Designing an Artificial Intelligent Tutoring System in Assessment for Learning

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Abstract
The study presented the step by step of designing artificial intelligent tutoring system in assessment for learning. This is a practical approach in explaining the methodology required for making computer to teach a student without the presence of a teacher. A teacher would have done his/her homework in designing the system. This system is useful for the assessment for learning. Assessment for learning or formative assessment involves a continuous way of checks and balances in the teaching learning processes. The five steps involved in the designing of the system are: selection of test items; provision of corrective mechanism; development of ITS architecture; deployment of the ITS for students; and development of users' manual. Teachers are encouraged to form their lesson around ITS. Formative assessment or assessment for learning is enhanced through the use of ITS. It is therefore recommended that teachers should develop ITS for use during assessment for learning in all subjects.

Introduction
Improving students' learning outcomes (cognitive, affective and psychomotor) in sciences and mathematics have been the main focus of many researchers. Such researchers have worked on different teaching methods like peer tutoring (Ogundipe, 2004, Adewale, 2010), brainstorming (Adewale, 2009 and Oyeniyi & Adewale, 2015), brain-based instruction (Awolola & Adewale, 2010 and Adewale & Awolola 2010), peer and self-assessment (Adewale & Oyenekan, 2013), formative testing (Adewale & Anjorin, 2010). This is because science and mathematics are very important subjects for national development as they form strong framework for STEM i.e. Science, Technology, Engineering and Mathematics.

Although, the use of STEM concepts has been implemented historically in many aspects of the business world like in the Industrial Revolution through the work of Thomas Edison and other inventors, it has not been utilized in traditional educational settings. The use of STEM was primarily used in engineering firms to produce revolutionary technologies such as the light bulb, automobiles, tools and machines, etc. Many of the people responsible for these innovations were only slightly educated and/or were in some type of apprenticeship. For example, Thomas Edison did not attend college (Beals, 2012), nor did Henry Ford; although Ford did work for Thomas Edison for a number of years. These "giants" of innovation used STEM principles to produce some of the most prolific technologies in history: however, STEM in education was virtually non-existent (Butz, Kelly, Adamson, Bloom, Fossum, & Gross, 2004). It is assumed that if the students are knowledgeable in Physics which is a compulsory subject for those who will be interested in

STEM, their aspiration will be achieved. Methods used by previous researchers have not achieved the set objective of making students higher achievers in Physics. It is postulated that assessment for learning through Artificial Intelligent Tutoring System (AITS) has potential to improve students' achievement in Physics, therefore, this study explore the design of an AITS. Before we discuss AITS, it is important to examine assessment for learning.

Assessment for learning or formative assessment involves a continuous way of checks and balances in the teaching learning processes (Jeri, 2018). The method allows teachers to check their learners' progress as well as the effectiveness of their own practice, thus allowing for self-assessment of the students. Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited (*Black, & Wiliam, 2009)*.

Michael Scriven coined the terms formative and summative evaluation in 1967, and emphasized their differences both in terms of the goals of the information they seek and how the information is used (*Scriven, 1967)*. For Scriven, formative evaluation gathered information to assess the effectiveness of a curriculum and guide school system choices as to which curriculum to adopt and how to improve it. Benjamin Bloom took up the term in 1968 in the book *Learning for Mastery* to consider formative assessment as a tool for improving the teaching-learning process for students (*Bloom, 1968)*. His subsequent 1971 book *Handbook of Formative and Summative Evaluation*, written with Thomas Hasting and George Madaus, showed how formative assessments could be linked to instructional units in a variety of content areas. It is this approach that reflects the generally accepted meaning of the term today (*Black, Paul; Wiliam, Dylan (2003)*. Black and Wiliam (2009) proposed that practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited (*Black, & Wiliam, 2009)*.

Formative assessment serves several purposes: to provide feedback for teachers to modify subsequent learning activities and experiences; to identify and remediate group or individual deficiencies; to move focus away from achieving grades and onto learning processes, in order to increase self-efficacy (*Huhta, 2010)* and reduce the negative impact of extrinsic motivation; to improve students' meta-cognitive awareness of how they learn (*Shepard, 2005)* and "frequent, ongoing assessment allows both for fine-tuning of instruction and student focus on progress" (*Cauley and McMillan, 2010)*.

