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Partial Least Square Structural Equation Modeling and Necessary Condition Analysis of the 21st Century Digital Literacy and Awareness of Physics Application of our Everyday life in Kwara State, Nigeria

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Abstract
The present study search on 21st century digital literacy and its relationship with students' awareness of the physics application in our everyday use of lens, optics, electricity and energy. The study sampled four hundred and eighty-four (484) education students' across all teacher-producing colleges and universities in Kwara state, Nigeria using a convenient sampling technique. An adapted and researchers' designed instruments were used to elicit data from the respondents. A Partial least square structural equation modeling approach was used and the data collected were analyzed via Smart PLS software version 4.0.9.2. The results of the study revealed that all three dimensions of 21st digital literacy were significantly related to students' awareness of physics applications in our everyday life. The study also found that necessary condition analysis and partial least square p-values result indicated that 21st digital literacy can influence significantly the students' awareness of physics applications in the use of lens and optics, and electricity and energy.

Keywords: Partial Least Square, Necessary Condition Analysis, 21st Century Digital Literacy, Physics Application in our daily life

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Introduction

Acquisition of knowledge and technology know-how is influenced in this digital age by the 21st century skills that also contribute to the development and improvement human scientific and technological knowledge. Rizaldi (2020) asserted that teachers and students are require to have 21st century skills like creativity, critical thinking, collaboration, communication and digital literacy among others. Digital literacy with well-informed critical literacy can uncover, solves any societal problem, improves the pedagogic approaches and increase the existing knowledge (Amgott, 2018).

Digital literacy capabilities have positive impact on knowledge, understanding and skills especially social networking sites that are lately used for information source by the users (Zulkarnain, et al. 2020). Sedaf and Gezer (2020) opined that digital literacy improves students' 21st century skills and prepare them for future career. Jimoyiannis (2018) concluded in a paper to explores how the digital literacy emerges, how it's been required for modern day society needs, how it improves the informed and active citizens and how it prepares the digital age employees, lifelong teachers and learners. The scholar considered the 21st century digital literacy to include computer and ICT literacy, information literacy, media literacy and visual literacy.

The teaching and learning of science especially physics to major or minor students of all categories of higher education institutions (HEIs) is aimed to equipped them with the course/subject applications into our immediate society. Many peopl e including the physics students still find it difficult to relate and explained some natural happening in our society in relation to the knowledge of physics. Taurian World School highlighted ten (10) major possible physics applications in our everyday li fe. The highlight cut across the physics application behind the use of lens for eye defects treatment, phone lens for taking picture, use of alarm clock, walking/locomotion activities and physics application in the use of medical equipment, electricity and energy use among others.

Literature Review and Hypotheses Development

Digital literacy

Soliman et al. (2022) searched on digital literacy and its effect on employees' innovation in Egyptian official tourism organizations. The study engaged three hundred and fifty (350) respondents while three hundred and twenty-eight (328) questionnaires were returned and three hundred and four questionnaires were found valid for the study. An adopted digital literacy scale that comprises of the twenty (20) items scale was used to elicit data with the reliability index (Cronbach alpha) of 0.947. The collected data were analyzed via partial least square structural equation modeling.

The measurement model result of the finding revealed that all items of information and communication technology (ICT literacy), Media literacy and information literacy's items has factor loading above 0.5, composite reliability value above 0.7 and average variance extracted (AVE) value above 0.5. The structural model result of the study revealed that information and communication technology (ICT), media and information are all positively, substantially and significantly related with employee innovation.

Haryanto et al. (2022) worked on the correlation between digital literacy and parents' roles towards elementary school students' critical thinking. The research was quantitative study of correlational type. Proportional random sampling technique was used to select seventy (70) from fourteen (14) identified districts in Yogyakarta. A researchers' designed questionnaire with seven (7) measuring items was used to gather information on students' digital literacy. The results of the study revealed that digital literacy has a significant relationship with students' critical thinking.

Physics concepts application to our everyday life

Munikwa and Ferreira (2018) worked on linking physics concepts to everyday life at advanced level: value, concerns and practice. The idea of this study was motivated by meaningful learning of physics relationship with everyday happenings in our life and society. The study eas a mixed method research with the usage of likert scale questionnaire and semi-structured interview protocol to elicit information from fifty-six (56) participants selected through probability sampling technique (Random sampling). Descriptive statistics was used to analyze the quantitative data and emerging themes was used for qualitative data analysis and discussion. The result of the study concluded that the linking of physics concepts to everyday life can be influenced by factors that includes teacher instructional skills, and detailed curriculum specifications among other.

