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DEVELOPMENT OF TEACHING MODULE BASED ON 7E INQUIRY CONSTRUCTIVIST LEARNING CYCLE

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ABSTRACT

The main goal of the research was to develop an instructional module for teaching and learning of matter and its changes of states. Studies have continued to report shreds of findings on student's low achievement in basic science. The resulting poor student success was due to the lack of an effective teachers approach during the learning process. Based on these reported studies, the researchers decided to develop a teaching module around 7E learning cycle to improve teaching and learning of students. The study draws attention to the design principles which adopt Dick and Carey Instructional Design Model. In choosing the participants, the researchers used a purposeful sampling method. However, a checklist questionnaire is given to teachers in the field of basic science to determine the usefulness, acceptability, and suitability of the developed module. The module was validated by experts (n=10) with S-CVI of 0.81 and KR-21 of 0.72 reliability. Findings from the evaluation of the drafted module suggested that the module is useful, acceptable, and suitable for Basic science students learning process. Moreover, results from this study indicate that Dick and Carey Instructional Design Model is ideal in developing modules based on the 7E learning cycle in a junior secondary educational setting.

Keywords: Basic Science, Matter and its changes of state, Instructional System Design Model, 7E learning cycle

INTRODUCTION

The role of science in the development of a nation can never be emphasized. Modular teaching has been widely reported in the improved academic achievement of students. Ali, Ghazi, Khan, Hussain, and Faitma (2010) recommended that modular teaching approach should be commonly used at different stages of education in traditional classrooms. Similarly, affirm that the creation of the instructional module in this study will contribute to enhancing the awareness and practice of teachers in teaching and learning science through a game-based approach in Malaysia. Furthermore, Guido (2014) in his findings reported that instructional module in materials science and engineering are useful for students' knowledge adaptation and shows suitability to the level of the students and acceptability to the faculty evaluators. A module is defined as an individual, self-contained unit of a designed series of learning activities to help students achieve specific, well-defined goals(Guido, 2014).

The need to improve the teaching and learning of science to provide headway to some of the identified factors militating against the achievement of students in science (Osuolale, 2014) has necessitated the development of this teaching module. The Nigerian junior secondary science core curriculum is in "integrated form" based on the concept of broad-based curriculum design (NERDC, 2013). The curriculum stressed the inclusion of various science subjects that are important to the child's needs and experience in order to underscore the fundamental unity of science and to lay the necessary framework for more advanced science education studies (NERDC, 2013). According to Awofala and Sopekan (2013), the overall objectives of basic science and technology curriculum is structured to allow learners to (i). Developing an interest in science; (ii). Acquire fundamental experience and skills of science; (iii). Adapt scientific knowledge and skills to the needs of society; (iv). Take advantage of the many job opportunities provided by science; (v). Be prepared for further studies. The enumerated objectives, among other reasons, are to prepare upper basic students for further study of science at the senior secondary school and subsequently Universities and Polytechnics (Agbidye, 2015; Bimbola & Daniel, 2010). This is one justification why the curriculum material is sequenced spirally, starting with the easiest to the most complex theory (Sunday, 2012).

Basic science subjects are taught in an integrated form, including the topics of biology, chemistry and physics, to allow learners to gain more knowledge and improve scientific skills. It is

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pointless to argue that active student engagement in the learning science process is the key to information acquisition. Conversely, according to (Asikhia (2010); Omorogbe and Ewansiha (2013); Samuel (2017)) report that poor academic performance of students is as a result of inappropriate instructional strategy which leads to students rote learning.