The following are some features of formative assessment according to Harlen and James (1997), formative assessment is essentially positive in intent, in that it is directed towards promoting learning; it is therefore part of teaching; it takes into account the progress of each individual, the effort put in and other aspects of learning which may be unspecified in the curriculum; in other words, it is not purely criterion-referenced. Formative assessment

requires that students have a central role to play; students have to be active in their own learning (teachers cannot learn for them) and unless they come to understand their strengths and weaknesses, and how they might deal with them, they will not make progress (*Harlen and James, 1997).*

It should be noted that feedback is the central function of formative assessment. It typically involves a focus on the detailed content of what is being learnt (*Huhta, 2010)* rather than simply a test score or other measurement of how far a student is falling short of the expected standard *Nicol and Macfarlane-Dick, 2005).* This explains why intelligent tutor is proposed in this study.

An **intelligent tutoring system** (**ITS**) is a computer system that provides immediate and customized instruction or feedback to learners usually without requiring intervention from a human teacher. Although, a human teacher may instructs the students on how to navigate with ITS. ITSs have the common goal of enabling learning in a meaningful and effective manner by using a variety of computing technologies. There are many examples of ITSs being used in both formal education and professional settings in which they have demonstrated their capabilities and limitations. There is a close relationship between intelligent tutoring, cognitive learning theories and design. An ITS typically aims to replicate the demonstrated benefits of one-to-one, personalized tutoring, in contexts where students would otherwise have access to one-to-many instruction from a single teacher (e.g., classroom lectures), or no teacher at all (e.g., online homework).

There were three ITS projects that functioned based on conversational dialogue: AutoTutor, Atlas and Why2 Graesser, VanLehn, the TRG and the NLT, 2003). The idea behind these projects was that since students learn best by constructing knowledge themselves, the programs would begin with leading questions for the students and would give out answers as a last resort. AutoTutor's students focused on answering questions about computer technology, Atlas's students focused on solving quantitative problems, and Why2's students focused on explaining physical systems qualitatively (Graesser, VanLehn, the TRG and the NLT, 2002). Other similar tutoring systems such as Andes (Gertner, Conati, and VanLehn, 1998) tend to provide hints and immediate feedback for students when they have trouble answering the questions. They could guess their answers and have correct answers without deep understanding of the concepts. Research was done with a small group of students using Atlas and Andes respectively. The results showed that students using Atlas made significant improvements compared with students who used Andes (Shelby, Schulze, Treacy, Wintersgill, VanLehn and Weinstein, 2001). However, since the above systems require analysis of students' dialogues, improvement is yet to be made so that more complicated dialogues can be managed.

Irrespective of the projects of Intelligent tutoring systems (ITSs), they consist of four basic components based on a general consensus amongst researchers (Nwana,1990; Freedman, 2000; and Nkambou, R., Mizoguchi, R., & Bourdeau, 2010):

1. The Domain model
2. The Student model
3. The Tutoring model, and

4. The User interface model

The *domain model* (also known as the cognitive model or expert knowledge model) is built on a theory of learning, such as the ACT-R theory which tries to take into account all the possible steps required to solve a problem. More specifically, this model "contains the concepts, rules, and problem-solving strategies of the domain to be learned. It can fulfill several roles: as a source of expert knowledge, a standard for evaluating the student's performance or for detecting errors, etc." (Nkambou et al., 2010). Another approach for developing domain models is based on Stellan Ohlsson's Theory of Learning from performance errors, Ohlsson, (1996) known as constraint-based modelling (CBM). In this case, the domain model is presented as a set of constraints on correct solutions (Ohlsson, & Mitrovic, 2007).

The *student model* can be thought of as an overlay on the domain model. It is considered as the core component of an ITS paying special attention to student's cognitive and affective states and their evolution as the learning process advances. As the student works step-by-step through their problem solving process, an ITS engages in a process called *model tracing*. Anytime the student model deviates from the domain model, the system identifies, or *flags*, that an error has occurred. On the other hand, in constraint-based tutors the student model is represented as an overlay on the constraint set (Ohlsson, & Mitrovic, 1999). Constraint-based tutors (Mitrovic, 2010) evaluate the student's solution against the constraint set, and identify satisfied and violated constraints. If there are any violated constraints, the student's solution is incorrect, and the ITS provides feedback on those constraints (Mitrovic, Martin & Suraweera, 2007). Constraint-based tutors provide negative feedback (i.e. feedback on errors) and also positive feedback (Mitrovic, Ohlsson, & Barrow, 2013).

