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DEVELOPMENT AND VALIDATION OF A PROGRAMMED INSTRUCTION PACKAGE FOR LEARNING PROBABILITY IN SENIOR SECONDARY SCHOOL MATHEMATICS CURRICULUM

Evbakoe Pedro IKUEREYE (Ph.D)[1] & Festus Osadebamwen IDEHEN (Ph.D)[2]
Instructional Technologist and Lecturer, Department of Curriculum & Instructional Technology, Faculty of Education, University of Benin, Benin City, Nigeria
evbakoe.ikuereye@uniben.edu[1] , *festus.idehen@uniben.edu[2]*

Abstract
This study was on the development and validation of a programmed instruction package for learning probability in senior secondary school mathematics curriculum in Benin metropolis. The study adopted production-oriented descriptive survey design employing the Design Science Research (DSR) approach. All the two hundred and ninety-one (291) teachers in Benin Metropolis, thirty (30) computer science lecturers from three different universities and five (5) instructional technologists formed the population for the study. From which thirty-seven (37) Mathematics teachers, eighty (8) computer experts and Five (5) Instructional technologists were sampled, using a multi-stage sampling procedure for the Mathematics teachers and proportional sampling technique for the other two. A rating scale was the instrument that was used for data collection. The instrument was validated by the supervisors and two other lecturers from the Faculty. Some findings of this study revealed that Mathematics teachers gave a favourable validation to the developed ADPIP in terms of typology, legibility, Navigation, interface, functionality and Content, that computer Experts gave a favourable validation to the ADPIP in terms of typology, legibility, navigation, interface, functionality and Content among others. It was recommended that since the Mathematics teachers gave a favourable validation to ADPIP its used should be encouraged in schools.

Keywords: Development, Validation, Programmed Instruction, Probability

Introduction

Education is designed to equip individuals with the knowledge and skills to deal with changes and challenges in the society. In Nigeria for example, her National Policy on Education (Federal Government of Nigeria (FGN), 2013) states that the philosophy of the Nigerian educational system is standing on the beliefs that: education is an instrument for national development and social change, which is important for the promotion of a progressive and united Nigeria, It maximizes the creative potentials and skills of the individual for self-fulfillment and general development of the society and that education is to be qualitative, comprehensive functional and relevant to the needs of the society among others. To produce the society that is desired, the body of knowledge is broken into courses and subjects with the different subjects having their own uniqueness. At the

secondary level of the Nigerian school system, some of the courses (subjects) offered includes: English language, Mathematics, Physics, Chemistry, Government among others.

Among other subjects, the importance of Mathematics to the body of knowledge and the society at large cannot be over emphasized. There is a continuous need to understand and use Mathematics in our everyday life and in the work place (Susanta, 2020). A good knowledge of Mathematics will give them a good chance to enter into any university and ultimately the opportunity to excel in the society (Adeneye, 2017). A good knowledge of basic mathematics is needed by individuals to survive in this modern society since consciously or unconsciously the knowledge of mathematics is used in our day to day activities as seen in exchange of currencies, telling of time, determining the distance between two places and even maybe little more complex activities like interpretation of charts, graphs and maps.

As important as Mathematics is to the body of knowledge and survival at workplace, it is still many students' night mere because they find it difficult to really flow with the subject (Capuno, Necesario, Etcuban, Espina, Padillo & Manguilimotan, 2019). That perhaps is an explanation to why student's performance in Mathematics in the Senior Secondary Certificate Examination (SSCE) organized by the West African Examination Council (WAEC) and the National Examination Council (NECO) has been poor over the years (Uche, Okafor and Anaduaka, 2013). Educators, administrators, researchers and all key players in the education industry over the years have sought for ways through which the teaching and learning of the subject can be improved so that students' performance in the subject can also improve. This is evident is the number of researches carried out to find out the causes as well as factors that make students not to do well in the subject. Despite these efforts, the performance of students in the subject is still not so satisfactory. The performance of students in General Mathematics in the May/June SSCE between 1991 and 2020 reveals that, the percentage of students that obtained credit and above in the subject was above fifty percent (50%) only in the 2004, 2016, 2017, 2019 and 2020editions of the examination as presented by WAEC with the percentages of 53.80%, 52.97%, 59.22%, 64.18% and 65.25% respectively. Having the mean of the percentages if pass to be 31.76% may suggest that there is still more work to be done. Whereas a credit pass in the subject is a pre-entry requirement for students to pursue their dreams in many Nigerian higher institutions in Nigeria. Many factors have been put forward as possible factors that may affect how students understand and relate with the subject. Some of the factors include the qualification of teachers teaching the subject, the learning environment where learning is supposed to take place, the interest and attitudes of learners, the leadership structure of the educational system, the availability and functionality of instructional media, the method and techniques for teaching the subject, student's phobia for the subject among others. Another major factor that has been identified that influence how mathematics students view the subject is gender. Mathematics has often been erroneously seen as a masculine subject (Abdu-Raheem, 2012). This could be as a result of the way the subject has been presented over time. The