Basic science teachers should be made to realize that active learning, particularly in the state of the matter, is not just a theoretical activity, but also more of hands and minds on student engagement in order to identify an appropriate solution to the real-life situation. It is important to note that teaching and learning should strike a

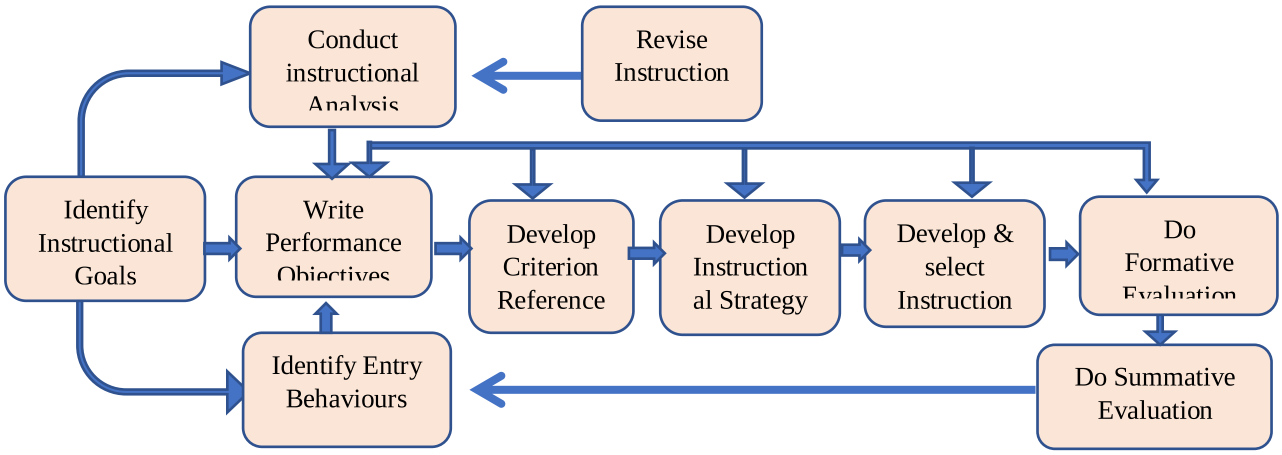

Figure 1. *Dick and Carey Model.* (Source Kurt (2015))

balance between the theoretical and practical aspect of the subject ((Adeleye, 2017; Wasagu, 2009). According to (Abdi, 2014; Augustinah & Bolajoko, 2014; Ekon, Ekwueme, & Meremikwu, 2014; Konicek-Moran & Keeley, 2015) teachers and teacher educators should centre teaching based on constructivists point of view. According to Telaumbanua and Surya (2017) module is an instructional learning series of activities well-coordinated that is relatively short and precise, with content arranged to achieve the learning objectives. In the 7IIM constructivist classroom, the teacher engages the students in a challenging task according to their ability and provide space for discussion. Through discussion, students had the opportunity to share their ideas with others, improve communication. At the same time, students could build their knowledge (Walker-Tileska, 2000).

INSTRUCTIONAL DESIGN MODELS

In developing the 7IIM, the researcher considered many Instructional system design model (ISDM). Although there are several versions of ISDM, among them is the ADDIE model, which is perhaps one of the most popular ISDM in business and organizational environments, while others are product-oriented like the Delphi technique (Akbulut, 2007) some are program-oriented while others are classroom oriented like the ASSURE model and Morrison and Kemp model, with the Dick and Carey model being the most popular model in schools and educational environments.

The Dick and Carey is chosen best on its applicability and acceptability as widely reported in the literature for decade (Hartman, 2017). Though the design model is not without any difficulties (Akbulut, 2007) several studies have reported its effectiveness and applicability in teaching and learning activities (Bose, 2012; Carlton, Kicklighter, Jonnalagadda, & Shoffner, 2000; Hartman, 2017; Perinpasingam & Balapumi, 2017; Singh, 2009). The design approach composed of ten components, as shown in figure 1.

Development 7E Inquiry Integrated Module

A great deal is required of the teacher at any level of education to accomplish sound instruction in the subject matter. Appropriate preparation and planning on how to make sure the success of the learning objectives is required; such instruction should involve the use of the Dick and Carey Models of the Procedural Approach to instructional design. 7E-Inquiry Integrated Module (7IIM) with seven phases of instructional events of "elicit", "engage", "explore", "elaborate", "explain", evaluate, and "extend" was designed following the Dick & Carey model. The resultant instructional material using the model meet not only the challenges of poor performance in science but also learner-centred, activity-oriented, problem-solving (Morrison, Ross, Morrison, & Kalman, 2019).