The *tutor model* accepts information from the domain and student models and makes choices about tutoring strategies and actions. At any point in the problem-solving process the learner may request guidance on what to do next, relative to their current location in the model. In addition, the system recognizes when the learner has deviated from the production rules of the model and provides timely feedback for the learner, resulting in a shorter period of time to reach proficiency with the targeted skills (Anderson, & Koedinger, 1997). The tutor model may contain several hundred production rules that can be said to exist in one of two states, *learned* or *unlearned*. Every time a student successfully applies a rule to a problem, the system updates a probability estimate that the student has learned the rule. The system continues to drill students on exercises that require effective application of a rule until the probability that the rule has been learned reaches at least 95% probability (Corbett & Anderson, 2008).

Knowledge tracing tracks the learner's progress from problem to problem and builds a profile of strengths and weaknesses relative to the production rules. The cognitive tutoring system developed by John Anderson at Carnegie Mellon University presents information from knowledge tracing as a *skillometer*, a visual graph of the learner's success in each of the monitored skills related to solving algebra problems. When a learner requests a hint, or

an error is flagged, the knowledge tracing data and the skillometer are updated in real-time (Anderson, 1986).

The *user interface* component "integrates three types of information that are needed in carrying out a dialogue: knowledge about patterns of interpretation (to understand a speaker) and action (to generate utterances) within dialogues; domain knowledge needed for communicating content; and knowledge needed for communicating intent" (Padayachee, 2002).

The Design

The steps employed in the design of the intelligent tutor in this paper are presented as follows:

    i.   Selection of test items
    ii.   Provision of corrective mechanism
    iii.   Development of ITS architecture
    iv.   Deployment of the ITS for students
    v.   Development of users' manual

Step 1: Selection of Formative Test Items

Test generally can be divided into two: subjective (essay) and objective. For the purpose of this paper, objective test will be considered. There are four different types of objective test:

    i.   Complete the sentence or fill in the gap or supply the answer test

A question is given and we expect the candidate to supply the answer in a word or short phrase like example 3. It can also be to fill in the gap to complete the sentence like examples 1 and 2. **Examples:**

    1. The class rep. for M.Ed 2013/2014 session is _____
    2. Matter is made up of _____ and non-living things.
    3. In which of the six geo-political zones is Oyo State located?

Note that dash should not start the question.

    ii.   Dichotomous or binary choice
        a. True/False ,
        b. Yes/No,
        c. Agree/Disagree,
        d. Right/Wrong,
        e. Correct/Incorrect

Note: when you are using Yes/No, your question should not be negative. E.g. Ibadan is **NOT** the capital of Lagos State. Many people know the answer that Ibadan is not the capital of Lagos State, yet their answer would be YES (use of English could have been a problem). Since the test is not on the use of English, then we advise test constructor to use positive statements for yes/or no items.

iii. **Matching Type:**

In matching, the number of options must be more than questions and it must be one to one matching. E.g.

Table 1: Example of Matching Questions

State	Capital
Lagos	Ibadan
	Jalingo
Ekiti	Ikeja
	Ado-Ekiti
Taraba	Sokoto
	Lafia

The usual practice was to have three questions and three answers and asked students to match. A student may know two and the third one will be a give-away. We recommend that the list of the answers should double the list of the question like the example in Table 1.

iv. **Multiple Choice Type**

- The respondents are free to select any of the options he/she thinks is correct
- Usually there are at least 3 options before we call a test multiple choice.
- There are two features:
  - stem and
  - option

The stem is the question that is posed or it is an introductory part of the item. The stem is the introductory statement which poses the problem. The stem may take the form of a question. For example, what is the S.I unit of force? It may take the form of an incomplete statement. For example, the S.I. unit of force is _____.

The options are those alternatives given to the examinee from which answer is selected from.

Good **item options** must have a key otherwise known as answer / correct option or response and Distracters, also known as incorrect responses. These are the alternatives from which candidates select what they think is correct. We encourage the 4 options A to D instead of 5 options A to E. Although, guessing is higher using the 4 options (25%) but 5 options is 20%. However, the 5% difference is not significant and the last option may be difficult to construct, that explains why many test developers resort to using "None of the above" and "All of the above." One of the options is the key (correct answer). The remaining 3 options are distracters. The options should be constructed in such a way that students who do not know the answer will find it difficult to guess

Example:

Who is the first president in Nigeria?