explosion of knowledge in the 21th century has perhaps modified the way things are done in different areas of our everyday life.

The introduction of Information and Communication Technologies (ICT) has influenced if not changed completely the way things are gone in different industries: for example,the banking sector has upgraded from book and pen to using packages like oracle, c++ and others to make their operations more effective and efficient, the music and film industry is taking advantage of the explosion in technology to make sounds and videos all from the studio as against the stress of going to the field and paying a lot of people to get the work done, just like in fields like medicine, law and Engineering, technology has been taken advantage of to provide room for effectiveness. The sport industry is not left out with the introduction of goal line technology as well as video assisted referee to the game of football and eagle eye to the game of tennis just as the deployment of other technologies in different aspects of sport; it has become more organized and interesting to watch. Therefore, the role ICT and other forms of technologies can play in the planning, implementation and evaluation of educational programmes cannot be over emphasized.

Scholars posit that when ICT just as other technologies are properly integrated into the education industry, it would improve the quality of Education (Jennifer, Mohammed, Jordan 2016, Kapur, 2019). Unfortunately, according to Adeleye and Omotayo (2020), teachers who teach in secondary schools in Nigeria still rely on the traditional “chalk and talk” method of teaching instead of deploying technology. Whereas taking into consideration the large class sizes witnessed in Nigeria Senior Secondary schools, the “chalk and Talk methods becomes largely ineffective. However, there are other forms of learning that can be deployed today some using different forms of technologies to give the instructional process new approaches, such as: inquiry based learning, blended learning, programmed instruction, among others. As a teaching technique, programmed instruction was initiated due to the complexity of applying scientific methods to instructional processes.

Programmed Instruction as an instructional process, deploys materials that are so structured that the need for the presence of a physical teacher is limited to the barest minimal. The materials used in a programmed instruction is designed to meet the specific instructional objective for the lesson and scrutinized properly by professionals to ensure its effectiveness. It involves presenting new concepts in any subject matter to students by carefully designing the new concept into small units of knowledge in such a way that one step leads to the other. Students for whom the programmed is met for are expected to go through the materials themselves at their own pace and at the end of every small unit, the learners are evaluated with instant feedback to make sure that they understand that unit before moving on to the next unit.

Rachumallu, (2020) posited that the use of programmed instruction to teach and learn Mathematics improves the achievement of students in the subject. *According to Nigerian communications commission (2020), the number of mobile subscribers* in

Nigeria is over two hundred million. It is expected that most of these mobile subscribers are youths or the youths largely have access to these technologies. They are generally referred to as digital natives. For these digital natives, using any form of technology is natural to them unlike the digital immigrants (Burcu and Sukru, 2021). Infact could be observed that most students prefer to spend time with their phones than their books. There are instructional packages in the web space today, packages such as: U-learn, Clax among others the uniqueness of ADPIP is that it is a programmed instruction package. If Mathematics must be made interesting to the digital natives there is need to teach them through their mobile phones, hence the need to develop and validate an Android Driven Programmed Instruction Package (ADPIP) through which students can learn probability in Senior Secondary Schools. Hence the need to develop and validate a programmed instruction package for the learning of Probability in Senior Secondary Schools in Benin Metropolis.