The Dick and Carey design model is reported to successfully be used in creating curriculum for several disciplines including science (Akbulut, 2007; Carlton et al., 2000; Hartman, 2017; Kurt, 2015; Oyelekan & Olorundare, 2009). Though the ASSURE and Morrison and Kemp model are classroom-oriented, the former is more of integration of technology in the learning environment and the latter is a non-linear arrangement (Akbulut, 2007; Onwuagboke, 2016) hence the adoption and use of the Dick and Carey model. According to Kurt (2015) the design model was developed as a guide to assist teachers in figuring out what to teach and how to teach it. All ten steps are connected, and some influence others directly or indirectly. Moreover, basic ISDM principles and steps common to all models were embedded in developing the instructional module.

The nine steps of the Dick and Carey Systems Approach Model Dick, Carey, and Carey (2001) used in this study will be broken down into individual steps and discussed. This description includes the identification and selection of participants, the procedure for data collection and the process for formative evaluations.

Instructional Analysis Phase

This phase was to determine the overall instructional goal of the target recipients. The analysis phase provides what need to be taught and the appropriate approach required (Gagne, Wager, Golas, Keller, & Russell, 2005). For objectives of the lesson to be achieved, there is a need to find what individuals need to learn, and this involves making decisions and selection of required knowledge and skills appropriate to solve a given learning problem. According to Morrison et al. (2019), creating an instructional material that is not within the performance problem of individuals is likely to not going to yield an improvement in learners' performance. For the basic science textbooks, the context, descriptions of concepts, diagrams, sequencing the sub-themes and students exercise for evaluation were considered. On the part of the teacher's lesson note and lesson plans, complexity with the syllabus and curriculum were checked. Several gaps were observed between what the students need to learn and what is being taught, most especially in the state of matter unit. For instance, teachers do not include hands-on activities in the lesson plans. The lesson plans lack detail and activities that allow the students to explore the transformation of states of matter.

The analysis of the textbook also revealed that the text material lacks details of contents. The textbook used lengthy words to explain the concepts. This, in turn, makes it difficult for low reasoners who required additional support to learn abstract concepts. The textbooks also make students bored. Analysis of the curriculum indicated that teachers should embed practical activities to connect the mind and skills of the students. Unfortunately, examining the lesson plans of the teachers revealed otherwise. These and many findings led to the realization of the instructional goal. According to Jamel, Ali, and Ahmad (2019), results from the need analysis help in designing and evaluating the quality of the instruction module. At this stage, the possible cause of the achievement gap and the recommendations of teachers for improvement are points to be considered in the design and production of the instructional module. The goals are stated base on verbal, intellectual and skills. The researcher also requested for the experts view to determine what instructional goals should be included in the 7E-IIM, based on the expert's feedback, instructional materials suitable to achieve the overall goal of the learners are developed.

Analysis of Learner and Context Phase

To ensure the instructional materials are within the individual level (Morrison et al., 2019). The researchers first identify the target audience. The present study learners were the form two Basic science students, and the context of the learning was State of matter. In every instructional design, the learner should be the centre of all instruction and learning (Gagne et al., 2005), the general characteristics of the basic science students were analyzed stating their number in the class, average age, gender etc. Considered was also their entering behaviour or relevant previous knowledge as regards the content of each lesson which was required for the basic science students to benefit from the new lessons. The basis of the analysis of the learners entering behaviour is supported by Vygotsky's theory which requires learning tasks to be above the learners' previous knowledge and within their ZPD (Schnotz & Kürschner, 2007). The learning styles of basic science students were also considered in line with Kolb (1984) and Piaget 1962 as different individual learners have their learning preferences.