A. Aguyi Ironsi
B. Nnamdi Azikwe

     C.   Ibrahim Babangida

     D.   Olusegun Obasanjo

Note

- The introductory part is the stem
- A, B,C and D are the options
- B is the key while A, C and D are the distracters

In formative testing, there are four important steps to obtaining good test items:

a. Define the objective
b. Outline the content
c. Develop a table of specification
d. Generate the items

Define the Objective

In specifying the learning outcomes, we make reference to the curriculum. Most curricula have the following features:

❖ Topic
❖ Performance objectives
❖ Content
❖ Teacher's activities
❖ Student's Activities
❖ Instructional Materials
❖ Evaluation guide

The reason for specifying instructional objectives is to point out specific learning outcome which are regarded as indicator to gauge whether the instructional objectives have been achieved or not and it also state the behaviour to be measure at the end of the lesson. Instructional objectives are measured via: Performance objectives and Behavioural objectives. An achievement test is design to measure a change in behaviour and such behaviour should be relevant and representative. To be representative we need curriculum.

     The most common used scheme for stating the objective is

❖ Knowledge
❖ Comprehension
❖ Application
❖ Analysis
❖ Synthesis ⎱
          ⎰——These have been swapped now
❖ Evaluation ⎰

Knowledge: Ability to remember or recall the previous learned materials, it is the lowest form of cognitive. For example, what is an atom? The verbs that describe the knowledge are; list, itemize, define, enumerate, mention, highlight, label etc.

Comprehension: it is the ability to understand the meaning of the material from one form to another. The indicator verbs are; Explain, Summarize, give example, illustrate the concept, discuss, demonstrate, distinguish etc. For example; Explain the formation of soil?

Application: ability to adapt learnt materials in a new and concrete situation. E.g. calculate, solve, apply etc.

Analysis: Ability to breakdown materials into component part so that it organizational structure could be understood e.g. Pass-over (pass and over)

Evaluation: Ability to judge the value of a material for a given purpose. The question that demand for student s' opinion or experience e.g justify, evaluate etc.

Synthesis: Ability to put part together to form a new whole. The indicator verbs are construct, build, generate etc.

To get the appropriate objectives, Figure 1 can be used:
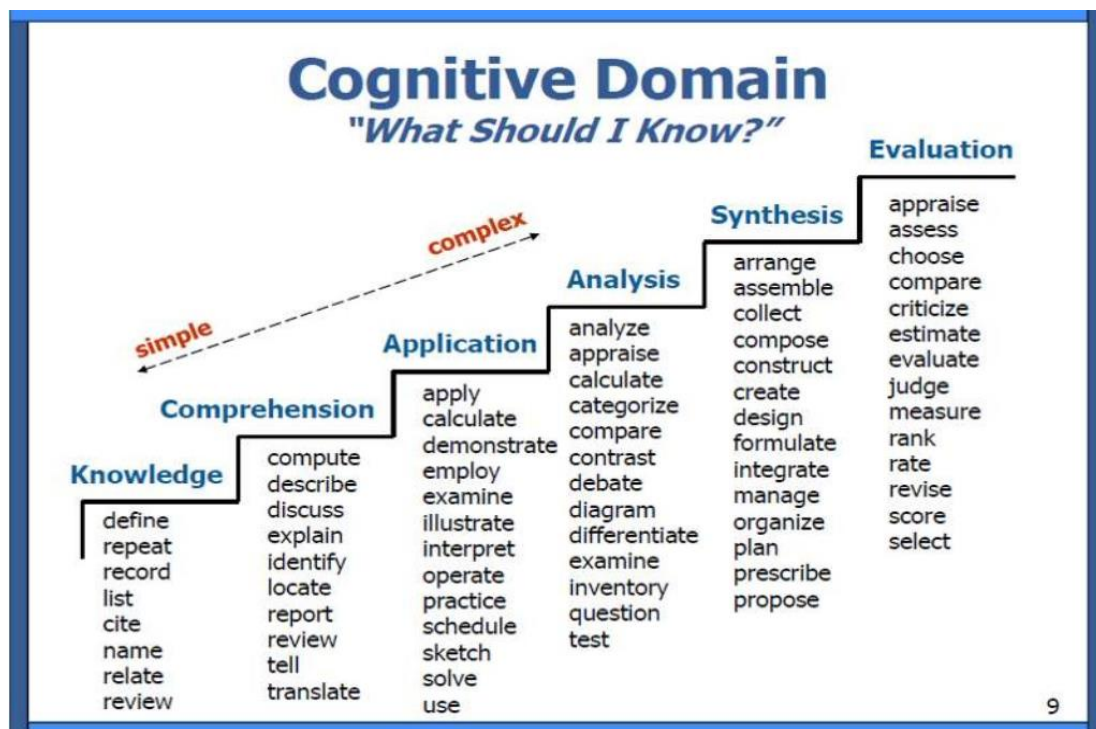
Figure 1 – Verbs for each of the level of Taxonomy of educational objectives