Research Questions

The following research questions were raised to guide the study:

1. What are Mathematics teachers' assessment of the developed ADPIP in terms of typology, legibility, Navigation, interface, functionality and Content?
2. What are computer experts' assessment of the developed ADPIP in terms of typology, legibility, Navigation, interface, functionality and Content?
3. What are Instructional technologists' assessment of the developed ADPIP in terms of typology, legibility, Navigation, interface, functionality and Content?
4. What is the level inter rater reliability of ADPIP

Methodology

The research design adopted in this study is a production oriented descriptive survey design employing the Design Science Research (DSR) approach. This research design is important and appropriate for social sciences and education because the study is to develop and validate an Android application. The population of the study consisted of the two hundred and ninety-one (291) teachers in the Benin Metropolis. There are four local government areas that form the Metropolis: Oredo local government area with 89 teachers, Egor L.G.A with 62 teachers. Ikpoba Okha local government area with 103 teachers and Ovia North East local government area with 37 teachers. However, the target populations for the study will be the mathematics teachers in the Metropolis. As for the computer experts, the computer science lecturers in the three (3) universities in the metropolis formed the population: University of Benin with sixteen (16) lecturers, Benson Idahosa University with eight (8) lecturers, Igbinedion and University with six (6) lecturers totaling 30 lecturers and the Instructional technologist in the fore mentioned higher institution in the metropolis formed the population. The sample of one study consist of thirty-seven (37) mathematics teachers, fifteen (15) computer experts and five (5) instructional technologist making a total of fifty-seven (57) participants all from the metropolis. To get the sampled teachers, the multi stage sampling technique was

adopted. Stage 1: Benin metropolis was divided into four (4) strata based on local government areas: Oredo, Egor, Ikpoba Okha and Ovia North East. Stage 2; at this stage, from the sampled local government areas, five (5) schools were randomly selected. Stage 3: from the selected schools, the Mathematics teachers in the schools were purposively selected to ensure that only Mathematics teachers validated the application. As for the computer experts, proportional sampling was used to select fifty percent (50%) of the computer lecturers in the three universities that formed the population of the study. Same was done to get the instructional technologist to validated the application. The instrument adopted for this study is a rating scale titled Probability Android Application Rating (PAARS) adapted from Arum, (2019). The rating scale had two sections has two sections: Section A and B: Section A was used to elicit the Bio data of the respondents while Section B contains items that will be used to validate the developed application. The instrument was grading from 4 to 1 and respondents were required to rate the items by ticking on the appropriate column. The instrument was validated by three lecturers in the University of Benin, Benin City: one being a Mathematics Educator and the others Instructional technologist. Their corrections and suggestions were used for the production of the final copies. To determine the reliability of the instrument it was determined to ten (10) teachers who were not part of the sample for this study. The data collected from the students were subjected to Cronbach's alpha reliability statistic with a reliability coefficient of 0.896. The rating scale was used to collect data from the groups of experts. The ADPIP was either installed in their android device or they were given a device where ADPIP has been installed so that the experts who want to rate the application can access, manipulate and determine the functionality, content ease of use, accuracy of the application among others. After they have manipulated the application, they were required to rate the application with the rating scale that was giving to them. At completion of their ratings the completely rated instrument was retrieved by the researcher. The data from the rating scale was analyzed using descriptive statistics of frequency counts, simple percentage, mean and standard deviation. Nominal values that were assigned in the rating scale range from 1 - 4. Any item that had a mean value of 2.50 and above was interpreted as an agreement; while an item below 2.50 was considered as disagreement. While inter rater reliability was used to determine the reliability of the developed ADPIP with the decision rule as follows: 0-0.30 = low Reliability, 0.31- 0.60 = Moderate Reliability, 0.61 And above = High Reliability

Results

Research Question 1: What are Mathematics teachers' assessment of the developed ADPIP in terms of typology, legibility, Navigation, interface, functionality and Content?

