CHAPTER 6

DESIGN, DEVELOPMENT AND EXPERIMENT
ON e-INSTRUCTIONAL MODEL

6.1 INTRODUCTION

Chapters IV and V have provided a clear picture of existing cognitive structures in the contents of NPTEL e-content modules and also the need for establishing a structured and Problem Based Instructional model respectively. It is thus established the need for a highly structured instructional model based on cognitive structures of the ‘First Principles of Instruction’. Chapter V has unleashed the need for a flexible and modular approach for designing an instructional model for e-contents, in addition to ‘Problem Based Learning’ approach. It therefore indicated the need for reusable objects for the instructional approach. This chapter in section 6.2 debates on the rationale for the proposed model. Section 6.3 presents the proposed instructional model that is based on reusable technique. Section 6.4 presents the contents of meta-data that is vital to e-learning.

6.2 BASIC DESIGN PRINCIPLES FOR THE DEVELOPMENT OF E-CONTENT

The initial design of a draft e-content was based on Merrill’s First Principles of Instructions, with restricted textual materials in slides based on Carroll’s Minimalist theory (chapter II). This draft e-content on CG (courseware) developed with a few slides (elaborated in later Section) was
administrated through a pilot study from 20 respondents (e-learners). The following conventional design and development principles was applied for development and implementation:

6.2.1 **Storyboard**

The storyboard shall be the base for development, but not limiting to the content specifications and the content script. The implementing model for the design of storyboard shall be based on SCORM. The following components have been considered for the design.

6.2.2 **Layout**

The screen layout shall portray the courseware to be developed. The format of a storyboard shall include

Title and version as header, prepared as per the metadata (presented in Section 6.4). Data for the storyboard is presented below.

(a) Page number as the footer

(b) Category of SCO (sample presented in section 6.3)

(c) Graphics/illustrations

(d) Voice over script

(e) Text script

(f) Navigation buttons

(g) Directions of the navigation

(h) Notes to programmer

(i) Descriptions on the media objects
The important strategies as per the derivatives of this research are briefed below. The following sections present the consideration of strategies followed. The strategy number taken in the questionnaire (chapter V) is indicated by the abbreviated letters ‘St.’.

6.2.3 **Strategy on Navigation (St. no. 15)**

Storyboard navigation function shall conform to SCORM. All instructions on navigation shall appear in graphical form/icon. All instructions on navigation shall represent the actual navigation in courseware. Only on essentially needed navigation procedures have been provided with clues.

6.2.4 **Strategy on Animation (St. nos. 3 and 9)**

Graphic’s animation shall be clearly illustrated or described. Graphics shall be clearly described whether still or animated. All animations shall be indicated by brief descriptions. The volume of Graphic animations shall be in medium order (10% to 50%). Animations used shall be smooth that is at least 12fps.

Blinking texts shall conform to the following:

(a) The numbers of blinks for text shall be 3.
(b) Pause between blinks shall be 0.5 second.
(c) Color of the blinks shall be contrasting.
(d) Blinking text shall coincide with the original text.

Animation shall be related to content and must be accurate. Animation shall be used with purpose to support and enhanced learning.
6.2.5 Strategy for Audio / Video Script Presentations (St. no. 16)

Voice Over shall be synchronized with text, video, animation or graphic. Voice Over used must be appropriate according to gender and age of the character portrayed. The voice talent used should be the same, or at least a person or persons of almost similar voice for the same character.

Volume, tone and pitch of audio shall be consistent and clear throughout the courseware. They shall not be auditory, shrill, tinny, bloomy, muddy, thin, distorted, scratchy, coarse, grainy, harsh, hiss, crackle or rustle.

Pronunciation must be correct and intonation must be clear and with neutral ethnic accent.

Language used shall be linguistically correct, relevant to the subject and appropriate for the target group.

- Standard British English shall be used.
- Background music used shall adhere to the copy right act.
- Sound effects shall be relevant to the context.
- There shall be no overlapping of audio.