Step 2: Provision of Corrective Mechanism

One of the objectives of a formative test is to provide feedback and remediation mechanisms for the students so that they will be able to identify where they have made mistake and correct themselves. After the test items have been generated, there is going to be a scheme that will explain to the students why they got an item right or wrong. A hyperlink will be created in MS PowerPoint to lead students to the feedback in terms of if the students got an

item right or wrong. Another feature of this ITS is that reinforcement and remediation are provided. If a student is correct, ITS will inform him/her why he or she is correct to reinforce his/her knowledge on the concept. In the same manner, if a student is wrong, ITS will inform the student why he/she is wrong and indicate the correct option and the reason why the correct option is the right one.

Step 3: Development of ITS Architecture
This can be done in 10 Strides:
Stride 1: Launch PowerPoint like this

Fig. 1 How to open a PowerPoint slide
Then you have something like Fig. 2
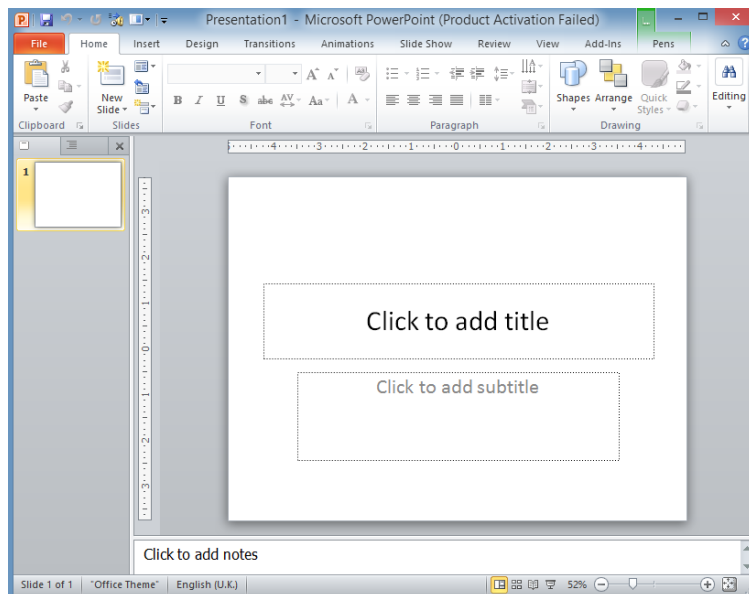
Fig. 2 PowerPoint interface
Stride 2: Create a master slide: This allows us have the same background and initial information
- Click on view
- Click on slide Master
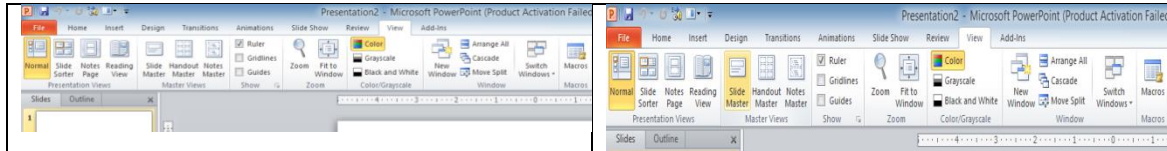
Fig. 3 Creating a Master Slide
Insert Slide Master
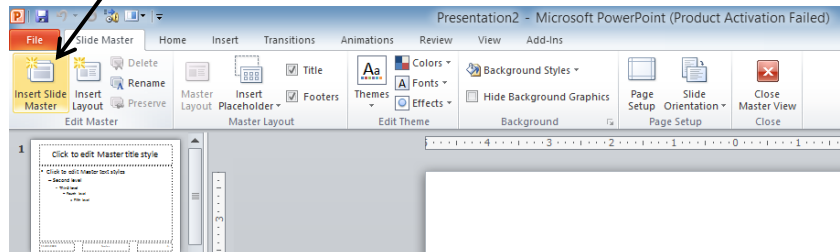
Figure 4 Inserting slide master

Stride 3: Formatting the Background

Once you click on the Slide Master, some slide slaves will also open. You may delete some of the slaves until you have only one that cannot be deleted. In order to design the slide master, click on Background Style to select colour for the background
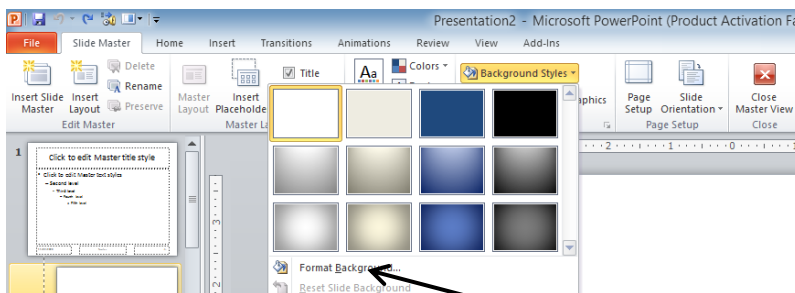

