

A model for the Instructional Design, Development, Delivery and Evaluation of a Web-based course in Computer Science

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The steps in producing software are usually organized into a lifecycle consisting of several phases of development. The systems development lifecycle (SDLC) provides a comprehensive framework for describing the process of solving information system problems. Given the SDLC success in software production for many years, a variant of this organized approach is put forward for Web based course production. This variant is called EMBER and consists of five steps. Although each step is presented individually, the steps are interrelated and occur in an iterative manner. The EMBER model is a structured approach to Web based course development. This model focuses on the design, development, delivery, and evaluation of instruction for a Web based course for students at secondary school level in the English speaking Caribbean. A key design decision is that the Web based course would be used to complement classroom teaching. The teacher plays the role of facilitator rather than a dispenser of instruction. This role is not new for the teacher. However, the technology provides the means whereby he/she can perform that role with effectiveness.

The five steps of the model are **E**valuate, **M**odel, **B**uild, **E**xecute, and **R**eview and are shown in Figure 1 and discussed in sections 1 to 5. This model supports the entire systems development lifecycle.

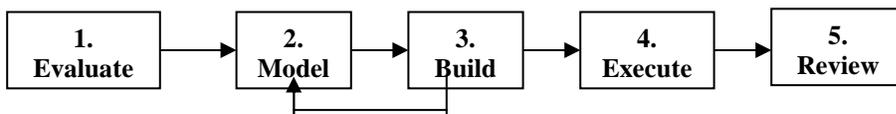


Figure 1 - The EMBER Model

Each of these steps/phases consists of a number of activities to perform and issues to consider. In this paper we present a brief overview of the steps, focussing mainly on the Model and Build activities.

1. Evaluate

Before moving courses from the traditional classroom to the quasi-virtual classroom, instructional designers should first evaluate the current syllabus with respect to its requirements [1]. The syllabus to be examined is the Caribbean Examinations Council (CXC) Information Technology [2]. This evaluation step involves a number of exercises that include - evaluation of schools IT status and readiness, evaluation and selection of Web learning management tools, evaluation of the technology and administrative resources required, evaluation of costs and benefits, and discussions with stakeholders.

2. Model

This phase of the system development focuses on analyzing the existing syllabus (which is already well defined by CXC), structuring the course and sequencing the instructions within the structure. By the end of this process the course developer would have a very good understanding of what the course is all really about.

The CXC Information Technology syllabus (see Fig 3) consists of three types of units that require different learning environments: concept-based learning, skills-based learning and problem-based learning (see Fig 2). Concept-based units are concerned with concept learning of the fundamental components of computer systems; evaluation is mainly testing understanding and memorization. In concept learning, the computer is used as a tutor providing immediate feedback to the answers submitted by students.

The skills-based units emphasize usage of and familiarization with the software, and as such the computer is used as a tool. The problem-based units are concerned with the application and use of knowledge to solve programming problems. These units develop the student's analytical and creative thinking. Emphasis is on algorithm development. In such situations the computer is used as a trainee because the student is instructing it instead of being taught by it.

O	O	O	{Type of Unit}
o			Concept-based Learning
	o		Skills-based Learning
	.	o	Problem-based Learning
M	M	M	{Unit}
v	.	.	Fundamentals of Hardware and Software
.	.	v	Introduction to Programming
v	.	.	Applications and Implications
.	v	.	Productivity Tools
.	v	.	Word processing
.	v	.	Spreadsheets
.	v	.	Database Management
.	.	v	Information Processing
.	.	v	Programming

Figure 2 – The CXC Information Technology Types of Units

Legend: **O** means Dominant set; **o** means Dominant set member; **M** means Many; **v** means cell marker.

The existing course syllabus is structured into a hierarchy consisting of Unit → Topic/Lesson → Lesson Components. A unit is divided into topics/lessons, which, in turn, are divided into lesson components. These components are described briefly below.

1. **Review** – This is used to connect the last lesson to the present one.
2. **Focus** – This lists the topic(s) to be covered in the lesson.
3. **Estimated Completion Time** – This indicates the approximate time it takes to complete the lesson.
4. **Objectives** – The objectives of the lesson are listed in this section.
5. **Presentation of Content** – The lesson material is determined. This may be presented in several forms: concept-based units are mostly descriptive instructional materials that may include links to other Web sites for additional reference material. Lessons for skills-based units may be in the form of instructions to complete certain tasks. Lessons for problem-based units may provide algorithmic solutions to some problem with the features of the solution highlighted.
6. **Assessment** – Exercises, in ascending order of difficulty, are determined for each lesson and the unit as a whole. The computer provides capabilities of generating several types of assessment methods: self-assessment exercises, quizzes, multiple choice and short answer exercises, and essay type case studies and projects. For the problem-based units, incomplete programs can be given for students to complete a missing module (students focus only on that part of the solution) or for students to practice debugging of their programs.

Sequencing of the units of the course as well as sequencing the lessons comprising the units must be carefully considered. Some units may be sequenced in parallel with the lesson units interspersed. Fig 3 shows that Unit 1, Fundamentals of Hardware and Software, and Unit 4, Productivity Tools are taught as the first units in the sequence (for

both technical and general level proficiencies). Fig 4 shows a possible sequencing of the lessons of these two units.

O	O	{Syllabus}
o		General Proficiency
	o	Technical Proficiency
S	S	{Unit}
1	1	Fundamentals of Hardware and Software
3	5	Introduction to Programming
2	6	Applications and Implications
1	1	Productivity Tools
.	2	Word processing
.	3	Spreadsheets
.	4	Database Management
4	.	Information Processing
5	.	Programming

Figure 3 – The CXC Information Technology syllabus with sequenced units
Legend: **O** means Dominant set; **o** means Dominant set member; **S** means Sequence.