Learning Objectives Phase

Instructional objectives help in identifying and solving the performance problems of the learner (Morrison et al., 2019). The learning goals were then formulated and specified by deciding what learners should be able to achieve after going through the 7IIM, having evaluated and made provisions for the general characteristics of the learners. As the State of Matter is a subject that requires theory and hands-on activities, the objective was stated considering component of learning objectives (condition, behavior and criteria) and the statement of the instructional objectives was done with serious efforts to make sure all the three learning domains namely affective, cognitive and psychomotor are covered. How the researcher composes the learning objectives have been limited; however, the learning objectives for this study has well stated, according to Dick and Carey Model. It's important to say that, experts were requested to give their assessment and based on the expert's feedback, the researcher made the appropriate adjustment on the statement of the objective.

Assessment of Instrument Phase

To assess the validity of the drafted instructional material. Only one instrument was developed for the present study, the teacher's questionnaire. The questionnaire was developed to seek teacher's opinions on the suitability and acceptability of the developed module. However, assessing the learner on the effectiveness of the module is a limitation to this present study, as rightly stated in the limitation section.

Instructional Strategy Phase

The next phase in the design process using Dick & Carey model entails selecting instructional method/strategy and media/materials. According to Morrison et al. (2019) Style of instruction that has failed to adapt accurate and relevant knowledge to learners may lead to an inefficient learning process, so they recommend choosing an appropriate teaching approach as the content and goals remain necessary for an effective and efficient learning process. To ensure that the information on the curriculum is well communicated to the learners, the 7E learning cycle has been adapted as an innovative way to help learners incorporate new information into the current one. Instructional approaches may differ depending on whether the researchers choose to use a face-to-face or online approach to instruction delivery. The 7IIM was designed to take a face to face approach. The researchers employed the constructivists' approach of learning because it has been widely demonstrated in the literature (Balta & Sarac, 2016; Blyth, 2010; Lamanna, 2010; Naade, Alamina, & Okwelle, 2018; Qarareh, 2012).

Developing and selecting Instructional Material Phase

The present study employed the use of models, worksheets, Ice blocks, Cardboard, water, ether, alcohol, writing materials, air, clay, colour, sand, syringes, beaker, microwaves, balloons, football substances of solid, liquid and gas and clay.

Development Phase

After appropriate adjustment from the teacher's feedback, the first draft of the module was presented to Professors in science education (n=2), content clarity, content difficulty, spelling errors and ethical suggestion were made. Final revised of the instructional module was done and subsequently the final draft.

Formative evaluation Phase

Assessment of the module is a useful activity as it helps the researcher to decide the

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strength of the instructional approach adapted and the instructional material used. Emphasis was placed on the question at the evaluation phase, which prompted the readjustment of the module. Significant variables are the suitability, applicability and usefulness of the content, objectives and also if the teaching strategy used was suitable, etc. These questions often helped improve the module, consequently, increases the chances of attaining the expected learning performance. Basic science teachers (n=10) are presented the module before the final development of the 7IIM. Based on teachers feedback, the necessary adjustment was made to suit the purpose of this study. The resultant teaching module is learner-centred, hands and mind on activity-oriented and science process skills-wise. As earlier stated, the steps are often only connected as far as what they do to support teachers/students to figure out what to teach/learn and how to teach/learn. All the stages are connected, while some influence others indirectly; others influence others directly (Kurt, 2015; Morrison et al., 2019).

OBJECTIVE

The main objective of this study is to obtain a suitable module applicable for Basic science students learning States of Matter.

METHODOLOGY

The present study is designed to include 8 phases of analyses, according to Dick and Carey Permission was granted to the authors to carry out the study by the Kebbi State Universal Basic Education, Nigeria. The module was validated by Basic Science Teachers (n=10) in different secondary schools. The teachers were selected using purposive sampling technique and were based on ten years and above teacher work experience, qualification, and area of specialization (See Table 1). A checklist questionnaire is presented to teachers who are experts in the field of Basic Science for content validity on the draft 7E Inquiry Integrated Module (7IIM) to determine the usefulness, suitability and acceptability of the developed module on the scale of 1 to 4. The ranking of items was based on one suggested by Davis (1992) in Polit and Beck (2006) (1=Not relevant, 2=Less relevant, 3=quite relevant, and 4=Highly relevant).