There shall be more active sentence than passive sentence in audio instruction and shall be direct

Example: “Click on the Next button to go to the next page” instead of “To go to the next page, click on the Next button”

Where possible, short sentences shall be used.
Measures, such as alternating male and female voices, shall be taken to avoid monotone, provide variety and to maintain users’ attention within a courseware.

The voice over shall tell only what is relevant.

Short and simple audio script shall be used. Long message shall be broken into chunks.

Audio icon shall be provided to enable learners to choose to listen.

Feedback in the form of the voice over shall be used appropriately and discriminately.

Negative feedback in the form of voice over shall be avoided

Example: “Your answer is wrong”

(i) Voice over shall be fully scripted.

(ii) Gender and age group of voice over narrator and talents shall be stated.

(iii) Sound effects shall be suitable to the requirement of learning content but shall not be limited.

The volume of audio/video shall be minimal in accordance with the strategy adapted.

6.2.6 **Strategy for Script Presentations on Conceptual Learning** (St. Nos. 8 and 17)

Each courseware content lesson shall be matched to be or more learning outcomes in the Curriculum Specifications. As the research will
focus more on the Instructional strategy or more specifically on objectives, conventional practices will be adapted in the draft e-content. They are explained first.

The Introduction section shall give a short overview of the lesson and acts as a set induction to motivate the learner to the lesson. The title of the e-content shall also be displayed in this section.

The Concept/Skill Learning section shall be used on learning theories that will enable learner to master the concept. Explanations shall be kept to the minimum; however should more information be required an option should be made available. Activities that elicit responses from learner shall be used as much as possible to engage them to learn. In this respect, the approach should always be that the learner shall be guided to discover or construct the concept or skill.

6.2.7 Strategy for Tests and guided exercises (St. nos. 7, 10 and 12)

The practice section shall contain guided exercises. These exercises shall elicit responses from learner as much as possible and not merely animated explanation. The practice section shall contain real life situations, where applicable.

The test section shall have the following features:

- The test questions shall be organized into three levels-easy, average and difficult.
- The questions shall also be presented according to its level of difficulty.
- It shall contain a variety of questions, including but not limited to multiple choice, matching, drag & drop and fill in the working/answers.

- The questions shall be chosen randomly generated by the systems.

- Templates for worded questions shall not be refused.

- The learner shall be free to choose which question to answer first. Navigation between unanswered and answered questions shall be permitted.

- At the end of the test, a score shall be displayed, stored and retrieved. Appropriate response shall be given next to the questions for answers which the learner has got them correctly or incorrectly.

- The extent with which the test items shall be designed in accordance with the strategy taken for the design.

After the submission of the test, the learner shall have the option to click on the question button to view the question, the wrong answer and the correct working (where applicable) and answer.

In any section of the e-content, a screen which explains the meaning of the term shall be popped up. The explanation shall be in form text, animations, or graphics. The learner shall have the choice to listen to the pronunciation of each term by clicking the audio button. The level of explanation shall be in accordance with the level of the learners.
In the test section:

(a) There shall be immediate response to learners input in the evaluation.

(b) All answers relating to fractions shall be in its simplest form but all forms (number) of correct answers shall be accepted and marked as correct. Where applicable, the question shall mention that the answer must be in its simplest form.

(c) There shall not be instructions specifying the number type (decimals, fractions etc.) for the answers except in very specific cases.

(d) Units of measurement shall be indicated in the answers. The learners shall not be required to input the units except for specific topic i.e measurements etc.

6.2.8 **Strategy on Text / Numeric Input (St. no. 11)**

Text must conform to the general educational courseware standards.

The font and size of the entry shall be similar to the size and font of the display.

The text entry shall be lowercase by default.

If the text entry is the beginning of a sentence, then the displayed answer shall show the first letter in uppercase after the learners hit the Enter/Return key.

Only text entry is allowed for box that requires text answer.
Only numeric entry is allowed for box that requires numeric answer.

All text boxes relating to text input have to be validated according to the answer types. Answers requiring numeric input must accept all types of numbers.

