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Development and Validation of Teacher-made Instructional Software Package for Teaching Chemical Bonding in Secondary Schools

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Abstract
Teachers using traditional lecture method find it difficult to communicate the concept of chemical bonding to students; and students find it difficult to learn the concept. The trend in the 21st century learning is the use of computer and software packages to facilitate teaching-learning process. This study set out to develop and validate a software package for teaching chemical bonding in secondary schools. The study produced chemical bonding instructional software package (CBISP), adopting the procedure suggested in FTCESP-model for teacher-made computer educational software package. It also produced an instrument for validation of the software package. The internal consistency (α) of the Chemical Bonding Instructional Software Package (CBISP) has a value of 0.781, obtained by Kendall's Coefficient of Concordance method used in determining it. The author asserts that the procedure adopted in the development and validation of the CBISP is a veritable way of ensuring sustainable supply of relevant software packages in the school system.
Keywords: Development, validation, teacher-made, instructional software package, chemical bonding

1.Introduction

Secondary school teachers and students classify some chemistry topics or concepts as difficult chemical concepts. Udo and Eshiet (2007) defined difficult chemical concepts as those that teachers find difficult to teach or students find difficult to understand. This is the case with chemical bonding (Peterson, Treagust and Garnett, 1986; Butts and Smith, 1987; Boo, 1998; Pereira and Pestana, 1991; Griffiths and Preston, 1992; and Nwahunanya, 2011). Nwahunanya (2011) asserted that secondary school teachers find it difficult to teach chemical bonding . The chemical bond is at the heart of chemistry and bonding between atoms is the essence of chemistry (Engel and Reid, 2006). In other words, understanding chemical bonding and the nature of the bonds is very fundamental in the study of chemistry. For example, a good understanding of bonding and the nature of bonds makes it easy for chemistry students to predict the overall energy change in a chemical reaction (Boo, 1998). WAEC (2010) showed that candidates in Senior School Certificate chemistry examination were unable 'to correctly distinguish between dative bond and covalent bond'. A covalent bond is one in which two atoms share a pair of electrons. A dative bond is just like any other covalent bond once it has been formed. The only difference is that one atom, rather than each atom donating one electron donate both electrons.
The crux of the matter is that teachers using the traditional lecture method find it difficult to communicate the concept of chemical bonding to the students; and students find it difficult to learn the concept. It is perhaps in consideration of the difficulties that students have in understanding; and their inability to explain, for example, the concept of dative bond and covalent bond, as explained above, that Oloyede (1998) concluded that learning of some chemical concepts by most Nigerian secondary school students is generally regarded as difficult.
The trend in the 21st century learning is the use of computer and software packages to facilitate the teaching-learning process. For this reason, and because of the dearth of relevant instructional computer software packages in the school system, there is need to develop them and ensure their sustainable supply in the school system.

2. Software development

Development of software entails all the activities involved between its conception through to the final manifestation of the software. Software development refers to the art of working or work that is accomplished through the design phase to the manufacture of the software (Mbam, 2005). Software development may include research, new development, modification, reuse, re-engineering, maintenance and indeed all activities that result in software product. It may also include the writing of its application programming interface (API), which includes features (both external and internal) that let the developer maintain user-specific and application-specific settings in a standard way to store short configuration values in an open and easy-to-understand text file format (Patrick, 2008). The design process involves an examination and or analysis of the software user's needs and massaging those needs into the software product.
There are needs that are specific to each software project, which require an understanding of the objectives of the task that the user needs to accomplish with the desired application. It is necessary that developers document and design the software to meet these project-specific needs. An example of a software that is project-specific is the

software for the teaching of chemical bonding that will facilitate the teaching of chemical bonding, and make meaningful instruction to beginning (SS1) students at the secondary. It should aid the students to visualise chemical bonding process, understand the subject matter and be able to explain the concept in concrete terms, using their own language. Gardner (1995:56) stresses on the importance of visual communication and asserts that as 'society advances, it relies less on text and more on visual communication'. Students, therefore, are likely to benefit more from visual communication, via the computer. Thus, a solid foundation would be laid for the students' further studies in chemistry. A good understanding of chemical bonding is key to making progress in further studies in chemistry.