Table 1: Mean and standard deviation of Mathematics teachers' assessment of the developed ADPIP in terms of typology, legibility, Navigation, interface, functionality and Content

S/N	ITEMS	N	Mean	Standard Deviation	Decision
	Typology				
1.	The appearance of characters on the screen	37	3.30	.46	Efficient
2.	Sequence of information on the screen	37	3.19	.62	Efficient
3.	Consistency of the position of information on the screen	37	3.70	.46	Efficient
4.	Brevity of the slide content	37	3.43	.77	Efficient
	Average Means		**3.41**	**.58**	Efficient
	Legibility				
5.	Use of readable font size	37	3.21	.63	Efficient
6.	Consistency in the use of upper and lower cases	37	3.32	.75	Efficient
7.	Clarity of figures and tables	37	3.51	.51	Efficient
8.	Conventional assignment of colour codes	35	3.11	1.02	Efficient
	Average Means		**3.29**	**0.72**	Efficient
	Navigation				
9.	The package allows learners to move around freely in different units	37	2.92	.76	Efficient
10.	The package encourages easy accessibility to and from the home page to the modules.	37	3.27	.99	Efficient
	Average Means		**3.10**	**0.88**	Efficient
	Interface				
11.	The package has attractive homepage	37	3.14	.75	Efficient
12.	The package has appropriate slide layouts	37	3.00	.81	Efficient
13.	The package has a well-organized interface	37	3.35	.59	Efficient
	Average Means		**3.16**	**0.72**	Efficient
	Functionality				
14.	The package encourages immediate knowledge of result	37	3.76	.43	Efficient
15.	The concepts and vocabularies are relevant to the learner's ability	37	3.24	.80	Efficient
16.	It is easy to use the application in different device	37	3.32	.58	Efficient
17.	The interactivity of the package corresponds to the maturity of the students	37	3.40	.50	Efficient
18.	The application response to commands are fast	37	3.60	.50	Efficient
19.	The package inspires students to apply what they have learnt rather than memorize it.	37	3.29	.66	Efficient
20.	It is easy to get feedback from the application	37	3.49	.61	Efficient
	Average Means		**3.44**	**0.58**	Efficient
	Content				
21.	The contents of the application is comprehensive	37	3.38	.49	Efficient
22.	The content of the package adequately covers the selected concepts	37	3.30	.57	Efficient
23.	The content of the application is presented in logical small frames	37	3.35	.59	Efficient
24.	The various sub-topics are sequentially arranged to allow for transitional learning	37	3.41	.76	Efficient
25.	The language/terminologies that were used are adequate so users can understand	37	3.43	.50	Efficient
26.	The examples used in the application are adequate	37	3.73	.45	Efficient
27.	The "end of unit tests" is relevant to the content of the respective units.	37	3.62	.49	Efficient
28.	The feedback of the "end of unit tests" are accurate	37	3.43	.50	Efficient
29.	The package is well designed and self-instructional.	37	3.41	.50	Efficient
	Average Means		**3.41**	**0.54**	Efficient
	Grand Mean		**3.37**		

From the data gathered from Table 1, a grand mean of 3.37 is obtained. Since the grand mean was greater than the bench mark of 2.5, this shows that Mathematics teachers gave a good validation to Android Driven Programmed Instruction Package (ADPIP). From the different criteria on which the application was validated, an average mean of 3.41, 3.29, 3.10, 3.16, 3.44 and 3.41 was gotten for typology, legibility, Navigation, interface, functionality and Content respectively.

Research Question 2: What are computer experts' assessment of the developed ADPIP in terms of typology, legibility, Navigation, interface, functionality and Content?

Table 2: Mean and standard deviation of Computer experts assessment of the developed ADPIP in terms of typology, legibility, Navigation, interface, functionality and Content