For example, integers, decimals, fractions and mixed fractions.

The validation of the text input shall be done in accordance to

Every permanent icon displayed shall be accompanied by tool-tips.

In calculations, there shall only be one equal in each line of calculation.

Calculations shall be “equal sign” aligned for equations and calculations.

\[ 3x = 2+7 \quad \frac{x}{2} + \frac{3}{2} \]

\[ 3x = 9 \quad = 5 \]

\[ x = 3 \]

Units related to the calculations, where relevant, shall be shown at the end of each line of calculation and not only at the end of the calculation.

Explanations/calculations shall be erased when it appears too long and cluttered on screen. A pop-up screen containing explanations/calculations when requested (example: “Mouse over” the appropriate area) shall be used.

- Highlighting shall be limited to 10% of the screen display.
- Words at the end of a line shall not be hyphenated.
- Generous white space shall be used to separate blocks of information.
- Headings shall be used as content summarizers.
- Complex information in Science and Mathematics shall be converted into tables.
- Reverse video or blanking shall be used with extreme discretion. Chunks of text to be read shall not be blinked.
- Not more than one attention-getting technique shall be used on a single screen.

6.2.9 **Strategy on Figures, Table and Graphs (St. no. 14)**

All figures, tables and graphs shall be titled.

- Numerical characters shall be decimal aligned.
- Text shall be left aligned.
- Column headings shall be centre aligned.
- Variables shall be italics and centre aligned.
- Row headings shall be left aligned.

- Lines in tables shall have 75% of the thickness of their borders.
- Grids shall be uniform in size.
- Lines shall be 100% tint
- Lines thickness of grids for graphs shall be 1.0 point, 0.75 point or 0.5
• Point or multiples of it so as to resemble the grid in graph paper.

• All diagrams shall be neatly labeled.

• Straight lines shall be used for labeling diagrams. These lines shall not intersect.

• Text for labeling shall be in lower case except for the case of proper nouns.

• Polygons shall be labeled in alphabetical order in an anti-clockwise direction.

• Labels of corners of polygons shall be in capital letters and italicized.

• Angles of polygons shall be labeled in lower case letters and italicized.

• Characteristics of the polygons shall be denoted with the appropriate mathematical symbol on the polygons, example parallel and perpendicular lines.

• Construction lines or projection lines of polygons shall be in a different color from the original line.

• Dashed lines, when used, shall begin and with a dash that intersects with relevant points.

6.2.10 Programming and Coding Concern

Due consideration shall be taken to avoid the approach of “hard-coding” the courseware, but instead to apply a more flexible and re-usable Modular Approach throughout the programming of the courseware.
The following is the standard for the Modular Approach:

(a) Use common function libraries.

(b) The name of variables, functions and procedures must reflect the meaning of its programme function.

(c) Use remark or description accordingly to highlight the respective functions, constants, variables, procedures and resource libraries.

(d) Avoid spaghetti-code (high usage of “go-to” functions) approach if possible.

All courseware produce shall complied to standard specified in SCORM 1.2 (Sharable Content Object Reference Model)

The standard for metadata shall be based on the SCORM

These elements shall be filled in

(a) Title: General Title

(b) Description: General Description

(c) Keyword: General Keyword

(d) Author or contributor Lifecycle: Contribute Entity

(e) Location, address or URL Technical : Location

Learning Resource type: Educational learning Resource Type

(f) Learner level: Educational Context

All Sharable Content Objects (SCO) shall be LMS-enabled. LMS refers to a Standard SCORM-compliant Learning Management System.
Al courseware shall be tested and passed the ADL Self Test Suite version 1.2.7. All content packages shall conform to ADLCP-PIF 1.

Run time Environment.

6.2.11 Content Package Design

Content packaging adhere to standard SCORM 1.2

Metadata file shall be saved as an external xml file to manifest file.