Figure 5a Formatting the Background

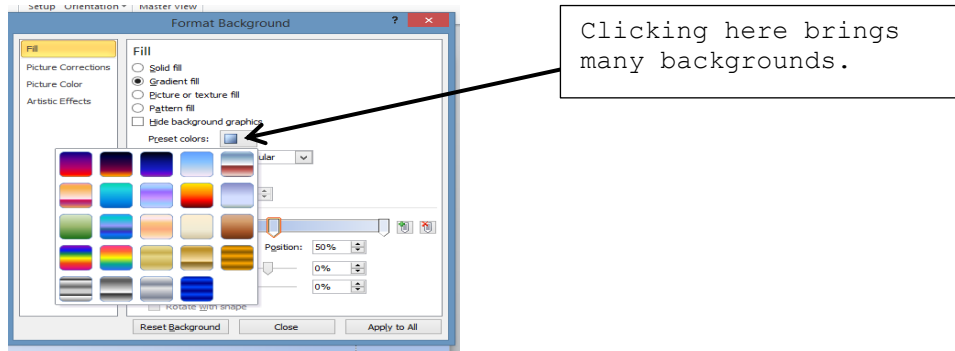You may decide to format the background further, then, click here

Figure 5b Formatting the Background

For more background, you can click on type, the following type will appear, linear, radial, rectangular, path and shade from title. For this background, rectangular was selected. Then, click on Apply to All, thereafter, close. This gives us
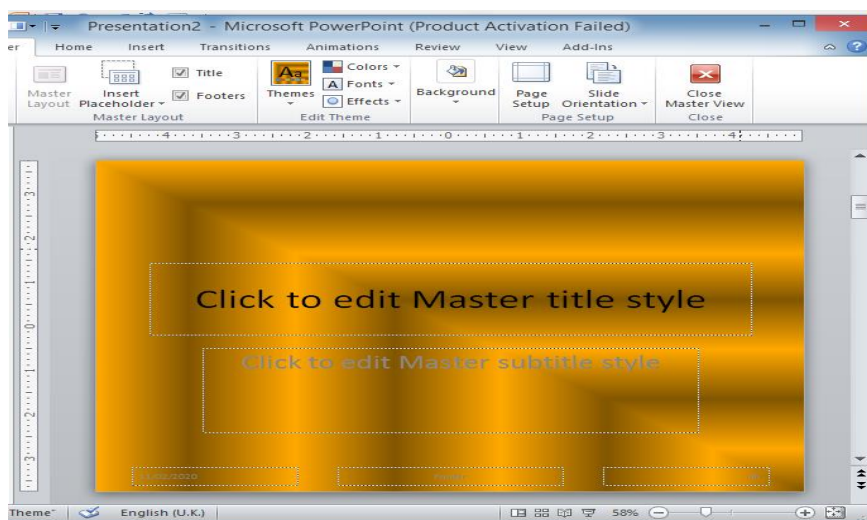

Figure 6 Formatted Background

Stride 4: More designs on the slide master

Design the master slide e.g. colour, logo, name, date and other designs. As you are designing the slide Master, the slide slave also is being designed like what we have in Figure 5
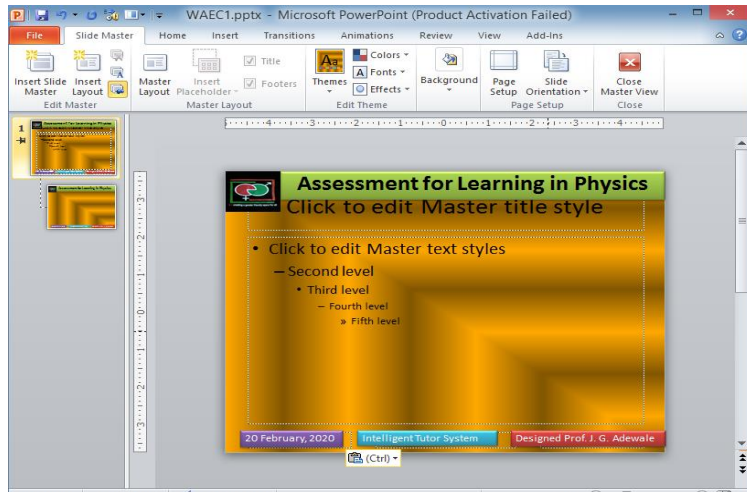
Figure 7: Slide Master and Slide Slave