1.2 Models of Software Development

There are several models for developing a software, each of these models describe approaches to a variety of tasks or activities that take place during the processes that give rise to the manifesting of the software. Some software development processes include: FTCESP-model and Waterfall model, which were very relevant to the present study. The FTCESP-model for teacher-made computer educational software package was suggested (Okorie & Akubuilo, 2013) in an effort to find a solution to problems arising from dearth of relevant instructional computer software packages in the school system.

2.2.1 FTCESP-model for teacher-made computer educational software package

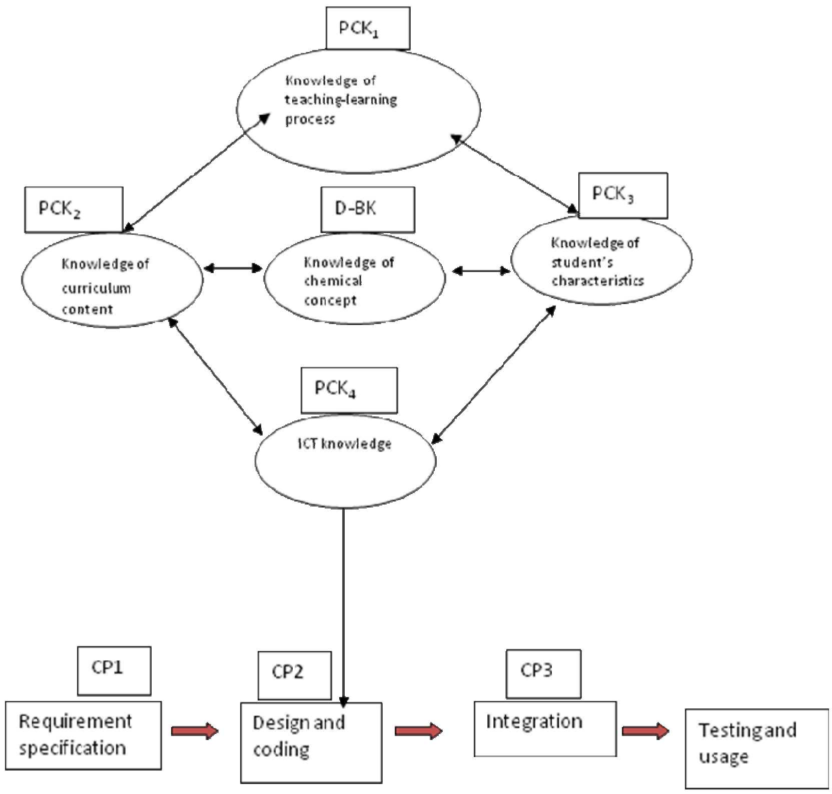

Fig 1**.** FTCESP-model for teacher-made computer educational software package (Okorie & Akubuilo,2013

The basic assumption of the FTCESP-model of software Development is that chemistry teachers by their training have pedagogical content knowledge (PCK), and discipline-based knowledge (D-BK). Because of these unique expertises, teachers should be able to communicate concepts to students in a teaching-learning process. Teachers are usually conversant with the curriculum content and very familiar with their students. Familiarity with the students places the teacher in a position to know the student's attributes and psychological dispositions in classroom situations. This knowledge lies within the domain of pedagogical content knowledge. With this knowledge as a guide, teachers are able to prepare lesson notes, provide relevant teaching aids such as suitable illustrations, diagrams, photographs and teacher-made tests for assessment and evaluation of students' understanding of the lessons delivered to them. This has always been the case before the advent of ICT. With the adoption in 21st century of ICT as a tool in facilitating the teaching-learning process, the FTCESP-model is based both on the assertion that there is need to align pedagogical orientation of teachers towards 21st century learning; and on the conviction that 21st century teachers should be computer literate and proficient in use of ICT to aid teaching-learning process. In addition, they should be able to develop multimedia platforms for communication and interaction between the learning material and students (Okorie & Akubuilo, 2013).

The present study shows how the FTCESP-model has been used to construct Chemical Bonding Instructional

Software Package.

2.2.2 Waterfall Model of Software Development

The waterfall model (Waterfall model, 2012) of creating software is one that organises various developmental phases in a linear order that progresses, systematically from one phase to another in a downward fashion, like a waterfall. The developmental phases are: requirements, design, implementation, verification and maintenance arranged in the order shown in Fig. 2. Aspects of Waterfall model of software development were also adopted in constructing the software.