S/N	ITEMS	N	Mean	Standard Deviation	Decision
	Typology				
1.	The appearance of characters on the screen	15	3.27	.46	Efficient
2.	Sequence of information on the screen	15	3.13	.64	Efficient
3.	Consistency of the position of information on the screen	15	3.87	.35	Efficient
4.	Brevity of the slide content	15	3.40	.83	Efficient
	Average Means		**3.41**	**.57**	
	Legibility				
5.	Use of readable font size	15	3.47	.74	Efficient
6.	Consistency in the use of upper and lower cases	15	3.33	.81	Efficient
7.	Clarity of figures and tables	14	3.64	.50	Efficient
8.	Conventional assignment of colour codes	13	2.77	1.01	Efficient
	Average Means		**3.30**	**0.76**	
	Navigation				
9.	The package allows learners to move around freely in different units	15	2.67	.98	Efficient
10.	The package encourages easy accessibility to and from the home page to the modules.	15	2.93	1.17	Efficient
	Average Means		**2.80**	**1.07**	
	Interface				
11.	The package has attractive homepage	15	3.40	.74	Efficient
12.	The package has appropriate slide layouts	15	2.80	.78	Efficient
13.	The package has a well-organized interface	15	3.47	.52	Efficient
	Average Means		**3.22**	**68**	
	Functionality				
14.	The package encourages immediate knowledge of result	15	3.80	.41	Efficient
15.	The concepts and vocabularies are relevant to the learner's ability	14	3.14	.77	Efficient
16.	It is easy to use the application in different device	14	3.50	.52	Efficient
17.	The interactivity of the package corresponds to the maturity of the students	11	3.45	.52	Efficient
18.	The application response to commands are fast	15	3.67	.49	Efficient
19.	The package inspires students to apply what they have learnt rather than memorize it.	15	3.33	.72	Efficient
20.	It is easy to get feedback from the application	15	3.53	.64	Efficient
	Average Means		**3.48**	**.58**	
	Content				
21.	The contents of the application is comprehensive	14	3.57	.51	Efficient

22.	The content of the package adequately covers the selected concepts	13	3.31	.48	Efficient
23.	The content of the application is presented in logical small frames	15	3.40	.63	Efficient
24.	The various sub-topics are sequentially arranged to allow for transitional learning	12	3.17	.83	Efficient
25.	The language/terminologies that were used are adequate so users can understand	14	3.64	.50	Efficient
26.	The examples used in the application are adequate	14	3.57	.51	Efficient
27.	The "end of unit tests" is relevant to the content of the respective units.	13	3.85	.38	Efficient
28.	The feedback of the "end of unit tests" are accurate	11	3.45	.52	Efficient
29.	The package is well designed and self-instructional.	14	3.50	.52	Efficient
	Average Means		**3.49**	**.54**	
	Grand Mean		**3.28**		

From the data gathered from Table 2, a grand mean of 3.28 is obtained. Since the grand mean was greater than the benchmark of 2.5, it reveals that Computer experts gave a good validation to Android Driven Programmed Instruction Package (ADPIP). From the different criteria with which the application was validated, an average mean of 3.41, 3.30, 2.80, 3.22, 3.48and 3.49 was obtained for typology, legibility, Navigation, interface, functionality and Content respectively.

Research Question 3: What are Instructional technologists' assessment of the developed ADPIP in terms of typology, legibility, Navigation, interface, functionality and Content?

Table 3: Mean and standard deviation of Instructional technologists' assessment of the developed ADPIP in terms of typology, legibility, Navigation, interface, functionality and Content

S/N	ITEMS	N	Mean	Standard Deviation	Decision
	Typology				
1.	The appearance of characters on the screen	5	3.00	.36	Efficient
2.	Sequence of information on the screen	5	3.27	.54	Efficient
3.	Consistency of the position of information on the screen	5	3.14	.45	Efficient
4.	Brevity of the slide content	5	2.98	.61	Efficient
	Average Means		**3.09**	**.49**	
	Legibility				
5.	Use of readable font size	5	3.02	.81	Efficient
6.	Consistency in the use of upper and lower cases	5	3.26	.72	Efficient
7.	Clarity of figures and tables	5	3.01	.52	Efficient
8.	Conventional assignment of colour codes	5	3.71	.97	Efficient
	Average Means		**3.25**	**.75**	
	Navigation				
9.	The package allows learners to move around freely in different units	5	3.12	.88	Efficient
10.	The package encourages easy accessibility to and from the home page to the modules.	5	2.91	.95	Efficient
	Average Means		**3.01**	**.91**	