Objectives

- The e-content should conform to the curriculum in terms of its aims, learning outcome, skills and values.
- The e-content should promote the acquisition of knowledge: content, problem solving, epistemic and inquiry knowledge.
- The e-content should depict some local real life problems.
- The e-content should permit self-paced, self-accessed and self-directed learning.
- For any exercise or practice activity, positive and negative reinforcements should be given.
- The content shall take the learner from the known to the new learning in appropriate stages on sound learning theories.
- The content shall follow a clear learning strategy to achieve learning.
- The content shall be accurate, valid, up-to-date and without errors.
- The e-content shall stimulate and motivate the learner.
6.2.12 **Standard References**

The standard reference for English language shall be the Oxford Advanced Learner’s dictionary.

These references shall minimize discrepancies in terms of content and language.

**Table 6.1 Story board Overview**

<table>
<thead>
<tr>
<th>COURSEWARE NO.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>COURSEWARE TITLE</td>
<td></td>
</tr>
<tr>
<td>LEARNING AREA</td>
<td></td>
</tr>
<tr>
<td>LEARNING OBJECTIVE(S)</td>
<td></td>
</tr>
<tr>
<td>LEARNING OUTCOME(S)</td>
<td>LO1, LO2, LO3</td>
</tr>
<tr>
<td>VOCABULARY</td>
<td></td>
</tr>
</tbody>
</table>

Navigation buttons for FORWARD, BACKWARD and REPEAT would be used for screen movements PAUSE, PLAY and MUTE would be provided for video & Animation.

The length of the text should be minimal but the contents should explain the graphics or animation displayed on screen. The contents of text should adhere to the learning outcome.
Subsequent screens which may include Progressive checks on learner’s understanding, and prompt questions.

Figure 6.1 Structure/Flowchart for Animation
Should describe specifically the nature of the graphics and/or the flow of the animation with regards to the intended learning outcome.

The location of on-screen texts should be placed strategically on the screen.

The location of the texts should be displayed in the storyboard. OST can be either labels or titles.

Example:

Text should be in synchronized with voice.

Play animation as long as voice is played.

**Table 6.2 Graphics properties**

<table>
<thead>
<tr>
<th>Element</th>
<th>Graphics</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1/A1</td>
<td>Should describe specifically the nature of the graphics and/or the flow of the animation with regards to the intended learning outcome.</td>
</tr>
<tr>
<td>TEXT</td>
<td>The location of texts on screen should be placed strategically on the screen. The location of the texts should be displayed in the storyboard.</td>
</tr>
</tbody>
</table>

Each e-content may be matched to one or more learning outcomes in the curriculum Specifications but they (the learning outcomes) shall be form the same learning objective. Graphical elements should clearly specify with properties (Table 6.2).

The Introduction section shall be a multimedia presentation, between 15-30 seconds, which shall include any combination of text,
animation, graphics and/or audio. These multimedia presentations shall be unique to a title, and not be refused in other titles.

The concept /Skill Learning section shall start with an induction set for every sub-topic, which should be effective in rousing curiosity and interest towards the topic to be learned. This can be in form of a story, a short quiz, or short activities and games. It shall them include the main idea to be presented and can be a simulation of an activity or/and experiments.

The practice section shall reinforce the learning objective. It shall be done in a manner and with activities that differ from that used in the presentation.

Activities which shall engage learner to use their scientific skills in a fun and challenging shall be developed in the Enrichment section. Examples of these activities are games, puzzles and problems with elements of prizes, treasures, scores and time limit. There shall be instruction for each activity. A summary of the lesson and may have some important facts, shall be easily accessible to the learners.

6.2.13 Language

Each courseware lesson shall be matched to a learning outcome in the Curriculum Specifications. However, a maximum of two learning outcome may be combined to form a courseware if each of these learning outcome is not meaningful for a courseware if each of these learning outcome is not meaningful for a courseware lesson to be developed from it. Combination of learning outcome shall be the exception rather than the norm.