Lessons	Sequence
1.01 - Focus of Unit 1	1
1.02 - Computer components and their functions	2
1.03 - Internal storage	5
1.04 - Data representation	6
1.05 - Secondary storage	7
1.06 - Input	8
1.07 - Output	9
1.08 - Applications and systems software	10
1.09 - Application software	11
1.10 - Types of user interface	12
1.11 - File management	13
1.12 - Operating hardware devices	15
1.13 - Data communications	16
1.14 - Unit's Highlights	17
1.15 - Unit's Exercises	18
4.01 - Focus of Unit 4	3
Word processing: 4.WP.01 to 4.WP.06	4
Spreadsheet: 4.SS.01 to 4.SS.09	14
Database Management: 4.DB.01 to 4.DB.06	19
4.02 - Unit's 4 Highlights	20
4.03 - Unit's 4 Exercises	21

Figure 4 – A grid chart showing the Course tree sequencing of lessons

3. Build

In this phase the Web course is actually constructed.

Navigation and presentation issues are of critical importance. The interface design should be one that provides maximum effectiveness. Functions and features should not

distract from the learning task at hand. The look and feel of the interface should be consistent from one screen to the next. Navigational buttons and instructions should be in the same place for each lesson. Course maps should let participants know where they are. The use of color, text effects, graphics and animation should be used effectively where appropriate in the presentation of the course. The developer should be alert to the fact that in many schools in the Caribbean, the low bandwidth and slow Internet connections limit the use of graphics and animation. In the IT course developed, a Launch button in the lesson provides for seamless navigation that allows students to move from a text screen to a productivity tool or programming language without opening or closing individual applications.

The developer *builds the lesson content* from the lesson framework that is developed in the previous stage. Instructional materials for a lesson are divided into information capsules; these are relatively small chunks of materials that make sense on their own. Each information capsule should contain instructions for only one objective. A chunk is a manageable unit of information. Chunks of information must be arranged on a screen so as to make them most useful for the students. The course designer must decide on which chunks fit on the first viewing screen, and which chunks or sub-chunks should be located elsewhere but link to chunks on this first screen.

The developer must *build the assessment exercises*. Two levels of assessment exercises can be built. One level is placed in the lesson and its purpose is to determine how well students have mastered the lesson's objective(s). The other is placed in the section on unit's exercises and its purpose is to reinforce what have been mastered from the various lessons. The teachers/facilitators should encourage and teach students how to assess their own learning. Thus helping them to become more competent at self-assessing so that they can improve their own chances of learning [3].

A guided tour is often a good introduction to either a new course or a new system. The guided tour should provide learners with information on how to navigate the course, the policies and procedures governing the course, tips for online behaviour, and how to get help [see Figure 5].

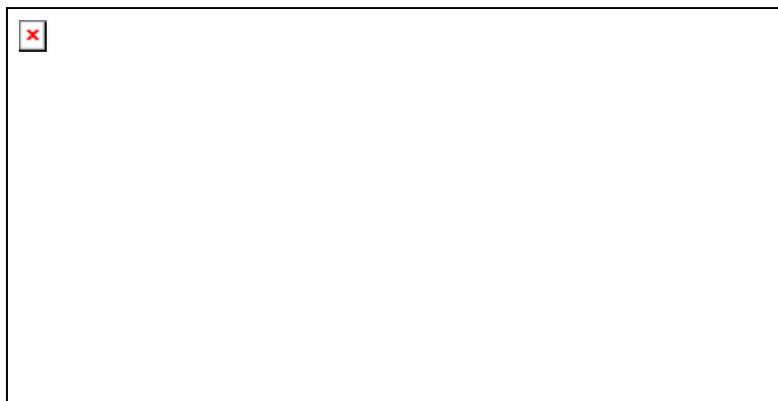


Figure 5 Guided Tour

4. Execute

Activities in this phase relate to going 'live' with the course. Decisions related to Web hosting, which would have been considered in phase 1, are now finalized. Course administration and procedures for registering teachers and students are set in place. The course can be tested in phases as the units are completed as well as testing should be carried out on the completed course. The IT course for which the EMBER model was put to work was presented in phases because of its size and the different types of units it

contains. Selected schools were scheduled at different times to test their respective units.

Participants in the course must be trained to use the delivered Web course in an efficient and effective manner. One training approach used was first to train the relevant teachers who, in turn, will train the students. Additionally, seminars can be organized for IT teachers to discuss the issue of using computers and the Web based course to be used to complement classroom teaching.

Support for the course was given great consideration. A key decision was that process support would be provided by IT teacher(s) at the schools. Problems that cannot be handled by the teacher(s) would be forwarded to the course developer for assistance. However, a teacher has the option of seeking online help from fellow registered Caribbean teachers.

5. Review

This step involves the review and revision of the delivered course instructions and materials contain in the Web based course. This takes place after the course has been in use for some time. It is important that thorough surveys or questionnaire be prepared so as to gauge teachers and students' reaction to teaching/learning in an online environment. Results from the evaluation exercise are used to improve the quality of the content, method of providing the materials over a distance, and the quality of instruction.

Conclusion

The EMBER model provides a framework for a structured and systematic approach to web-based course development. This methodology does not call for the replacement of the teacher in the classroom. What it does is to provide a way of complementing the teacher's work. The teacher's role will change from that of a dispenser of information to that of a facilitator/coach/guide. In the Caribbean, the average student of secondary school age is not mature enough to work exclusively in an online course environment. This requires self-discipline and independent thinking and reading that many students in this age group have not yet acquired. IT teachers, therefore, should be used to play the role of facilitator/coach/guide.

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