research

Nigeria

Contact e-mail: *afeezjinadu95@gmail.com*

Eugenia Okwilagwe

https://orcid.org/0009-0001-0684-7494

Institute of Education

University of Ibadan Nigeria

Nigeria