The aforementioned reviewed works lead to the following research hypotheses:

- $H1_A$. Media Literacy significantly relate to students' awareness of physics application in our everyday use of lens and optics;
- $H1_B$. Media Literacy significantly relate to students' awareness of physics application in our everyday use of electricity and energy;
- $H2_A$. Computer and ICT literacy significantly relate to students' awareness of physics application in our everyday use of lens and optics;
- $H2_B$. Computer and ICT literacy significantly relate to students' awareness of physics application in our everyday use electricity and energy;
- $H3_A$. Information literacy significantly relate to students' awareness of physics application in our everyday use of lens and optics;
- $H3_B$. Information literacy significantly relate to students' awareness of physics application in our everyday use of electricity and energy.

Method

Population, sample and sampling technique

This study was correlation study of descriptive research type that use structural equation modeling for its analysis. The populations for this study were education students across all the public and private teachers producing universities and colleges in Kwara state. "Items to variable" sample size selection technique was used to select four hundred and eighty four (484) education students for this study through convenient sampling technique. Multivariate statistical tools like structural equation model encourages many sample size selection techniques like sample to variables, items to variables, G-power statistical software, Krejie and Morgan table

among others. Items to sample selection technique proposed at least minimum of ten times the number of items to sample.

Measures of construct

21st century digital literacy was measured on three different dimensions. This work builds on Jimoyiannis (2015) that postulated that the 21st century digital literacy as a requirement to live as an informed citizen is divided into four dimensions: Computer and ICT literacy dimension, Information literacy dimension, Media literacy dimension and Visual literacy dimension. The present search only considered three dimensions from the four dimensions earlier propounded by Jimoyiannis (2015) except for the visual literacy dimension.

The Computer and ICT literacy dimension of 21st century digital literacyitems was adapted from Son and Robb (2008). The instrument has ten (10) items which were modified to reflect physics teaching, learning and its application. The content of the measure ranges from items on the usage of computer and other ICT gadgets for physics lesson, willingness to use computer for physics lesson and teaching, usage of online computer application to aid physics lesson, and usage of computer aided instructions. All items of the construct were measured using five (5) likert scale of strongly agree, agree, undecided, disagree and strongly disagree.

Information literacy dimension of 21st century digital literacy consists of seven (7) items that were rated on five Likert scales of strongly agree, agree, undecided, disagree, and strongly disagree. The items of the measure were adapted from Arra (2017). The content of the measure were centered on availability of physics concepts in internet, awareness of some artificial intelligence software like ChatGPT among others to search physics contents, and acquisition of physics concepts' knowledge and its application to our everyday life.

The Media literacy dimension of 21st century digital literacy consists of five (5) items. The items of the measure were adopted from PISA (2018). The items were rated on five Likert scales strongly agree, agree, undecided, disagree, and strongly disagree. The content of the measure was centered on to seek and proffer solution to societal problem on internet, software installation proficiency and sharing of useful information on internet.

Table 1: *21st Century Digital Literacy Measure*

21st Century Digital Literacy Dimension	Source	Number of adapted Items
Computer and ICT Literacy dimension	Son and Robb (2018)	10
Information Literacy dimension	PISA (2018)	7
Media Literacy dimension	Arra (2017)	5

Source: Field work, 2023

Awareness of physics application in our everyday use of lens and optics

The awareness of physics application of our everyday use of lens and optics items were developed by researchers based on the experience gathered from the available

resources on internet. The measure consists of four (4) items that were rated on a five Likert scale of strongly agree, agree, undecided, disagree, and strongly disagree. The content of the measure focuses on usage of awareness of the use of concave and convex lens to correct eye defects, awareness of principle of lens behind taking selfie picture, and awareness of physics application in car head lamp and mirror use.

Awareness of physics application in our everyday use of electricity and energy

The awareness of physics application of our everyday use of electricity and energyitems were developed by researchers based on the experience gathered from the available resources on daily energy and electricity use on internet. The measure consists of three (3) items that were rated on a five Likert scale of strongly agree, agree, undecided, disagree, and strongly disagree. The content of the measure focuses on awareness of the physics application in the use of car and phone batteries, and awareness of physics application in the use electricity.