Table 1: Teachers Bio Data

Participant	Level of education	Area of Specialization	Teaching experience
P1	NCE	Biology/chemistry	21
P2	BSc	chemistry	10
P3	BSc/Edu	Physics	12
P4	BSc/Edu	Chemistry	11
P5	BSc/Edu	Biology	14
P6	BSc/Edu	Chemistry	10
P7	BSc	Physics	18
P8	NCE	Chemistry/physics	15
P9	BSc/Edu	Biology	10
P10	NCE	Physics/mathematics	10

*BSc: Bachelor of science. *BSc/Edu: Bachelor of science/Education. * NCE: National Certificate of Education

Module Validation

The drafted instructional material was presented to experts in the field of Basic science, educational research, and science education. The instrument used standardized Module Evaluation Checklist to assess the content, objective, language and assessment, and the acquired skills in the module Based on their observations and suggestions, necessary correction was made in the final draft version of the module. The Content Validation index was used to measure the validity of the module. This validation is useful to ascertain whether the module is suitable, useful, and appropriate to the target learners. A four-point scale (1-4) was adopted as recommended by Lynn (1986) as cited in Polit and Beck (2006). According to Polit and Beck (2006), 0.78 upwards and 0.80 upwards is an acceptable index for Individual Content validation index (I-CVI) and Scale

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Content Validation Index (S-CVI) respectively. It is good to state that if the validation failed based on expert analysis, the validation would be repeated until the accepted level is met. In the present study, all the I-CVI are more significant than 0.78, except for item number 15 and 16, which has I-CVI of 0.60 and 0.70, respectively (see Table 2). On the other hand, the S-CVI of this study is 0.81 which is within the accepted validity index (see Table 2)

Table 2: Ratings 20-Items on the module Scale by Ten Experts

Item	Exp1	Exp2	Exp3	Exp4	Exp5	Exp6	Exp7	Exp8	Exp9	Exp10	A/N	CVI
1	√	X	√	√	X	√	√	√	√	√	8	.80
2	√	√	√	√	√	X	√	X	√	√	8	.80
3	√	√	√	X	√	√	√	√	X	√	8	.80
4	√	√	X	√	√	√	√	√	√	X	8	.80
5	X	√	√	√	√	√	√	√	√	√	9	.90
6	√	√	X	√	X	√	√	√	√	√	8	.80
7	√	√	√	√	√	√	√	X	X	√	8	.80
8	√	√	√	√	√	√	√	√	√	X	9	.90
9	X	√	√	√	√	X	√	√	√	√	8	.80
10	√	√	√	X	√	√	X	√	√	√	8	.80
11	√	X	√	√	X	√	√	√	√	√	8	.80
12	√	√	√	√	√	X	√	√	√	√	9	.90
13	√	√	√	√	√	√	√	X	√	X	8	.80
14	X	√	√	√	√	√	√	√	X	√	8	.80
15	√	√	X	X	√	√	√	√	√	√	8	.80
16	√	X	√	√	X	√	√	√	X	√	7	.70
17	X	√	X	X	√	√	√	√	√	X	6	.60
18	√	X	√	√	√	√	√	√	√	X	8	.80
19	√	√	√	√	√	X	√	√	√	√	9	.90
20	√	√	√	√	√	√	√	√	√	√	9	.90
Mean I-CVI	.80	.80	.85	.85	.80	.80	.90	.80	.80	.80	S-CVI=	.81

*Exp=Expert. *A/N= Number in Agreeable.
*Individual Content validation index (I-CVI) and Scale Content Validation Index (S-CVI).

Reliability of the Instrument

A 20-item questionnaire was presented to basic science teachers (n=10) for their expertise to validate the module. To obtain and increase the internal consistency of a research instrument, responses obtained from the Basic science teachers were subjected to a statistical analysis using the Kuder-Richardson (KR-21) and a coefficient KR=.72 was realized. According to George and Mallery (2016), .70 is acceptable reliability. According to Ghenghesh (2010), reliability coefficients ranged from .57 to .88 with a mean coefficient of .72, the more items a category contains, the higher the reliability estimate. Looking at the shortness of the scales in this present study, it is assumed that most of these estimates are acceptably high.