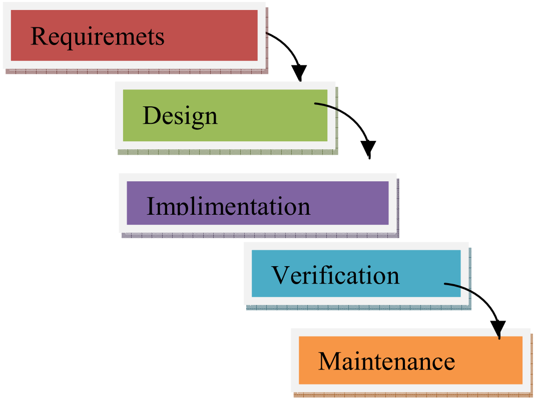

Fig. 2 Waterfall model of software development (Waterfall model, 2012)

3. Research Design

Instrumentation design (ID) was used in this study. Instrumentation is the study, development and manufacture of instruments for a specific purpose (http://www.thefreedictionary.com). The dictionary explains further that instrumentation includes the design, development or manufacture of, and ***using*** the instruments needed for some implementation in science, medicine, technology or industry. Lyons and Seow (2000) noted that instrumentation design is concerned with a creative thinking process that revolves around making tools or instruments to meet a specific need, or to solve a specific problem. Instrumentation requires the possession of a sound knowledge of the process of transforming problem-solving ideas into reality.

The emphasis in instrumentation is on the realisation of an object, an instrument or tool that can be tested and evaluated to check whether the design really solves the problem that informed its development. The International Centre for Educational Evaluation (1982) cited in Agbir (2004) asserts that 'a study belongs to instrumentation research if it is aimed at developing new or modifying content, procedure , technology or instrument of educational practice. From the point of view of its definition and explanation, instrumentation involves ***process*** and ***product*** or end of the process. Both aspects of instrumentation are significant in understanding the design and why it was used in this study, where it was construed to mean any process that involves and results in designing, constructing, testing and using tangible products, objects, tools or instruments for specific purpose.

The design of the present study fits into the definition of instrumentation. Firstly, there was a specific purpose – execution of the job of teaching and learning of chemical bonding, for which there was need for an instrument (a tool and product of a process) for the specific purpose. In the context of this study, the instrument developed was the Chemical Bonding Instructional Software Package (CBISP). It was designed to meet the needs of teachers and students who find the concept of chemical bonding difficult in a teaching-learning process.

4. Development of Chemical Bonding Instructional Software Package

The chemical bonding instructional software package (CBISP) is a computer software package that teaches specific skills and knowledge in chemical bonding to first year chemistry students in Senior Secondary schools. It presents instructional activities in ten lessons tailored to meet the needs of the learners in understanding the concept of chemical bonding, thus laying a strong foundation needed for further studies in chemistry.

5. Method

In creating the software package, the FTCESP-model was adopted as follows: (i) requirement specification, (ii) design and coding; and **(**iii) integration.

5.1 Requirement specification, design and coding: At this stage, all that was needed to design , create and animate electronic slides that run on computers were identified and recorded. The electronic slides are dynamic slides that automatically change after a set time. This involved designing of slides, inserting text and graphics and animations of slides and their objects.

5.2 Integration: This entails adding animation effects to slides. The following steps were taken:

a). Transition effect, using this option, the way one slide leaves the screen and another one appearing could be controlled.

b). *Custom animation,* this enables the user to control the appearance of various slide elements, which could be some text image, illustration, photographs, etc.

c). *Adding voice* to the slide presentation, saving and burning the presentation in a compact disk (CD) .

This is the software package. The aspect of this linear ordering of phases, which was adopted in this study, is this: 'after each phase is completed and its outputs are certified, these outputs become the inputs to the next phase and should not be changed or modified' (Waterfall model, 2012).

6. Validation of Chemical Bonding Instructional Software Package (CBISP)

The following question guided this second part of the study: What is the content validity of the Chemical Bonding Instructional Software Package (CBISP)?