Findings

The data collected for this current study were analyzed using SmartPLS software version 4.0.9.2 due to the software's relationship with the partial least square structural equation model (PLS-SEM). The PLS-SEM like other multivariate tools is an advanced statistical method that can determine the causal relationship between multiple variables (exogenous and endogenous).

The measurement model analysis part of PLS-SEM shows the psychometric properties (validity and reliability of the constructs). The structural model analysis part of PLS-SEM presents the relationship strength, direction, significance, findings on the coefficient of determination, and predictive relevance. The study present the result of the necessary condition and analysis and compare it with the PLS result. The bottleneck table was presented so as to show the level at which exogenous variables can influence the endogenous variables.

Table 2: ***Demographic Profile of the Respondents***

Gender		N	%
	Female	235	48.6
	Male	246	50.8
	Missing	3	0.6
	Total	**484**	**100**
Level			
	100	79	16.3
	200	146	30.2
	300	90	18.6
	400	138	28.5
	Missing	31	6.4
	Total	**484**	**100**
Age			
	15-20	157	32.4
	21-25	303	62.6

	26-30	13	2.7
	31-Above	11	2.3
	Missing	0	0
	Total	**484**	**100**

Results of the measurement model

The validity and reliability of the constructs were assessed using average variance extracted, Cronbach Alpha, and composite reliability.

Table 3: ***Heterotrait-monotrait (HTMT) of Correlations of the Constructs***

Construct	Awareness of Physics Application in the use of energy and electricity in our everyday life	Awareness of Physics Application in the use of lens and optics in our everyday life	ICT Literacy	Information Literacy	Media Literacy
Awareness of Physics Application in the use of energy and electricity in our everyday life					
Awareness of Physics Application in the use of lens and optics in our everyday life	0.880				
ICT Literacy	0.544	0.585			
Information Literacy	0.566	0.519	0.665		
Media Literacy	0.613	0.603	0.777	0.480	

Table 4: ***Convergent Table***

Construct	Cronbach Alpha	Composite Reliability	Average variance Extracted (AVE)
Media Literacy	0.815	0.814	0.383
ICT Literacy	0.782	0.812	0.310
Information Literacy	0.753	0.805	0.346
Awareness of Physics Application in the use of lens and optics in our everyday life	0.683	0.798	0.499
Awareness of Physics Application in the use of energy and electricity in our everyday life	0.654	0.794	0.491

Findings of the structural model

Structural model analysis determines the constructs (exogenous and endogenous) relationship strength (weak/moderate/substantial), direction (positive and negative) and significance ($p<.05$, $t>1.96$). The necessary condition analysis results in table 5 indicate that media literacy, computer and ICT literacy and information literacy' dimension of 21st century digital literacy has significant relationship with education students' awareness of physics application in our everyday use of lens and optics, electricity and energy. The result of partial leas t square of structural equation modeling in table 7 shows positive, weak, moderate, substantial and significant relationship with education students' awareness of physics application in our everyday use of lens and optics, electricity and energy. The result of PLS-SEM in table 7 is confirming the result of the necessary condition analysis results in table 5 that has all the exogenous variables (media, computer and ICT, and information of 21st century digital literacy)' p-value less than 0.05.

This implies that proper usage of 21st century digital literacy can aid the education students' awareness of physics application in our everyday use of lens and optics, electricity and energy. The comparison of necessary condition analysis and partial least square result in table 8 revealed that on average, an increase in media literacy, computer and ICT literacy and information literacy will increase the students and masses awareness of physics application in the everyday use of lens and optics, electricity and energy use.

Table 5: ***NCA effect sizes table***

Construct	Awareness of Physics Application in use of lens and optics CE-FDH	p-value	Awareness of Physics Application in use of energy & electricity CE-FDH	p-value
Media Literacy	0.108	0.004	0.142	0.004
ICT Literacy	0.165	0.004	0.237	0.002
Information Literacy	0.139	0.010	0.163	0.029

Table 6: ***Pls predict Indicator Prediction Summary***

Endogenous constructs indicators	PLS-SEM_RMSE	PLS-SEM_MAE	Q^2predict	LM_RMSE	LM_MAE
APE1	0.727	0.593	0.073	0.717	0.576
APE2	0.820	0.665	0.137	0.840	0.840
APE3	0.742	0.624	0.145	0.748	0.748
APE4	0.725	0.607	0.173	0.745	0.745
APL1	0.736	0.604	0.138	0.729	0.729
APL2	0.723	0.612	0.194	0.715	0.715
APL3	0.826	0.689	0.072	0.836	0.836
APL4	0.747	0.625	0.134	0.762	0.762