RESULT

Level of Acceptability and suitability of the Developed Module in learning State of Matter as Evaluated by the Basic science teachers concerning Content, Objective, Language and Assessment as presented in Table 3.

Table 3. Teachers Mean Scores

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Teacher	Content	Objective	Language	Assessment
1	3.2	3.2	3.2	3.4
2	3.4	3.4	3.4	3.4
3	3.2	3.4	3.2	3.6
4	3.2	3.6	3.2	3.6
5	3.6	3.2	3.6	3.2
6	3.2	3.2	3.4	3.2
7	3.8	3.2	3.8	3.2
8	3.2	3.6	3.4	3.4
9	3.4	3.4	3.4	3.4
10	3.6	3.2	3.6	3.2
Composite Mean	**3.74**	**3.88**	**3.78**	**3.72**

Table 3 has shown that for the teachers, the contents of the module are acceptable as evidenced by a composite mean of 3.74. The content is adaptive to the culture of the learner, the content suits the learning skills of the 7E Inquiry Integrated Module, the subjects are essential to the daily work of the learner, and the themes are basic and straightforward to comprehend. This means that they are agreeable on the contents of the module; thus the instructional materials are indeed basic and suitable to the level of learners and at the same time relevant to their day to day activities. However, the objectives are within the ability to achieve, and the goals are clear and well stated according to the content of the module. The teachers have indicated the acceptability of the module, as evidenced by a composite mean of 3.88.

The teachers believe that the module adheres to the requirements with respect to language as proven by the items. This means the language used in the 7IIM is suitable and acceptable at a composite mean of 3.78. The result implies that the researcher employs simple and clear words which easily appeal to the learners understanding. Moreover, the language of the module considers the values of the learners. Care has been taken in the usage of the language, in particular, the terms used by the researcher in the development of the module. The mean scored has shown that "Evaluation matched the content of the topic," at 3.72. This has indicated that teachers agree on the type of questions that lead the learner to think critically and creatively. Assessments measure the knowledge and skills acquired in every lesson.

FINDINGS

Overall findings revealed that the module is useful, appropriate, accepted, and suitable for Basic science students learning States of Matter. This study is related to the finding of (Ali et al., 2010; Alias & Siraj, 2012; Matanluk, Mohammad, Kiflee, & Imbug, 2013; Nor, 2014; Tobias & Duffy, 2009) who in their findings attributed that the instructions prepared as a module are found to be suitable on students learning process.

DISCUSSION

According to Ali et al. (2010), Modular teaching is an innovative learning tool in classroom settings, and a lot of attention is now being paid to it. The creation of a self-learning package to contend with a specific subject or unit is a learning module. There are numerous theories and methods to demonstrate modular teaching in our learning activities. The primary goal behind the creation of modules in the teaching and learning phase of basic science was to help both the teacher and the student solve problems in and outside the classroom. It is expected that using 7IIM for students learning in the classroom help improve their performances. This is based on the results reported by (Ali et al., 2010; Alias & Siraj, 2012; Matanluk et al., 2013; Nor, 2014) who indicate the need for instructors to adapt the use of the module because of its usefulness in the learning process in their different research report studies. The process involved in designing the module, however, is related to the work of Carlton et al. (2000).

LIMITATION

Although the module has been validated to be useful, suitable and appropriate for the learning process of basic science students, Morrison et al. (2019) believe that there is no single best way to design instructional material. However, the question of whether the module is effective in improving the academic achievement of students, remain unanswered, which is a limitation to the present study. Therefore, it is recommended that empirical research should be conducted to determine the effectiveness of the module in enhancing basic science student's performance.

CONCLUSION

Overall, the study suggests that Dick and Carey Instructional Design Model, which pays more attention to instruction from the learner perspective than from content perspective is suitable in designing and developing Basic science module based on 7IIM. However, a more robust study involving a population greater than the present study should be conducted to determine the effectiveness of the module in improving student's performance.

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