	Interface				
11.	The package has attractive homepage	5	3.54	.77	Efficient
12.	The package has appropriate slide layouts	5	2.96	.64	Efficient
13.	The package has a well-organized interface	5	3.52	.62	Efficient
	Average Means		**3.34**	**.67**	
	Functionality				
14.	The package encourages immediate knowledge of result	5	3.64	.52	Efficient
15.	The concepts and vocabularies are relevant to the learner's ability	5	3.24	.75	Efficient
16.	It is easy to use the application in different device	5	3.11	.64	Efficient
17.	The interactivity of the package corresponds to the maturity of the students	5	2.97	.68	Efficient
18.	The application response to commands are fast	5	3.15	.42	Efficient
19.	The package inspires students to apply what they have learnt rather than memorize it.	5	3.23	.87	Efficient
20.	It is easy to get feedback from the application	5	3.78	.89	Efficient
	Average Means		**3.30**	**.68**	
	Content				
21.	The contents of the application is comprehensive	5	3.28	.61	Efficient
22.	The content of the package adequately covers the selected concepts	5	3.41	.51	Efficient
23.	The content of the application is presented in logical small frames	5	3.25	.62	Efficient
24.	The various sub-topics are sequentially arranged to allow for transitional learning	5	3.07	.85	Efficient
25.	The language/terminologies that were used are adequate so users can understand	5	3.14	.64	Efficient
26.	The examples used in the application are adequate	5	2.83	.61	Efficient
27.	The "end of unit tests" is relevant to the content of the respective units.	5	3.16	.39	Efficient
28.	The feedback of the "end of unit tests" are accurate	5	2.74	.59	Efficient
29.	The package is well designed and self-instructional.	14	3.50	.52	Efficient
	Average Means		**3.15**	**.59**	
	Grand Mean		**3.19**		

From the data gathered from table 3, a grand mean of 3.19 is obtained. Since the grand mean was greater than the bench mark of 2.5, it reveals that Instructional technologists gave a good to validation Android Driven Programmed Instruction Package (ADPIP). From the different criteria with which the application was validated, an averSage mean of 3.09, 3.25, 3.01, 3.34, 3.30and 3.15 was gotten for typology, legibility, Navigation, interface, functionality and Content respectively.

Table 4a: Inter-Item Correlation Matrix of ADPIP by Mathematics Teachers, Computer Experts and Instructional Technologists

	N	Mean	Std. Deviation	Mathematics Teachers	Computer Experts	Instructional Technologist
MATHEMATICS TEACHERS	37	3.16	.196	1.000	.950	.789
COMPUTER EXPERTS	15	3.21	.263	.950	1.000	.860
INSTRUCTIONAL TECHNOLOGIST	5	3.37	.236	.789	.860	1.000

Table 4a shows the inter item correlation matrix of ADPIP by Mathematics teachers, Computer Experts and Instructional Technologist. It reveals that the inter item Correlation between Mathematics teachers and Computer Experts is 0.950, the inter item Correlation between instructional technologist and Mathematics teachers is 0.789 while the inter item Correlation between Computer Experts and Instructional TechnologistS is 0.860

Table 4b: Intraclass Correlation Coefficient of ADPIP from Mathematics Teachers, Computer experts and Instructional Technologists

	Interclass correlation	Value	Sig.
Single Measures	.726	.458	.765
Average Measures	.857	.458	.765

Table 4b shows the Intraclass Correlation (ICC) statistics by a 2-way random-effect model with the three sets of raters: Mathematics teachers, Computer Experts and Instructional technologists across the twenty items in the rating scale. The obtained ICC value was 0.857 indicating that the application is highly reliable.

Discussion of Findings

Based on the analysis of the research questions, the following were revealed. The developed Android Driven Programed Instruction Package was given a favourable validation by the different groups of validators: Mathematics teachers, Computer Experts and Instructional technologists. It is revealed that following the different criteria with which the application was validated, all the means were above the benchmark of 2.5 which implies that the application is Efficient. As for the reliability of the application, an inter class reliability was established.

Conclusion

Based on the findings of the study it was concluded that the android driven programmed instruction package for the learning of Probability by Senior Secondary school students is valid and reliable for the teaching of probability in Senior Secondary Schools.

Recommendations

In view of the findings and conclusion drawn from this study, the following recommendations were made.

- That since the mathematics teachers gave a favourable validation to ADPIP its used should be encouraged in schools
- Other Applications with similar features should be developed by other experts to give room for verities.

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