Table 7: ***PLS Result***

Path Relationship	**Path Coefficient**	**p-value**	**t-value**	**Effect size (f^2)**	**R^2 (Use of Lens and Optics)**	**R^2 (Use of Energy and Electricity)**
Media Literacy -> Awareness of physics application on use lens and optics in our everyday life	0.269	0.000	5.655	0.068		
Media Literacy -> Awareness of physics application on use of energy and electricity in our everyday life	0.294	0.000	6.134	0.082	0.297	0.292
ICT Literacy -> Awareness of physics application on use lens and optics in our everyday life	0.212	0.000	4.427	0.035		
ICT Literacy -> Awareness of physics application on use of energy and electricity in our everyday life	0.138	0.003	2.948	0.015		
Information Literacy -> Awareness of physics application on use lens and optics in our everyday life	0.175	0.000	3.615	0.030		
Information Literacy -> Awareness of physics application on use of energy and electricity in our everyday life	0.234	0.000	4.806	0.053		

Table 8: ***Comparison of PLS-SEM and NCA Results***

Scenario	PLS-SEM results (p-value)	NCA results (p-value)	Conclusion
Media Literacy as determinant of awareness of physics application on use of lens and optics in our everyday life	0.000 (p<0.05)	0.004 (p<0.05)	On average, an increase in media literacy will increase the students and masses awareness of physics application in the everyday use of lens and optics. An increase of 0.4% of current students' media literacy will placed them on average level of their awareness of physics application in our everyday life.
Media Literacy as determinant of awareness of physics application on use of energy and electricity in our everyday life	0.000 (p<0.05)	0.004 (p<0.05)	On average, an increase in media literacy will increase the students and masses awareness of physics application in the everyday use of lens and optics. An increase of 0.4% of current students' media literacy will placed them on average level of their awareness of physics application in our everyday life
ICT Literacy as determinant of awareness of physics application on use of lens and optics in our everyday life	0.000 (p<0.05)	0.004 (p<0.05)	On average, an increase in ICT literacy will increase the students and masses awareness of physics application in the everyday use of lens and optics. An increase of 0.413% of current students' ICT literacy will placed them on average level of their awareness of physics application in our everyday life
ICT Literacy as determinant of awareness of physics application on use of energy and electricity in our everyday life	0.003 (p<0.05)	0.002 (p<0.05)	On average, an increase in ICT literacy will increase the students and masses awareness of physics application in the everyday use of lens and optics. An increase of 0.2% of current students' ICT literacy will placed them on average level of their awareness of physics application in our everyday life
Information Literacy as determinant of awareness of physics application on use of lens and optics in our everyday life	0.000 (p<0.05)	0.010 (p<0.05)	On average, an increase in information literacy will increase the students and masses awareness of physics application in the everyday use of lens and optics. An increase of 0.413% of current students' information literacy will placed them on average level of their awareness of physics application in our everyday life
Information Literacy as determinant of awareness of physics application on use of energy and electricity in our everyday life	0.000 (p<0.05)	0.029 (p<0.05)	On average, an increase in information literacy will increase the students and masses awareness of physics application in the everyday use of lens and optics. An increase of 1.03% of current students' information literacy will placed them on average level of their awareness of physics application in our everyday life

Discussion and Conclusion

The use of partial least square structural equation modeling in research has gain more strength, momentum and experienced growth in all field of studies for research and analysis purposes among other multivariate statistical methods.

The present study explain the comparison of necessary condition analysis (NCA) and partial least square results of the 21st century digital literacy's dimensions and awareness of physics application in our everyday use of lens and optics, electricity and energy in Kwara state, Nigeria. The research hypotheses raised focuses on direct relationship of 21st century digital literacy's dimensions and awareness physics application in our everyday use of lens and optics, electricity and energy. The path coefficients (β), p and t-statistics' revealed that all 21st century digital literacy's dimensions had weak, moderate, substantial and significant relationship awareness of physics application in our everyday use of lens and optics, electricity and energy. The study also revealed that necessary condition analysis (NCA) and partial least square (PLS) results of exogenous variable (21st century digital literacy's dimension) can influence the endogenous variables (awareness of students' physics applications in our everyday use of lens and optics, and electricity and energy). In conclusion, proper usage of the 21st century digital literacy's dimension will influences the awareness of students' physics applications in our everyday use of lens and optics, and electricity and energy based on the findings of the study.

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