To answer the above question, four expert chemical educators assessed the software package, using Chemical Bonding Instructional Software Package Inventory (CBISPI) (Appendix). The CBISPI is an Educational Software Package Rating Scale (ESPRS) and has a reliability constant of 0.81, based on Cronbach Alpha method used in determining the internal consistency of the instrument. The CBISPI is based on the 14 most important evaluation criteria used by educational software evaluation consortium (Bitter and Wighton, 1987). The rating scores of the above experts is shown in Table 1. The scores were used in determining the internal consistency of the Chemical Bonding Instructional Software Package (CBISP) by Kendall's Coefficient of Concordance method. A value of 0.781 was obtained (Tables 2 & 3).

Table 1. Rating Pattern of CBISP by 4 Chemical Educators on CBISPI

Criteria for Evaluation	No scoring Excellent(	No scoring Good(4)	No scoring Fair(3)	No scoring Poor(2)	No scoring Very poor(1)
1	4				
2	2	2			
3	2	2			
4	3	1			
5	1	3			
6	2	2			
7	2	2			
8		4			
9	2	2			
10	4				
11	3	1			
12		3	1		
13		4			
14		4			

Table 2. Kendall's W Test

Item No	**1**	**2**	**3**	**4**	**5**	6	**7**	**8**	**9**	**10**	**11**	**12**	13	**14**
Mean Ranks	11.38	8.00	8.00	9.75	6.26	8.00	8.00	4.50	8.00	11.38	9.75	3.00	4.50	4.50

Table 3. Test Statistics

N	Kendall's W^a	Chi-Square	df	Asymp. Sig.
4	.781	33.842	13	.001

a. Kendall's Coefficient of Concordance

7. Discussion

This study set out to develop and validate a software package for teaching chemical bonding in secondary schools. The study produced chemical bonding instructional software package (CBISP), adopting the procedure suggested in FTCESP-model for teacher-made computer educational software package. It also produced an instrument for validation of the software package. The internal consistency (α) of the Chemical Bonding Instructional Software Package (CBISP) has a value of 0.781, obtained by Kendall's Coefficient of Concordance method used in determining it.

8. Conclusion

The result of this study should be of interest to teacher training institutions and ministries of education, which should encourage teachers in the education system to acquire the necessary knowledge and skills for development of teacher-made educational software packages. The procedure adopted in the development and validation of the CBISP could serve as a model, for training and retraining teachers on development and validation of educational or instructional software packages. This study is very significant because as more teachers acquire more ICT knowledge and skills, and are able to fashion out their self-made instructional software packages, there will be proliferation of instructional software packages in the school system. There is need therefore, to have acceptable standard for quality expected of teacher-made educational software packages; and an instrument for determining such expected standard quality. This is a veritable way of ensuring sustainable supply of relevant software packages in the school system.

9. Suggestion for Further Studies

It should be interesting to investigate the effect of teacher-made educational software packages on students' motivation, interest and achievement in certain concepts.

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Appendix

Chemical Bonding Instructional Software Package Inventory (CBISPI)

Instruction: Please evaluate this **Chemical Bonding Instructional Software Package (CBISP)** using the criteria provided for it. Please rate each of the criteria, by ticking (√) in the column that fits your assessment.
Key: Excellent = 5, Good =4, Fair =3, Poor =2 , Very poor =1

PART A

No	**Criteria for evaluation of Chemical Bonding Instructional Software**	Excellent	Good	Fair	Poor	Very poor
1	Content information and grammar in Chemical Bonding Instructional Software Package (CBISP).					
2	Pedagogical approach in CBISP to content presentation for learning to take place.					
3	Ease of integration of CBISP into classroom use.					
4	User friendly of CBISP program.					
5	CBISP content support of the curriculum.					
6	Effectiveness of feedback message in CBISP.					
7	Motivational features of CBISP program.					
8	Ease of modification of CBISP program.					
9	User control of CBISP program with regard to the rate and sequence or presentation.					
10	Clarity of statement and meeting of the objectives in CBISP program.					
11	Comprehensiveness and ease to understand teacher documentation in CBISP.					
12	Effectiveness of use of colour, sound, graphic and animation in CBISP.					
13	Freedom of CBISP program from technical errors.					
14	Freedom of CBISP program from content bias.					

PART B

Expert No: --
Affiliation: --
Signature: --

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