When you are satisfied with the design of the Slide Master, then you save the two slides, that is, the Slide Master and the Slide Slave and thereafter you close the window (the file). Instead of closing the window or the file, you may decide to close Master view as shown in Figure 8
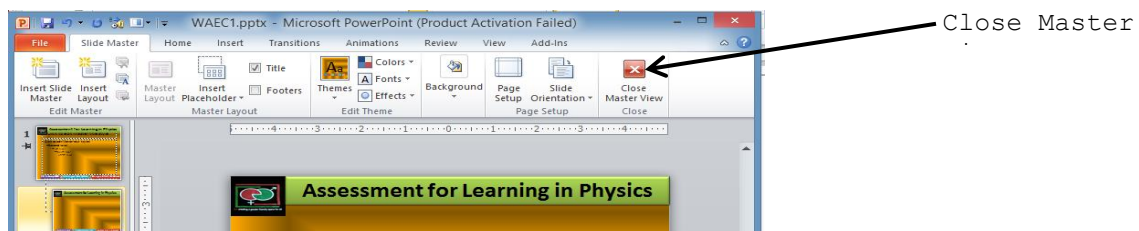

Figure 8: Closing the Master view

Either you open the saved file or you close the Master View, it is only the Slide Slave that will appear like Figure 9. When this happen, you can then duplicate to the number of slides you want.
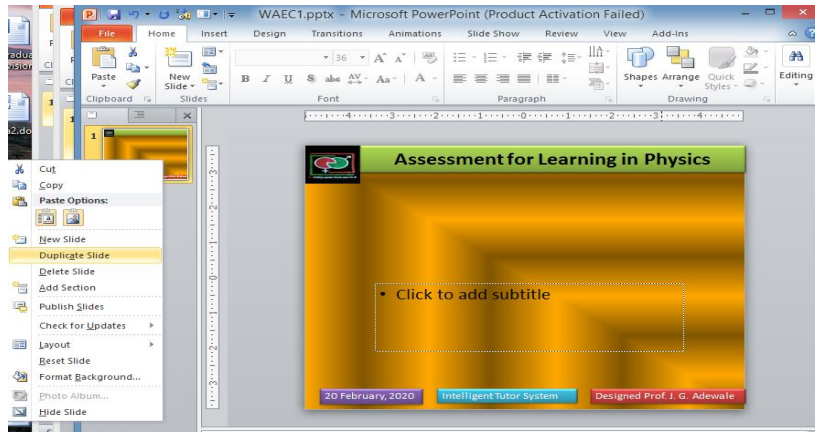
Figure 9: Duplicating Slide Slave

Whatever you type on the Slide Master cannot be edited after closing it. If you want to edit, you have to open the same Slide Master. Once the Slide Slave is made and duplicated, you cannot edit the content again. The number of Slide Slave you need to create is a function of the number of test items you want to publish.

The next stage is to lay out the formative test items. For the purpose of this paper only one item will be used.
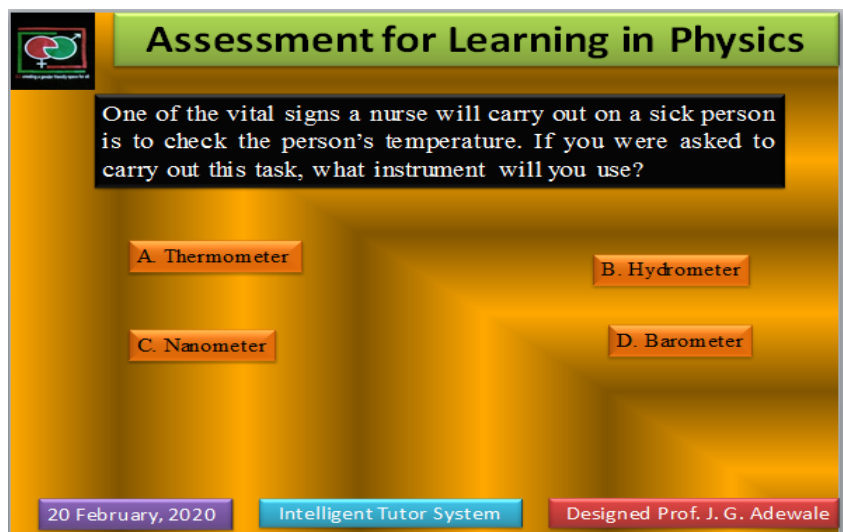
Stride 6: Laying Out the Formative test items