The courseware lesson shall have five sections:

(a) Introduction
(b) Skills Learning
The introduction section shall give a short overview of lesson and acts as a set induction to motivate the learners to the lesson. This shall be in form of an animated cartoon clip. The title of the courseware shall also be displayed in this section.

The skills learning section shall be based on learning theories that will enable learners to master the skills. Explanations shall be kept to minimum and activities that elicit responses from learners shall be used as much as possible to engage them to learn. In this respect, the approach should always be that the learner shall be guided to master the skills.

The practice section shall contain drill and practice exercises. A sub-section, Re-learn shall be available. If a learner does not get the exercise correct after two tries, he shall be automatically taken to the re-learn section so that the courseware shall guide the user to the correct answer. This guide shall elicit responses from the user as much as possible and not merely animated explanation. The Practice section shall help the child to master the skills. It should cover the relevant topics/learning area. It shall contain a minimum of 5 questions, arranged according to its level difficulty.

Activities which shall engage learners to use their language skills in a fun and challenging scenario shall be developed in the Enrichment section. Examples of these activities are games, Puzzles and problems with elements of prizes, treasures, scores and time limit. There shall be instruction for each activity.

Once an important word in any section of the courseware is clicked, a screen which explains the meaning of this word shall be popped up. The explanation shall be in text or explains the meaning of this word shall be
popped up. The explanation shall be in text or graphic or both. The learner shall have the choice to listen to pronunciation of each term. The level of explanation shall be consistent with the level of the learning outcome. Help Icon shall be available for learner on the technical aspects of the courseware.

6.3 THE PROPOSED E-CONTENT DEVELOPMENT MODEL

There are three essential layers in the model. The lowermost layer has all reusable objects of the e-content. The section’s layer has concepts for instruction based on each section at a time. A section may have one or more objects, but an object alone cannot describe a concept. The top layer has modules layer under the SCO (Sharable Content Objects). The model is presented below.

6.3.1 The Model Design

Figure 6.2 Proposed Instructional Model for e-Content
Layers of the Model

There are three essential layers in the model. The lower layer, called ‘Objects layer’ has all reusable independent small objects of the e-content in databases. The middle layer called ‘Section’s layer’ has concept based groups of topics or objects. A section may have one or more objects, but an object can or cannot describe a whole concept, whereas sections will. The top layer called ‘Modules layer’ has full-fledged instructional module. The model is shown in figure 6.3.

Salient Features of the established Model

The model represents three components namely 1) The Module, 2) SCO - The Black Box and 3) The Objects Base as shown in the Figure 6.2. The module is a software procedure or a task that creates a whole module or an instructional episode, which consists of the five components of the ‘First Principles of Instruction’ of David Merrill’s theory. The five components are: i) Ill structured Real World Problem; ii) Activation – Recalling structure of already learnt/experienced material; iii) Demonstration – Describing or demonstrating structure of the concept; iv) Application – Problem solving structure with numerical examples and v) Integration – Analytical or critical thing structure to test the learnt concept. Except the first component namely the Ill structured Real world problem, all the rest (four) of the components are called ‘Cognitive Structures’ or ‘Portrayals’. Each of the cognitive structures (except the ill structured Real World Problem) consists of two parts: a) Procedure to find out the required object from the Object Base and b) Additional instructions for concatenating each portrayal. The module thus creates a highly structured and hierarchical instruction.
The second component namely SCO - The Black Box contains three layers as depicted in Figure 6.3. It is called the ‘Black Box’ as the entire subject contents in the form of concept keywords for a subject topic such as “Introduction to CG” or GUI etc. The requests received from users are processed by this unit. Using the concept keywords, the required instructional module is identified by the module’s layer of the ‘Black Box’. The sections buried for each module is identified in this sections layer, which in turn picks the required objects from the object layer (databases). This component then copies the required objects from the object data base to the procedure. The procedure processes the creating and editing of the metadata.

The object database has scores of reusable objects called SCOs (Figure 6.2) of each piece of information/instructions in the form of the four Cognitive structures. The data in the metadata include: Object title, object ID, Segment title, classification etc., (Section 6.4).