Figure 10: Laying out the formative test items

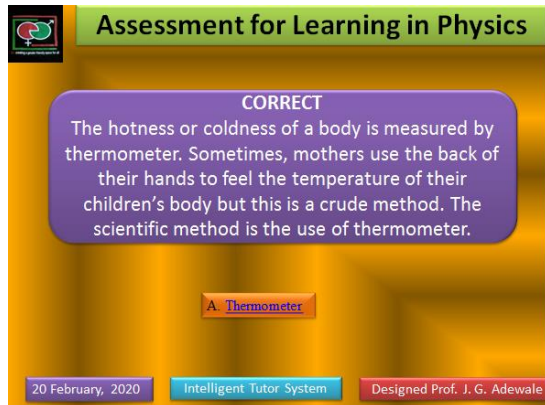If a student picks option A, automatically, this will appear

Figure 9: Feedback on the correct option

Other slides will appear depending on the answer picked. For example, the following appear if a student picks options B, C or D.
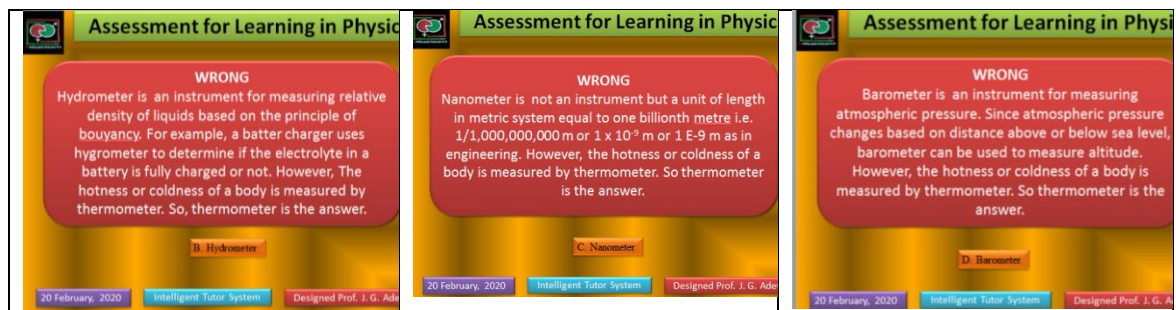

Figure 10a to 10c: Feedback on the wrong options

Step 4: Deployment of the ITS for students

The developed ITS can now be deployed for students' use. This can be done via offline or online. The offline approach is through the creation of Compaq Disks while the online approach can be hosted on a website and students are encouraged to visit the website. In each of the two approaches, students will be asked to make use the of the ITS

Step 5: Development of users' manual

The users' manual describes how the ITS can be used; some of the content of the users' manual include:

Off-line:
      a. Inside the CD on the CD drive,
      b. Double click the ITS Icon
      c. Read the instructs thoroughly and make sure you understand the instruction before moving to the next step.
      d. Time is not of essence, make sure you understand the question before you answer because penalties will not be issues if you use a lot of time.
      e. Answer the questions and make sure all questions are answers.

f. Jot down new information you have gained from the ITS.
g. Record number of questions you got right.
h. When you finish the whole exercise, you are advised to repeat the whole process so as to have a mastery of what you have learnt.
i. Each time you try, record your score and compare with the previous ones. If you like, you may plot a progression chart to show your achievement.

On-line:

a. Clink on the website or the link to ITS
b. Read the instructs thoroughly and make sure you understand the instruction before moving to the next step.
c. Time is not of essence, make sure you understand the question before you answer because penalties will not be issues if you use a lot of time.
d. Answer the questions and make sure all questions are answers.
e. Jot down new information you have gained from the ITS.
f. Record number of questions you got right.
g. When you finish the whole exercise, you are advised to repeat the whole process so as to have a mastery of what you have learnt.
h. Each time you try, record your score and compare with the previous ones. If you like, you may plot a progression chart to show your achievement.

Conclusion and Recommendations

Many studies show that ITS increases students achievement in both STEM and non-STEM subjects. Teachers are encourage to form their lesson around ITS. Formative assessment or assessment for learning is enhanced through the use of ITS. It is therefore recommended that teachers should develop ITS for use during assessment for learning in all subjects.

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