**Legend**

- Q / A: Question and Answer under Multiple Choice
- A set of Object(s) may be under one Concept
- But a Concept cannot be under one Object
- Application & Integration do not request for object(s)
6.3.2 SCO The ‘BLACK BOX’

Figure 6.3 SCO Black Box for a Typical Section

6.3.3 Experimental Instructional Episode on Section “Introduction to CG”

REAL WORLD PROBLEM

Section Title : Introduction to CG

Number of objects in the section : Titles of the objects of the section: **Real World Problem (RWP)**

Object Type : Unique to Section

Total number of slides : 2 (An Airplane cockpit with a pilot as shown below.)
Do you know that Airplane pilots need not get their training from actual cockpits?

Object: “Define”; Type: Unique to Section

Slide: 2 of 2 “Computer Graphics involves display, manipulation and storage of pictures and experimental data for proper visualization using a computer”, as shown below.
Computer Graphics involves display, manipulation and storage of pictures and experimental data for proper visualization using a computer.

**Activation**

**Question (Audio)** : What is the difference between TV and CG?

**Object: “Define”** : Type: Unique to Section

**Total number of slides** : 1 (a TV monitor as shown below)
Demonstration

Object: “Components”; Type: Reusable

Total number of slides: 4

Audio: Explains different components (see slide below)
Demonstration

Object: “Devices”; Type: Reusable

Slide: 2 of 4

Audio: Explains CRT (see slide below)

Demonstration

Object: “Devices”; Type: Reusable

Slide: 3 of 4

Audio: Explains CRT Components (see slide below)
Demonstration

Object: “Frame Work”; Type: Reusable

Slide: 4 of 4

Audio: Explains Frame Works (see slide below)
Application

Object: “Applications”; Type: Unique to Section

Total number of slides: 2

Audio: Explains a house (see slide below)

Application

Object: “Applications”; Type: Unique to Section

Slide: 2 of 2

Audio: Explains a hut (see slide below)
Integration

Object: “Integration”; Type: Unique to Section

Total number of slides: 1

Audio: Do you think one can stimulate airplane’s cockpit using CG for pilot training?
Yes of course! (see slide below)

End of episode (Section).
### 6.4 DESIGN OF META DATA FOR OBJECTS

The designed meta-data as per the SCO’s black box for a typical section is presented below:

1. Object Title (Texts)
2. Object ID (Numeric)
3. No. of Segments (Numeric)
   i. Segment 1 Title (Texts)
   ii. Segment 2 Title (Texts)
       :
       :
       :
4. No. of Pre-requisite Objects (Numeric)
   i. Pre-requisite Object ID (Numeric)
   ii. Pre-requisite Object ID (Numeric)
       :
       :
       :
5. Classification (2)
   i. Section No. (Numeric)
   ii. Session No. (Numeric)
6. Objectives of Object concept (Texts)
7. Learning Resources (Numeric) /* Each Resource (Video/Audio/Animation/Picture) has an ID*/
8. Object Size (in Bytes) (Long Unsigned Integer)
9. Instructional Duration (in Minutes) (Integer)

10. Location (Path name)

11. Location of Pre-requisite Objects (Numeric - Same as Data 4)
   i. Path of Pre-requisite Object 1
   ii. Path of Pre-requisite Object 2
      :
      :
      :

12. No. of Frames (Slides) for Segments (Numeric – Same as Data 3)
   i. Frames of Segment1
   ii. Frames of Segment2
      :
      :
      :

13. Total No. of Frames excluding Pre-requisite Objects (Numeric)

14. No. of Branches for Segments (Numeric – Same as Data 3)
   i. Branches in Segment1
   ii. Branches in Segment2
      :
      :
      :
6.5 SUMMARY

As demonstrated earlier the ‘Black Box’ of SCO liberally re-uses objects in every section. The model has explicitly applied Merrill’s cognitive structures and ‘Real World Problem’. The model was subjected to experiment with one section as elaborated above.